Exhibit VGS-AG-102

Exhibit VGS-CC-2



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 RESULTS						
	Calculated Effective Stress (psi					
Soil type	3' Cover	4' Cover	5' Cover			
Soft to medium clays and silts with high plasticities	31,239	31,437	31,234			
Soft to medium clays and silts with low/medium plasticities	31,180	31,370	31,159			
Loose sands and gravels	30,360	30,550	30,427			
Stiff to very stiff clays and silts	30,216	30,366	30,193			
Medium dense sands and gravels	30,278	30,453	30,318			
Dense to very dense sands and gravels	29,422	29,554	29,437			
ALLOWABLE EFFECTIVE STRESS (psi)		32,500				
Note:						

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

5/25/2016

Rev. 1



Calculation cover sheet

Project Title:	VERMONT GAS SYSTEMS	Project No:	351481KK01
File No:		No. of Sheets:	18
Section:		Subject:	
Calc No:			
Project Manager:		Designer:	
Design Phase:	A - Concept or preliminary	C - Design verifica	ation
	B - Analysis and detailed design	D - Other (specify)	

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

Scopes for Checking Manual and Computer Generated Calculations:

,Back Back	chux check	project infinitividual	calculations	to	verify	results
Ī	Back Back	Back check Back check	Back check project int Back check individual	Back check project information Back check individual calculations	Back check project information Back check individual calculations to	Back check project information Back check individual calculations to verify

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
		$\left[\right]$			0	
		0				
· ·	•	uter file has been che ed. (PiMS nickname				
		Source and Refe				<i>xy</i>
> Design > API IIC	. Into. pe	r Mike Ri 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	rovided	to die	nt	
			1			
Approved by P	roject Manager:	Signature: Print name:	Juseph	WOJNAS	5000000000	Date: 5/2.5/16

Distribution: Original

Original to project file



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

Prepared By Kelsey Kibbe Approved By

Location Burlington, VT		Date 5/24/20	16	
API 1102 - Gas Pipeline	e Crossing High	way		ж.
PIPE AND OPERATIONAL DATA	:	SITE A	ND INSTALLATION DA	TA:
Operating Pressure [psi]	1440	Soil Ty	•	ays and silts with high
Location Class:	3	E' - Mo	plasticities odulus of Soil Reaction [k	(si] 0.2
Operating Temperature [°F]	60.0		esilient Modulus [ksi]	5.0
Pipe Outside Diameter [in]	12.75		ge Unit Weight of Soil [lb/	
Pipe Wall Thickness [in]	0.312	-	epth [ft]	4
Pipe Grade: X65		•	Diameter [in]	12.75
Specified Minimum Yield Stress	65,000		ationTemperature [°F]	60.0
Design Factor	0.50		Wheel Load from Single	
Longitudinal Joint Factor	1.0	•	Wheel Load from Tand	-
Temperature Derating Factor	1.000	-	nent Type: None	
Pipe Class: API 5L Electric Re	esistance Welded		Factor Method: ASCE -	- Highway
Young's Modulus for Steel [ksi]	30,000	·		0
Poisson's Ratio for Steel	0.30			
Coefficient of Thermal Expansion	[per°F] 0.0000065	Safety	Factor Applied: API 11	102 Procedure
RESULTS				
Hoop Stress [psi]		29,423	Maximum Circumferen	itial Stress [psi] 34,5
Allowable Hoop Stress [psi]		32,500	Maximum Longitudinal	Stress [psi] 12,3
Stiffness Factor for Earth Load Ci	rcumferential Stress	2,196	Maximum Radial Stres	is [psi] -1,4
	unformation Officers	0.07	Total Effective Stress [psi] 31,4
Burial Factor for Earth Load Circu	mierential Stress	0.97		pol] 01,4
			Allowable Effective Str	
Excavation Factor for Earth Load	Circumferential Stress			
Excavation Factor for Earth Load Circumferential Stress from Earth	Circumferential Stress	0.83	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]	0.83 1,555	Allowable Effective Str Stress [psi] Calculat Hoop 29,423	ed Allowable PASS/F/ 32,500 PASS
Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycli	Circumferential Stress Load [psi] ic Circumferential	0.83 1,555 1.50	Allowable Effective Str	ess [psi] 32,5
Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor	Circumferential Stress Load [psi] ic Circumferential clic Circumferential	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
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 clic 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 32,500 PASS 6,000 PASS
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 ic Longitudinal Stress	0.83 1,555 1.50 16.60 1.22 4,271 13.20	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 32,500 PASS 6,000 PASS
Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycli Highway Geometry Factor for Cycl Cyclic Circumferential Stress [psi] Highway Stiffness Factor for Cycli	Circumferential Stress Load [psi] ic Circumferential clic Circumferential ic Longitudinal Stress	0.83 1,555 1.50 16.60 1.22 4,271 13.20	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 32,500 PASS 6,000 PASS

Operating Pressure [psi]1440Soil Type:: Soft to medium clays and silts with high plasticitiesLocation Class:3E' - Modulus of Soil Reaction [ksi]0.2Operating Temperature [°F]60.0Er - Resilient Modulus [ksi]5.0Pipe Outside Diameter [in]12.75Average Unit Weight of Soil [lb/ft³]120.00Pipe Wall Thickness [in]0.312Pipe Depth [ft]5Pipe Grade:X65Bored Diameter [in]12.75Specified Minimum Yield Stress65,000InstallationTemperature [°F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel0.30Safety Factor Applied: API 1102 ProcedureRESULTS29,423Maximum Circumferential Stress [psi]34,28Allowable Hoop Stress [psi]29,423Maximum Longitudinal Stress [psi]12,13Stiffness Factor for Earth Load Circumferential Stress2,196Maximum Radial Stress [psi]-1,444Burial Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]31,23	Location Burlington, VT		Date 5/24/20	16			
Operating Pressure [psi]1440Soil Type:Soft to medium clays and silts with high plasticitiesLocation Class:3E' - Modulus of Soil Reaction [ksi]0.2Operating Temperature [°F]60.0Er - Resilient Modulus [ksi]5.0Pipe Outside Diameter [in]12.75Average Unit Weight of Soil [lb/ft³]120.00Pipe Wall Thickness [in]0.312Pipe Depth [ft]5Pipe Grade:X65Bored Diameter [in]12.75Specified Minimum Yield Stress65,000InstallationTemperature [°F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel0.30Coefficient of Thermal Expansion [per"F]0.0000065Coefficient of Thermal Expansion [per"F]0.0000065Safety Factor Applied: API 1102 ProcedureRESULTS29,423Maximum Circumferential Stress [psi]34,28Allowable Hoop Stress [psi]29,423Maximum Cadial Stress [psi]1,144Burial Factor for Earth Load Circumferential Stress2,196Maximum Radial Stress [psi]31,23Stiffness Factor for Carth Load Circumferential Stress1.08Total Effective Stress [psi]32,500Inspact Factor1.50Stress [psi]2,250PASSEffective Air Load Circumferential Stress1.732Effective 31,23432,500 </th <th>API 1102 - Gas Pipelin</th> <th>e Crossing High</th> <th>way</th> <th></th> <th></th> <th></th> <th></th>	API 1102 - Gas Pipelin	e Crossing High	way				
Location Class:3E' - Modulus of Soil Reaction [ksi]0.2Operating Temperature [°F]60.0Er - Resilient Modulus [ksi]5.0Pipe Outside Diameter [in]12.75Average Unit Weight of Soil [lb/ft ^a]120.00Pipe Wall Thickness [in]0.312Pipe Depth [ft]5Pipe Grade:X65Bored Diameter [in]12.75Specified Minimum Yield Stress65.000InstallationTemperature [°F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel0.30Coefficient of Thermal Expansion [per°F]0.0000065RESULTSHoop Stress [psi]29,423Maximum Circumferential Stress [psi]12,13Allowable Hoop Stress [psi]29,423Maximum Longitudinal Stress [psi]12,24Allowable Hoop Stress [psi]32,500Maximum Radial Stress [psi]12,25Circumferential Stress1.08Total Effective Stress [psi]32,500Circumferential Stress from Earth Load Circumferential1.732Impact Factor for Cyclic Circumferential1.732Impact Factor1.50Stress [psi]23,2500PASSHighway Geometry Factor for Cyclic Circumferential1.00Stress [psi]32,500Circumferential Stress [psi]3,85011,500PASSGirth Weids 3,0066,000 <th>PIPE AND OPERATIONAL DATA</th> <th>:</th> <th>SITE A</th> <th>ND INSTALLA</th> <th></th> <th></th> <th></th>	PIPE AND OPERATIONAL DATA	:	SITE A	ND INSTALLA			
Location Class: 3 E' - Modulus of Soil Reaction [ksi] 0.2 Operating Temperature [°F] 60.0 Er - Resilient 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 [kips] 18.4 Temperature Derating Factor 1.000 Pavement Type: None Impact Factor Method: ASCE - Highway Young's Modulus for Steel 0.30 Coefficient of Thermal Expansion [per*F] 0.000065 RESULTS 29,423 Maximum Circumferential Stress [psi] 12,13 Allowable Hoop Stress [psi] 32,500 Maximum Radial Stress [psi] 12,43 Burial Factor for Earth Load Circumferential Stress 1.08 Total Effective Stress [psi] 31,23	Operating Pressure [psi]	1440	Soil Ty			s and silts	with high
Operating Temperature (°F) 60.0 Er - Resilient 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 [kips] 18.4 Temperature Derating Factor 1.000 Pavement Type: None Impact Factor Method: ASCE - Highway Young's Modulus for Steel 0.30 Coefficient of Thermal Expansion [per*F] 0.0000065 RESULTS Hoop Stress [psi] 29,423 Maximum Circumferential Stress [psi] 34,28 Allowable Hoop Stress [psi] 29,423 Maximum Radial Stress [psi] 12,13 Stiffness Factor for Earth Load Circumferential Stress 2,196 Maximum Radial Stress [psi] 31,23 Excavation Factor for Earth Load Circumferential Stress 0.83 Allo	Location Class:	3	E' - Mo				0.2
Pipe Outside Diameter [in] 12.75 Average Unit Weight of Soil [lb/ft ^a] 120.00 Pipe Wall Thickness [in] 0.312 Pipe Depth [ft] 5 Pipe Grade: X65 Bored Diameter [in] 12.75 Specified Minimum Yield Stress 65,000 Installation Temperature [°F] 60.0 Design Factor 0.50 Design Wheel Load from Single Axle [kips] 18.4 Longitudinal Joint Factor 1.0 Design Wheel Load from Tandem Axles [kips] 18.4 Temperature Derating Factor 1.000 Pavement Type: None Impact Factor Method: ASCE - Highway Young's Modulus for Steel [ksi] 30,000 Safety Factor Applied: API 1102 Procedure 4.11102 Procedure RESULTS 0.30 Safety Factor Applied: API 1102 Procedure 12.13 RESULTS 29,423 Maximum Circumferential Stress [psi] 12.13 Stiffness Factor for Earth Load Circumferential Stress 1.08 Total Effective Stress [psi] 12.23 Stiffness Factor for Earth Load Circumferential Stress 0.83 Allowable Effective Stress [psi] 31.23 Excavation Factor for Earth Load Circumferential Stress 0.83 Allowable Effective Stress [psi] 32.500	Operating Temperature [°F]	60.0					
Pipe Wall Thickness [in]0.312Pipe Depth [ft]5Pipe Grade:X65Bored Diameter [in]12.75Specified Minimum Yield Stress65,000InstallationTemperature [°F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel [ksi]30,00030Coefficient of Thermal Expansion [per°F]0.0000065Poisson's Ratio for Steel0.30Safety Factor Applied: API 1102 ProcedureAPI 1102 ProcedureRESULTSHoop Stress [psi]29,423Maximum Circumferential Stress [psi]34.28Allowable Hoop Stress [psi]29,423Maximum Longitudinal Stress [psi]1.24Burial Factor for Earth Load Circumferential Stress2,196Maximum Radial Stress [psi]1.24Burial Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Impact Factor1.50Stress [psi]29,42332,500PASSHighway Stiffness Factor for Cyclic Circumferential1.60Hoop29,42332,500Circumferential Stress1.08Total Effective Stress [psi]32,500Circumferential Stress [psi]32,500Maximum Circumferential Stress [psi]32,500 <t< td=""><td>Pipe Outside Diameter [in]</td><td>12.75</td><td></td><td></td><td></td><td></td><td></td></t<>	Pipe Outside Diameter [in]	12.75					
Pipe Grade:X65Bored Diameter [in]12.75Specified Minimum Yield Stress65,000InstallationTemperature [°F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel [ksi]30,00030Safety Factor Applied:API 1102 ProcedurePoisson's Ratio for Steel0.30Safety Factor Applied:API 1102 ProcedureCoefficient of Thermal Expansion [per°F]0.0000065Safety Factor Applied:API 1102 ProcedureRESULTS429,423Maximum Circumferential Stress [psi]12,13Stiffness Factor for Earth Load Circumferential Stress2,196Maximum Radial Stress [psi]12,25Iwadi Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]32,500Circumferential Stress fore Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Impact Factor1.50Stress [psi]2,500PASSHighway Stiffness Factor for Cyclic Circumferential1.00Effective 31,23432,500PASS1.150PASS1.150PASSHighway Geometry Factor for Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress [psi]3,85011,500PASSHighway Geometry Factor for Cyclic Longitudinal Stress	Pipe Wall Thickness [in]	0.312	-	_	si con fisire i		
Specified Minimum Yield Stress65,000InstallationTemperature [°F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel [ksi]30,000NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel0.30Safety Factor Applied: API 1102 ProcedureCoefficient of Thermal Expansion [per°F]0.000065Safety Factor Applied: API 1102 ProcedureRESULTS29,423Maximum Circumferential Stress [psi]12,13Moop Stress [psi]29,423Maximum Longitudinal Stress [psi]12,13Stiffness Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]31,23Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Pass1.50Stress [psi]29,42332,500PASSImpact Factor1.50Stress [psi]29,500PASSInghawy Stiffness Factor for Cyclic Circumferential1.60Effective 31,23432,500Pass1.50Stress [psi]3.85011,500PASSHighway Geometry Factor for Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress [psi]3.85011,500PASSLinghway Geometry Factor for Cyclic Longitudinal Stress1.08Cyclic Lo	Pipe Grade: X65						
Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayPipe Class:API 5L Electric Resistance WeldedImpact Factor Method: ASCE - HighwayImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel [ksi]30,00030Safety Factor Applied: API 1102 ProcedurePoisson's Ratio for Steel0.30Safety Factor Applied: API 1102 ProcedureCoefficient of Thermal Expansion [per*F]0.000065Safety Factor Applied: API 1102 ProcedureRESULTS29,423Maximum Circumferential Stress [psi]34,28Allowable Hoop Stress [psi]29,423Maximum Longitudinal Stress [psi]12,13Stiffness Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]31,23Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load Circumferential1.732Impact Factor1.50Stress [psi]22,500Impact Factor1.50Stress [psi]Calculated Allowable PASS/FAHighway Geometry Factor for Cyclic Circumferential1.00Effective 31,23432,500Cyclic Circumferential1.00Sa5011,500PASSEffective 31,23432,500PASSEffective 31,23432,500Highway Geometry Factor for Cyclic Longitudinal Stress1.08Cyclic Cir	Specified Minimum Yield Stress	65,000			re [°F]		
Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel [ksi]30,00030Safety Factor Applied: API 1102 ProcedurePoisson's Ratio for Steel0.30Safety Factor Applied: API 1102 ProcedureCoefficient of Thermal Expansion [per°F]0.0000065Safety Factor Applied: API 1102 ProcedureRESULTS400 Stress [psi]29,423Maximum Circumferential Stress [psi]12,13Allowable Hoop Stress [psi]29,423Maximum Longitudinal Stress [psi]1,444Burial Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]31,23Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load Circumferential1.732Impact Factor1.50Impact Factor1.50Stress [psi]Calculated Allowable PASS/FAHighway Geometry Factor for Cyclic Circumferential1.08Girth Welds 3,0066,000Cyclic Circumferential Stress [psi]3,85011,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress1.08Cyclic Vields 3,85011,500Highway Geometry Factor for Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress [psi]3,0061.08Cyclic Longitudinal Stress1.08	Design Factor	0.50				xle [kips]	
Temperature Derating Factor1.000Pavement Type: NonePipe Class:API 5L Electric Resistance WeldedImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel [ksi]30,000Poisson's Ratio for Steel0.30Coefficient of Thermal Expansion [per°F]0.0000065RESULTSSafety Factor Applied:API 1102 ProcedureHoop Stress [psi]29,423Maximum Circumferential Stress [psi]34,28Allowable Hoop Stress [psi]32,500Maximum Longitudinal Stress [psi]12,13Stiffness Factor for Earth Load Circumferential Stress2,196Maximum Radial Stress [psi]-1,444Burial Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load [psi]1,732Impact Factor1.50Impact Factor1.50Stress [psi]Calculated Allowable PASS/FAHighway Geometry Factor for Cyclic Circumferential1.00Effective 31,23432,500Cyclic Circumferential1.10Girth Welds 3,0066,000PASSHighway Stiffness Factor for Cyclic Longitudinal Stress13.201.081.08Highway Geometry Factor for Cyclic Longitudinal Stress1.082.06Highway Geometry Factor for Cyclic Longitudinal Stress3.0063.006Highway Stiffness Factor for Cyclic Longitudinal Stress3.006	Longitudinal Joint Factor	1.0	•		•		
Pipe Class:API 5L Electric Resistance Welded Impact Factor Method: ASCE - HighwayYoung's Modulus for Steel [ksi]30,000Poisson's Ratio for Steel0.30Coefficient of Thermal Expansion [per*F]0.0000065RESULTS29,423Hoop Stress [psi]29,423Allowable Hoop Stress [psi]32,500Maximum Longitudinal Stress [psi]12,13Stiffness Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]31,23Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load [psi]1,732Impact Factor1.50Highway Stiffness Factor for Cyclic Circumferential1.10Girth Welds3,006Cyclic Circumferential Stress1.320Highway Stiffness Factor for Cyclic Longitudinal Stress1.08Cyclic Circumferential Stress [psi]3.850Lingway Stiffness Factor for Cyclic Longitudinal Stress1.08Cyclic Circumferential Stress [psi]3.850Highway Stiffness Factor for Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress [psi]3.006	Temperature Derating Factor	1.000	•				
Young's Modulus for Steel [ksi] 30,000 Poisson's Ratio for Steel 0.30 Coefficient of Thermal Expansion [per°F] 0.0000065 RESULTS Safety Factor Applied: API 1102 Procedure Hoop Stress [psi] 29,423 Maximum Circumferential Stress [psi] 34,28 Allowable Hoop Stress [psi] 32,500 Maximum Longitudinal Stress [psi] 12,13 Stiffness Factor for Earth Load Circumferential Stress 2,196 Maximum Radial Stress [psi] -1,440 Burial Factor for Earth Load Circumferential Stress 1.08 Total Effective Stress [psi] 31,23 Excavation Factor for Earth Load Circumferential Stress 0.83 Allowable Effective Stress [psi] 32,500 Circumferential Stress from Earth Load [psi] 1,732 Impact Factor 1.50 Stress [psi] Calculated Allowable PASS/FA Highway Stiffness Factor for Cyclic Circumferential 1.60 Hoop 29,423 32,500 PASS Cyclic Circumferential Stress [psi] 3,850 11,500 PASS Girth Welds 3,006 6,000 PASS Highway Stiffness Factor for Cyclic Longitudinal Stress 1.320 Highway Geometry Factor for Cyclic Longitudinal Stress 1.08 Long.	Pipe Class: API 5L Electric Re	esistance Welded		• •		ighway	
Coefficient of Thermal Expansion [per°F] 0.0000065Safety Factor Applied: API 1102 ProcedureRESULTSHoop Stress [psi]29,423Maximum Circumferential Stress [psi]34,28Allowable Hoop Stress [psi]32,500Maximum Longitudinal Stress [psi]12,13Stiffness Factor for Earth Load Circumferential Stress2,196Maximum Radial Stress [psi]1,44Burial Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]31,23Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load [psi]1,7321,7321Impact Factor1.50Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential16.60Effective31,234Highway Geometry Factor for Cyclic Circumferential1.10Girth Welds3,0066,000PASSHighway Stiffness Factor for Cyclic Longitudinal Stress13.2011,500PASS1.08Highway Geometry Factor for Cyclic Longitudinal Stress1.082.042.042.042.042.04Highway Geometry Factor for Cyclic Longitudinal Stress1	Young's Modulus for Steel [ksi]	30,000	mpaor			.g	4
RESULTSHoop Stress [psi]29,423Maximum Circumferential Stress [psi]34,28Allowable Hoop Stress [psi]32,500Maximum Longitudinal Stress [psi]12,13Stiffness Factor for Earth Load Circumferential Stress2,196Maximum Radial Stress [psi]-1,44Burial Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]31,23Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load [psi]1,732Impact Factor1.50Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential16.60Hoop29,42332,500PASSHighway Geometry Factor for Cyclic Circumferential1.10Girth Welds 3,0066,000PASSCyclic Circumferential Stress [psi]3,85011,500PASSHighway Geometry Factor for Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress [psi]3,0063,00611,500PASS	Poisson's Ratio for Steel	0.30					
Hoop Stress [psi]29,423Maximum Circumferential Stress [psi]34,28Allowable Hoop Stress [psi]32,500Maximum Longitudinal Stress [psi]1,144Stiffness Factor for Earth Load Circumferential Stress2,196Maximum Radial Stress [psi]-1,444Burial Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]31,23Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load [psi]1,7321.7321.732Impact Factor1.50Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential1.660Hoop29,42332,500Highway Geometry Factor for Cyclic Circumferential1.10Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Longitudinal Stress13.2011,500PASSHighway Geometry Factor for Cyclic Longitudinal Stress1.08Curcu Stress [psi]1.08Cyclic Longitudinal Stress [psi]3,0063,0061.092.00	Coefficient of Thermal Expansion		Sofoty	Easter Applied			
Allowable Hoop Stress [psi]32,500Maximum Longitudinal Stress [psi]12,13Stiffness Factor for Earth Load Circumferential Stress2,196Maximum Radial Stress [psi]-1,444Burial Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]31,23Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load [psi]1,7321,732Impact Factor1.50Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential16.60Effective31,234Highway Geometry Factor for Cyclic Circumferential1.10Girth Welds3,0066,000Cyclic Circumferential Stress [psi]3,85011,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress13.2013.20Highway Geometry Factor for Cyclic Longitudinal Stress1.0829,4233,850Cyclic Longitudinal Stress [psi]3,0063,006Allowable PASS/FA	Soundent of Thermal Expansion	[per°F] 0.0000065	Salety	racio Applieu.	API 1102	Procedur	re
Stiffness Factor for Earth Load Circumferential Stress2,196Maximum Radial Stress [psi]-1,440Burial Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]31,23Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load [psi]1,7321.732Impact Factor1.50Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential16.60Hoop29,42332,500Highway Geometry Factor for Cyclic Circumferential1.10Girth Welds3,0066,000Cyclic Circumferential Stress [psi]3,85011,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress13.201.08Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress [psi]3,0063,0063,0061.081.08		[per°F] 0.0000065	Salety	Factor Applied.	: API 1102	Procedur?	e
Burial Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]31,23Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,50Circumferential Stress from Earth Load [psi]1,7321.50Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential16.60Hoop29,42332,500PASSHighway Geometry Factor for Cyclic Circumferential1.10Girth Welds3,0066,000PASSCyclic Circumferential Stress [psi]3,85011,500PASSLong. Welds3,85011,500Highway Geometry Factor for Cyclic Longitudinal Stress1.083,0063,0063,006	RESULTS	[per°F] 0.0000065					
Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,50Circumferential Stress from Earth Load [psi]1,732Impact Factor1.50Highway Stiffness Factor for Cyclic Circumferential16.60Highway Geometry Factor for Cyclic Circumferential1.10Cyclic Circumferential Stress [psi]3,850Highway Stiffness Factor for Cyclic Longitudinal Stress13.20Highway Geometry Factor for Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress [psi]3,006	RESULTS Hoop Stress [psi]	[per°F] 0.0000065	29,423	Maximum Cire	cumferential	l Stress [p	si] 34,28
Circumferential Stress from Earth Load [psi]1,732Impact Factor1.50Highway Stiffness Factor for Cyclic Circumferential16.60Highway Geometry Factor for Cyclic Circumferential1.10Cyclic Circumferential Stress [psi]3,850Highway Stiffness Factor for Cyclic Longitudinal Stress13.20Highway Geometry Factor for Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress [psi]3,006	RESULTS Hoop Stress [psi] Allowable Hoop Stress [psi]		29,423 32,500	Maximum Ciro Maximum Lor	cumferential ngitudinal St	l Stress [p ress [psi]	si] 34,28 12,13
Impact Factor1.50Highway Stiffness Factor for Cyclic Circumferential16.60Highway Geometry Factor for Cyclic Circumferential1.10Cyclic Circumferential Stress [psi]3,850Highway Geometry Factor for Cyclic Longitudinal Stress13.20Highway Geometry Factor for Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress [psi]3,006	RESULTS Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Ci	rcumferential Stress	29,423 32,500 2,196	Maximum Ciro Maximum Lor Maximum Rad	cumferential ngitudinal St dial Stress [l Stress [p ress [psi] psi]	si] 34,28 12,13 -1,440
Highway Stiffness Factor for Cyclic Circumferential16.60Highway Geometry Factor for Cyclic Circumferential1.10Cyclic Circumferential Stress [psi]3,850Highway Geometry Factor for Cyclic Longitudinal Stress13.20Highway Geometry Factor for Cyclic Longitudinal Stress13.20Highway Geometry Factor for Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress [psi]3,006	RESULTS Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Ci Burial Factor for Earth Load Circu	rcumferential Stress mferential Stress	29,423 32,500 2,196 1.08	Maximum Cire Maximum Lor Maximum Rae Total Effective	cumferential ngitudinal Sti dial Stress [J e Stress [psi	l Stress [p ress [psi] psi] i]	si] 34,28 12,13 -1,440 31,23
Highway Stiffness Factor for Cyclic Circumferential18.00Highway Geometry Factor for Cyclic Circumferential1.10Cyclic Circumferential Stress [psi]3,850Highway Stiffness Factor for Cyclic Longitudinal Stress13.20Highway Geometry Factor for Cyclic Longitudinal Stress13.20Cyclic Longitudinal Stress [psi]3,006	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	rcumferential Stress mferential Stress Circumferential Stress	29,423 32,500 2,196 1.08 0.83	Maximum Cire Maximum Lor Maximum Rae Total Effective	cumferential ngitudinal Sti dial Stress [J e Stress [psi	l Stress [p ress [psi] psi] i]	si] 34,28 12,13 -1,440 31,23
Highway Geometry Factor for Cyclic Circumferential1.10Girth Welds3,0066,000PASSCyclic Circumferential Stress [psi]3,850Long. Welds3,85011,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress13.20Highway Geometry Factor for Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress [psi]3,006	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	29,423 32,500 2,196 1.08 0.83 1,732	Maximum Cire Maximum Lor Maximum Rae Total Effective Allowable Effe	cumferential ngitudinal St dial Stress [J e Stress [psi ective Stress	l Stress [p ress [psi] psi] i] s [psi]	si] 34,28 12,13 -1,440 31,23 32,50
Cyclic Circumferential Stress [psi]3,850Long. Welds3,85011,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress13.20Highway Geometry Factor for Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress [psi]3,006	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	rcumferential Stress mferential Stress Circumferential Stress Load [psi]	29,423 32,500 2,196 1.08 0.83 1,732 1.50	Maximum Ciro Maximum Lor Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop	cumferential ngitudinal Str dial Stress [j e Stress [psi ective Stress Calculated 29,423	l Stress [p ress [psi] psi] i] s [psi] Allowable 32,500	si] 34,28 12,13 -1,440 31,23 32,50 PASS/FAI PASS
Highway Geometry Factor for Cyclic Longitudinal Stress 1.08 Cyclic Longitudinal Stress [psi] 3,006	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 Cycl	rcumferential Stress mferential Stress Circumferential Stress Load [psi] ic Circumferential	29,423 32,500 2,196 1.08 0.83 1,732 1.50 16.60	Maximum Cire Maximum Lor Maximum Rae Total Effective Allowable Effe Stress [psi] Hoop Effective	cumferential ngitudinal Str dial Stress [psi ective Stress Calculated 29,423 31,234	l Stress [p ress [psi] psi] s [psi] Allowable 32,500 32,500	si] 34,28 12,13 -1,440 31,23 32,50 PASS/FA PASS PASS
Cyclic Longitudinał Stress [psi] 3,006	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 Cycl Highway Geometry Factor for Cycl	rcumferential Stress mferential Stress Circumferential Stress Load [psi] ic Circumferential clic Circumferential	29,423 32,500 2,196 1.08 0.83 1,732 1.50 16.60 1.10	Maximum Ciro Maximum Lor Maximum Rad Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds	cumferential ngitudinal Str dial Stress [psi ective Stress Calculated 29,423 31,234 3,006	I Stress [p ress [psi] psi] [] [] [] [] [] [] [] [] [] [] [] [] []	si] 34,28 12,13 -1,440 31,23 32,50 PASS/FA PASS PASS PASS
Cyclic Longitudinał Stress [psi] 3,006	RESULTS Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Circu Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycl Highway Geometry Factor for Cycl Cyclic Circumferential Stress [psi]	rcumferential Stress mferential Stress Circumferential Stress Load [psi] ic Circumferential clic Circumferential	29,423 32,500 2,196 1.08 0.83 1,732 1.50 16.60 1.10 3,850	Maximum Ciro Maximum Lor Maximum Rad Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds	cumferential ngitudinal Str dial Stress [psi ective Stress Calculated 29,423 31,234 3,006	I Stress [p ress [psi] psi] [] [] [] [] [] [] [] [] [] [] [] [] []	si] 34,28 12,13 -1,440 31,23 32,50 PASS/FA PASS PASS PASS
Notes: Open cut construction, calculations run using HS-20 loading + 15%	RESULTS Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Circu Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycl Highway Geometry Factor for Cycl Cyclic Circumferential Stress [psi]	rcumferential Stress mferential Stress Circumferential Stress Load [psi] ic Circumferential clic Circumferential	29,423 32,500 2,196 1.08 0.83 1,732 1.50 16.60 1.10 3,850 13.20	Maximum Ciro Maximum Lor Maximum Rad Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds	cumferential ngitudinal Str dial Stress [psi ective Stress Calculated 29,423 31,234 3,006	I Stress [p ress [psi] psi] [] [] [] [] [] [] [] [] [] [] [] [] []	si] 34,28 12,13 -1,440 31,23 32,50 PASS/FA 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 Cycl Highway Geometry Factor for Cycl Highway Stiffness Factor for Cycl Highway Stiffness Factor for Cycl	rcumferential Stress mferential Stress Circumferential Stress Load [psi] ic Circumferential clic Circumferential	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 Ciro Maximum Lor Maximum Rad Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds	cumferential ngitudinal Str dial Stress [psi ective Stress Calculated 29,423 31,234 3,006	I Stress [p ress [psi] psi] [] [] [] [] [] [] [] [] [] [] [] [] []	si] 34,28 12,13 -1,440 31,23 32,50 PASS/FA 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 Cycl Highway Geometry Factor for Cycl Highway Stiffness Factor for Cycl Highway Stiffness Factor for Cycl Highway Stiffness Factor for Cycl Cyclic Circumferential Stress [psi]	rcumferential Stress mferential Stress Circumferential Stress Load [psi] ic Circumferential clic Circumferential clic Longitudinal Stress 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 -20 loadin	Maximum Cire Maximum Lor Maximum Rae Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds Long. Welds	cumferential ngitudinal Str dial Stress [psi ective Stress Calculated 29,423 31,234 3,006	I Stress [p ress [psi] psi] [] [] [] [] [] [] [] [] [] [] [] [] []	si] 34,28 12,13 -1,440 31,23 32,50 PASS/FAI PASS PASS PASS

٤.

API 1102 - Gas Pipeline Crossing Highway PIPE AND OPERATIONAL DATA: Operating Pressure [psi] 1440 Soil Type: Soft to medium clays and silts with Location Class: 3 Certaing Temperature [°F] 60.0 Er - Resilient Modulus [ksi] 5.0 Pipe Outside Diameter [in] 12.75 Average Unit Weight of Soil Tgecino [ksi] 12.75 Average Unit Weight of Soil Tgecino [ksi] 12.75 Specified Minimum Yield Stress 65,000 Installation Temperature [°F] 60.0 Design Factor 0.50 Design Wheel Load from Single Axle [kips] 18.4 Congitudinal Joint Factor 1.0 Design Wheel Load from Single Axle [kips] 18.4 Congitudinal Joint Factor 1.0 Design Wheel Load from Tandem Axles [kips] 18.4 Congitudinal Joint Factor 1.0 Design Wheel Load from Tandem Axles [kips] 18.4 Congitudinal Stress [psi] 30,000 Poisson's Ratio for Steel 0.30 Coefficient of Thermal Expansion [per"F] 32,500 Maximum Circumferential Stress 2,088 Maximum Radial Stress [psi] 32,500 Circumferential Stress 2,088 Maximum Radial Stress [psi] 32,500 Circumferential Stress 2,088 Maximum Radial Stress [psi] 31,18 Excavation Factor for Cyclic Circumferential 16.60 Effective Stress [psi] 32,20 National Stress [psi] 32,20 Nat	Location Burlington, VT		Date 5/24/20	16			
PIPE AND OPERATIONAL DATA:SITE AND INSTALLATION DATA:Operating Pressure [psi]1440Soil Type:: Soft to medium clays and silts with low/medium plasticitiesLocation Class:3E' - Modulus of Soil Reaction [ksi]0.5Operating Temperature [°F]60.0Er - Resilient Modulus [ksi]5.0Pipe Outside Diameter [in]12.75Average Unit Weight of Soil [lb/ft*]120.00Pipe Wall Thickness [in]0.312Pipe Depth [ft]3Pipe Grade:X65Bored Diameter [in]12.75Specified Minimum Yield Stress65,000InstallationTemperature [°F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Pipe Class:API 5L Electric Resistance WeldedImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel0.30Safety Factor Applied:API 1102 ProcedureCoefficient of Thermal Expansion [per'F]0.0000065Safety Factor Applied:API 1102 ProcedureRESULTSHoop Stress [psi]32,500Maximum Circumferential Stress [psi]14,44Burial Factor for Earth Load Circumferential Stress0.83Total Effective Stress [psi]32,500Circumferential Stress from Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load Circumferential1.265Impact Factor Vacio PASSImpact Factor1.50Stress [psi]32,500PASS<		e Crossina Hiah					
Operating Pressure [psi] 1440 Soil Type:: Soft to medium clays and silts with low/medium plasticities Location Class: 3 E' - Modulus of Soil Reaction [ksi] 0.5 Operating Temperature [°F] 60.0 Er - Resilient Modulus [ksi] 5.0 Pipe Outside Diameter [in] 12.75 Average Unit Weight of Soil [lb/ft ³] 120.00 Pipe Grade: X65 Bored Diameter [in] 12.75 Specified Minimum Yield Stress 65.000 InstallationTemperature [°F] 60.0 Design Factor 0.50 Design Wheel Load from Single Axle [kips] 18.4 Longtiudinal Joint Factor 1.00 Design Wheel Load from Tandem Axles [kips] 18.4 Temperature Derating Factor 1.000 Pavement Type: None Impact Factor Method: ASCE - Highway Young's Modulus for Steel [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 29,423 Maximum Circumferential Stress [psi] 12.21 Stiffness Factor for Earth Load Circumferential Stress 2,08 Maximum Calai Stress [psi] 14.44 Burial Factor for Earth Load Circum						ζ.	
Location Class:3E' - Modulus of Soil Reaction [ksi]0.5Operating Temperature [°F]60.0Er - Resilient Modulus [ksi]5.0Pipe Outside Diameter [in]12.75Average Unit Weight of Soil [lb/ft ^s]120.00Pipe Wall Thickness [in]0.312Pipe Depth [ftj3Pipe Grade:X65Bored Diameter [in]12.75Specified Minimum Yield Stress65.000InstallationTemperature [°F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel [ksi]30,000Safety Factor Applied:API 1102 ProcedurePoisson's Ratio for Steel0.30Coefficient of Thermal Expansion [per'F]0.033Coefficient of Thermal Expansion [per'F]0.033Total Effective Stress [psi]12.21Allowable Hoop Stress [psi]32,500Maximum Longitudinal Stress [psi]12.21Stiffness Factor for Earth Load Circumferential Stress0.83Total Effective Stress [psi]32,500Circumferential Stress from Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load Circumferential1.265Hoop 29,42332,500PASSImpact Factor1.50Stress [psi]32,500PASSHoop 29,42332,500PASSImpact Factor for Cy							with
Operating Temperature [°F] 60.0 Er - Resilient Modulus [ksi] 5.0 Pipe Outside Diameter [in] 12.75 Average Unit Weight of Soil [lb/ft ^a] 120.00 Pipe Grade: X65 Bored Diameter [in] 12.75 Specified Minimum Yield Stress 65.000 InstallationTemperature [°F] 60.0 Design Factor 0.50 Design Wheel Load from Single Axle [kips] 18.4 Longitudinal Joint Factor 1.0 Design Wheel Load from Tandem Axles [kips] 18.4 Temperature Derating Factor 1.000 Pavement Type: None Impact Factor Method: ASCE - Highway Young's Modulus for Steel [ksi] 30,000 Poisson's Ratio for Steel 0.30 Coefficient of Thermal Expansion [per"F] 0.000065 RESULTS 29,423 Maximum Circumferential Stress [psi] 12,21 Allowable Hoop Stress [psi] 22,500 Maximum Longitudinal Stress [psi] 12,21 Stiffness Factor for Earth Load Circumferential Stress 0.83 Total Effective Stress [psi] 32,500 Gircumferential Stress from Earth Load Circumferential 1.265 Impact Factor 1.60 Hoop 29,423 32,500 PASS Highway Stiffness Factor for Cyclic Circumfere			•	low/med	ium plasticit	ties	
Pipe Outside Diameter [in]12.75Average Unit Weight of Soil [lb/ft³]120.00Pipe Orade:X65Average Unit Weight of Soil [lb/ft³]120.00Pipe Grade:X65Bored Diameter [in]12.75Specified Minimum Yield Stress65,000InstallationTemperature ["F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel [ksi]30,00030Safety Factor Applied: API 1102 ProcedurePoisson's Ratio for Steel0.30Safety Factor Applied: API 1102 ProcedureRESULTS10,0000065Safety Factor Applied: API 1102 ProcedureResult TS29,423Maximum Circumferential Stress [psi]14,43Burial Factor for Earth Load Circumferential Stress0.83Total Effective Stress [psi]1,16Stress Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Impact Factor1.50Stress [psi]32,500PASSImpact Factor1.50Stress [psi]32,500PASSHighway Geometry Factor for Cyclic Circumferential12.22Girth Welds32,290PASSCyclic Circumferential Stress [psi]1,265Impact Factor1.50Stress [psi]22,500Impact Factor1.50Stress [psi]32,500PASSHighway Stiffn]	
Average of int Weight of Stirl12.00Pipe Wall Thickness [in]0.312Pipe Grade:X65Specified Minimum Yield Stress65,000Design Factor0.50Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Congitudinal Joint Factor1.0Temperature Derating Factor1.000Pipe Class:API 5L Electric Resistance WeldedYoung's Modulus for Steel [ksi]30,000Poisson's Ratio for Steel0.30Coefficient of Thermal Expansion [per°F]0.000065RESULTS29,423Hoop Stress [psi]32,500Maximum Circumferential Stress [psi]34,23Allowable Hoop Stress [psi]32,500Maximum Radial Stress [psi]1.44Burial Factor for Earth Load Circumferential Stress0.83Circumferential Stress for Earth Load Circumferential Stress0.83Allowable Hoop Stress [psi]1.265Impact Factor1.50Stress [psi]32,500Pipe Carth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Pipe Tarth Load Circumferential Stress1.66Hoop29,423Allowable Effective Stress [psi]32,500Pipe Carth Load Circumferential1.265Impact Factor1.50Stress [psi]32,500PASSEffective 31,180Stress [psi]4,271Highway Geometry Factor for Cyclic Circumferential1.22Girth Welds 3,2296,000<						a.	
Pipe Grade:X65Bored Diameter [in]12.75Specified Minimum Yield Stress65,000Bored Diameter [in]12.75Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Pipe Class:API 5L Electric Resistance WeldedImpact Factor Method:ASCE - HighwayYoung's Modulus for Steel0.30Safety Factor Applied:API 1102 ProcedureRESULTSESULTS29,423Maximum Circumferential Stress [psi]12.21Hoop Stress [psi]29,423Maximum Longitudinal Stress [psi]12.21Stiffness Factor for Earth Load Circumferential Stress0.83Total Effective Stress [psi]14.24Burial Factor1.50Stress [psi]32,500PASSImpact Factor1.50Stress [psi]32,500PASSImpact Factor1.50Stress [psi]32,500PASSImpact Factor1.50Stress [psi]32,500PASSCircumferential Stress [psi]1.225Stress [psi]32,500PASSImpact Factor1.50Stress [psi]2.900PASSInghway Stiffness Factor for Cyclic Circumferential1.22Girth Weids3.2296,000Highway Geometry Factor for Cyclic Longitudinal Stress1.321.16Cyclic Longitudinal Stress1.16Cyclic Longitudinal Stress [psi]3.2293.2293.2293.2293.229			Averag	je Unit Weight o	of Soil [lb/ft ³]	120.00
DescriptionDescriptionDescriptionSpecified Minimum Yield Stress65,000InstallationTemperature ["F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayViong's Modulus for Steel [ksi]30,00030Safety Factor Applied: API 1102 ProcedurePoisson's Ratio for Steel0.30Safety Factor Applied: API 1102 ProcedureRESULTSHoop Stress [psi]29,423Maximum Circumferential Stress [psi]12,21Hoop Stress [psi]29,423Maximum Longitudinal Stress [psi]12,21Stiffness Factor for Earth Load Circumferential Stress0.83Total Effective Stress [psi]1,18Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]31,18Excavation Factor for Earth Load Circumferential1.20Stress [psi]2,500Impact Factor1.50Stress [psi]2,500PASSInduct Factor1.50Stress [psi]2,500PASSInduct Factor1.50Stress [psi]2,250PASSInghway Geometry Factor for Cyclic Circumferential1.22Girth Weids 3,2296,000PASS[psiway Geometry Factor for Cyclic Longitudinal Stress1.16Cyclic Longitudinal Stress1.16Cyclic Longitudinal Stress [psi]3,2293,2291.161.22 <td></td> <td>0.312</td> <td>Pipe D</td> <td>epth [ft]</td> <td></td> <td></td> <td>3</td>		0.312	Pipe D	epth [ft]			3
Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayPipe Class:API 5L Electric Resistance WeldedImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel [ksi]30,000Safety Factor Applied: API 1102 ProcedurePoisson's Ratio for Steel0.30Safety Factor Applied: API 1102 ProcedureCoefficient of Thermal Expansion [per"F]0.0000065Safety Factor Applied: API 1102 ProcedureRESULTSHoop Stress [psi]29,423Maximum Circumferential Stress [psi]12,21Stiffness Factor for Earth Load Circumferential Stress0.83Total Effective Stress [psi]1,44Burial Factor1.50Stress [psi]32,500PASSCircumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load Circumferential1,265Impact Factor1.50Impact Factor1.50Stress [psi]29,42332,500Instantion Factor for Cyclic Circumferential1,226Impact Factor1.22Inghway Geometry Factor for Cyclic Circumferential1.22Girth Welds 3,2296,000Highway Geometry Factor for Cyclic Longitudinal Stress1.3201.161.150Highway Geometry Factor for Cyclic Longitudinal Stress1.161.221.16Cyclic Longitudinal Stress [psi]3,2293.2291.29 <td></td> <td>05 000</td> <td>Bored</td> <td>Diameter [in]</td> <td></td> <td></td> <td>12.75</td>		05 000	Bored	Diameter [in]			12.75
Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Longitudinal Joint Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayPipe Class:API 5L Electric Resistance WeldedImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel0.30Safety Factor Applied: API 1102 ProcedureCoefficient of Thermal Expansion [per°F] 0.0000065Safety Factor Applied: API 1102 ProcedureRESULTS4000 Stress [psi]29,423Hoop Stress [psi]29,423Allowable Hoop Stress [psi]32,500Maximum Circumferential Stress [psi]1,44Burial Factor for Earth Load Circumferential Stress0.83Total Effective Stress [psi]1,44Burial Factor for Earth Load Circumferential Stress0.83Circumferential Stress from Earth Load Circumferential Stress0.83Circumferential Stress from Earth Load Circumferential1,265Impact Factor1.50Stress [psi]Circumferential Stress from Earth Load [psi]1,265Impact Factor1.50Stress [psi]Highway Geometry Factor for Cyclic Circumferential1.22Girth Welds 3,2296,000PASSCyclic CircumferentialHighway Stiffness Factor for Cyclic Longitudinal Stress13.20Highway Geometry Factor for Cyclic Longitudinal Stress1.22Highway Geometry Factor for Cyclic Longitudinal Stress1.22Highway Geometry Factor for Cyclic Longitudinal Stress1.20Highway Geometry Factor for Cyclic Longitudinal Stress1.2			Installa	tionTemperatu	re [°F]		60.0
Design Wheel Coad from Failed Axes [ki]s] 18.4Temperature Derating Factor1.000Pipe Class:API 5L Electric Resistance WeldedPipe Class:API 5L Electric Resistance WeldedVoung's Modulus for Steel0.30Coefficient of Thermal Expansion [per°F]0.0000065Safety Factor Applied:API 1102 ProcedureRESULTS29,423Hoop Stress [psi]29,423Maximum Circumferential Stress [psi]32,500Allowable Hoop Stress [psi]32,500Maximum Radial Stress [psi]1.44Burial Factor for Earth Load Circumferential Stress0.83Total Effective Stress [psi]31,18Excavation Factor for Earth Load Circumferential Stress0.83Circumferential Stress from Earth Load Circumferential1.265Impact Factor1.50Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential1.22Girth Welds3.229Highway Stiffness Factor for Cyclic Longitudinal Stress1.320Highway Stiffness Factor for Cyclic Longitudinal Stress3.229Key Longitudinal Stress [psi]3.229	•		Desigr	Wheel Load fr	om Single A	Axle [kips]	18.4
Pipe Class: API 5L Electric Resistance Welded Impact Factor Method: ASCE - Highway Young's Modulus for Steel [ksi] 30,000 Safety Factor Method: ASCE - Highway 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] 29,423 Maximum Circumferential Stress [psi] 12,21 Allowable Hoop Stress [psi] 32,500 Maximum Longitudinal Stress [psi] 12,21 Stiffness Factor for Earth Load Circumferential Stress 0.83 Total Effective Stress [psi] 1,44 Burial Factor for Earth Load Circumferential Stress 0.83 Allowable Effective Stress [psi] 31,18 Excavation Factor for Earth Load Circumferential 1,265 Impact Factor 1.50 Stress [psi] 29,423 32,500 PASS Impact Factor 1.50 Stress [psi] 29,423 32,500 PASS Impact Factor 1.50 Stress [psi] 26,000 PASS Impact Factor 1.50 Stress [psi] 22,600 PASS Highway Stiffness Factor for Cyclic Circumferential 1.60 Effective 31,180 32,500 PASS </td <td>0</td> <td></td> <td>Desigr</td> <td>Wheel Load fr</td> <td>om Tandem</td> <td>n Axles [kip</td> <td>os] 18.4</td>	0		Desigr	Wheel Load fr	om Tandem	n Axles [kip	os] 18.4
Young's Modulus for Steel [ksi] 30,000 Poisson's Ratio for Steel 0.30 Coefficient of Thermal Expansion [per°F] 0.0000065 RESULTS Hoop Stress [psi] 29,423 Allowable Hoop Stress [psi] 32,500 Maximum Circumferential Stress [psi] 12,21 Stiffness Factor for Earth Load Circumferential Stress 2,088 Maximum Radial Stress [psi] 1,444 Burial Factor for Earth Load Circumferential Stress 0.83 Total Effective Stress [psi] 31,18 Excavation Factor for Earth Load Circumferential Stress 0.83 Allowable Effective Stress [psi] 32,500 Circumferential Stress from Earth Load [psi] 1,265 Impact Factor 1.50 Stress [psi] Calculated Allowable PASS/FA Highway Stiffness Factor for Cyclic Circumferential 1.22 Cyclic Circumferential Stress [psi] 4,271 Highway Stiffness Factor for Cyclic Longitudinal Stress 1.20 Highway Geometry Factor for Cyclic Longitudinal Stress 1.320 Highway Geometry Factor for Cyclic Longitudinal Stress 1.16 Cyclic Longitudinal Stress [psi] 3,229			Pavem	ent Type: Non	Э		
Poisson's Ratio for Steel0.30 0.0000065Safety Factor Applied:API 1102 ProcedureRESULTSHoop Stress [psi]29,423Maximum Circumferential Stress [psi]34,23Allowable Hoop Stress [psi]32,500Maximum Longitudinal Stress [psi]12,21Stiffness Factor for Earth Load Circumferential Stress2,088Maximum Radial Stress [psi]11,44Burial Factor for Earth Load Circumferential Stress0.83Total Effective Stress [psi]31,18Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load Circumferential1,265Impact Factor1.50Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential16.60Hoop29,42332,500PASSHighway Geometry Factor for Cyclic Circumferential1.22Girth Welds3,2296,000PASSHighway Stiffness Factor for Cyclic Longitudinal Stress13.2011.50PASSImpact Factor1.6Highway Geometry Factor for Cyclic Longitudinal Stress1.163,2296,000PASSCyclic Longitudinal Stress [psi]3,2293,2293,2291.15Highway Geometry Factor for Cyclic Longitudinal Stress1.163,2293,2293,229Highway Geometry Factor for Cyclic Longitudinal Stress1.163,2293,2293,229Highway Geometry Factor for Cyclic Longitudinal Stress1.163,2293,229Highway Geometry Factor for Cyclic			Impact	Factor Method	: ASCE - H	lighway	
Coefficient of Thermal Expansion [per°F] 0.0000065Safety Factor Applied: API 1102 ProcedureRESULTSHoop Stress [psi]29,423Maximum Circumferential Stress [psi]34,23Allowable Hoop Stress [psi]32,500Maximum Longitudinal Stress [psi]12,21Stiffness Factor for Earth Load Circumferential Stress2,088Maximum Radial Stress [psi]11,44Burial Factor for Earth Load Circumferential Stress0.83Total Effective Stress [psi]31,18Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load [psi]1,26512,2512,25Impact Factor1.50Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential16.60Hoop29,42332,500Highway Geometry Factor for Cyclic Circumferential1.22Girth Welds3,2296,000Highway Stiffness Factor for Cyclic Longitudinal Stress13.2011.6Highway Geometry Factor for Cyclic Longitudinal Stress1.16Cyclic Longitudinal Stress [psi]3,2293,229Highway Geometry Factor for Cyclic Longitudinal Stress3.229Highway Geo	• • • •						
RESULTSHoop Stress [psi]29,423Maximum Circumferential Stress [psi]34,23Allowable Hoop Stress [psi]32,500Maximum Longitudinal Stress [psi]12,21Stiffness Factor for Earth Load Circumferential Stress2,088Maximum Radial Stress [psi]-1,440Burial Factor for Earth Load Circumferential Stress0.83Total Effective Stress [psi]31,18Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load [psi]1,2651.50Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential16.60Hoop29,42332,500PASSHighway Geometry Factor for Cyclic Circumferential1.22Stress [psi]Calculated Allowable PASS/FAHighway Geometry Factor for Cyclic Longitudinal Stress13.2011,1500PASSHighway Geometry Factor for Cyclic Longitudinal Stress1.162.21Cyclic Longitudinal Stress [psi]3,2293.2293.229	Poisson's Ratio for Steel	0.30	Cofoty	Fastar Applied		Droodur	~
Hoop Stress [psi]29,423Maximum Circumferential Stress [psi]34,23Allowable Hoop Stress [psi]32,500Maximum Longitudinal Stress [psi]12,21Stiffness Factor for Earth Load Circumferential Stress0.83Total Effective Stress [psi]31,18Burial Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load [psi]1,2651,2651,265Impact Factor1.50Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential16.601,2211,180Highway Stiffness Factor for Cyclic Longitudinal Stress13.2013.2013.20Highway Geometry Factor for Cyclic Longitudinal Stress1.161.601.60Highway Geometry Factor for Cyclic Longitudinal Stress13.201.16Cyclic Longitudinal Stress [psi]3.2293.2295.00Highway Stiffness Factor for Cyclic Longitudinal Stress1.16Cyclic Longitudinal Stress [psi]3.229	Coefficient of Thermal Expansion	[per°F] 0.0000065	Galety		7111102		0
Allowable Hoop Stress [psi]32,500Maximum Longitudinal Stress [psi]12,21Stiffness Factor for Earth Load Circumferential Stress2,088Maximum Radial Stress [psi]-1,444Burial Factor for Earth Load Circumferential Stress0.83Total Effective Stress [psi]31,18Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load [psi]1,2651,2651Impact Factor1.50Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential16.60Effective31,180Highway Geometry Factor for Cyclic Circumferential1.22Girth Welds3,2296,000Cyclic Circumferential Stress [psi]4,27111,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress13.201.16Highway Geometry Factor for Cyclic Longitudinal Stress1.162.29Cyclic Longitudinal Stress [psi]3,2293.229							
Stiffness Factor for Earth Load Circumferential Stress2,088Maximum Radial Stress [psi]-1,44Burial Factor for Earth Load Circumferential Stress0.83Total Effective Stress [psi]31,18Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load [psi]1,265Impact Factor1.50Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential16.60Hoop29,42332,500Highway Geometry Factor for Cyclic Circumferential1.22Girth Welds3,2296,000Cyclic Circumferential Stress [psi]4,27111,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress13.201.16Highway Geometry Factor for Cyclic Longitudinal Stress1.163,2293,229	RESULTS						
Burial Factor for Earth Load Circumferential Stress0.83Total Effective Stress [psi]31,18Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,50Circumferential Stress from Earth Load [psi]1,2651.50Stress [psi]Calculated Allowable PASS/FAImpact Factor1.50Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential16.60Effective31,180Highway Geometry Factor for Cyclic Circumferential1.22Girth Welds3,229Cyclic Circumferential Stress [psi]4,27111,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress1.163,2296,000Cyclic Longitudinal Stress [psi]3,2293,2293,229			29,423	Maximum Cire	cumferentia	ll Stress [p:	si] 34,23
Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load [psi]1,265Impact Factor1.50Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential16.60Effective31,18032,500Highway Geometry Factor for Cyclic Circumferential1.22Girth Welds3,2296,000PASSCyclic Circumferential Stress [psi]4,27111,500PASSLong: Welds4,27111,500PASSHighway Geometry Factor for Cyclic Longitudinal Stress1.163,2293,2295,000PASSCyclic Longitudinal Stress [psi]3,2293,2293,2295,000PASS	Hoop Stress [psi]		,				•
Circumferential Stress from Earth Load [psi]1,265Impact Factor1.50Highway Stiffness Factor for Cyclic Circumferential16.60Highway Geometry Factor for Cyclic Circumferential1.22Cyclic Circumferential Stress [psi]4,271Highway Stiffness Factor for Cyclic Longitudinal Stress13.20Highway Geometry Factor for Cyclic Longitudinal Stress1.16Cyclic Longitudinal Stress [psi]3,229	Hoop Stress [psi] Allowable Hoop Stress [psi]	rcumferential Stress	32,500	Maximum Lor	ngitudinal St	tress [psi]	12,21
Impact Factor1.50Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential16.60Hoop29,42332,500PASSHighway Geometry Factor for Cyclic Circumferential1.22Effective31,18032,500PASSCyclic Circumferential Stress [psi]4,2711.20PASSHighway Stiffness Factor for Cyclic Longitudinal Stress13.2013.20Highway Geometry Factor for Cyclic Longitudinal Stress1.16Cyclic Longitudinal Stress [psi]3,229	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Ci		32,500 2,088	Maximum Lor Maximum Rae	ngitudinal Sf dial Stress [tress [psi] [psi]	12,21 -1,44
Highway Stiffness Factor for Cyclic Circumferential16.60Highway Geometry Factor for Cyclic Circumferential1.22Cyclic Circumferential Stress [psi]4,271Highway Stiffness Factor for Cyclic Longitudinal Stress13.20Highway Geometry Factor for Cyclic Longitudinal Stress13.20Highway Stiffness Factor for Cyclic Longitudinal Stress1.16Cyclic Longitudinal Stress [psi]3,229	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Ci Burial Factor for Earth Load Circu	mferential Stress	32,500 2,088 0.83	Maximum Lor Maximum Rad Total Effective	ngitudinal Sf dial Stress [e Stress [ps	tress [psi] [psi] i]	12,21 -1,44 31,18
Highway Stiffness Factor for Cyclic Circumferential18.80Highway Geometry Factor for Cyclic Circumferential1.22Cyclic Circumferential Stress [psi]4,271Highway Stiffness Factor for Cyclic Longitudinal Stress13.20Highway Geometry Factor for Cyclic Longitudinal Stress13.20Cyclic Longitudinal Stress [psi]3,229Stress [psi]3,229	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Ci Burial Factor for Earth Load Circu Excavation Factor for Earth Load	mferential Stress Circumferential Stress	32,500 2,088 0.83 0.83	Maximum Lor Maximum Rad Total Effective	ngitudinal Sf dial Stress [e Stress [ps	tress [psi] [psi] i]	12,21 -1,44 31,18
Highway Geometry Factor for Cyclic Circumferential1.22Girth Welds3,2296,000PASSCyclic Circumferential Stress [psi]4,27111,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress13.20Highway Geometry Factor for Cyclic Longitudinal Stress1.16Cyclic Longitudinal Stress [psi]3,229	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Ci Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth	mferential Stress Circumferential Stress	32,500 2,088 0.83 0.83 1,265	Maximum Lor Maximum Rad Total Effective Allowable Effe	ngitudinal Si dial Stress [e Stress [ps ective Stress	tress [psi] [psi] i] s [psi] Allowable	12,21 -1,44 31,18 32,50 PASS/FA
Cyclic Circumferential Stress [psi]4,271Long. Welds4,27111,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress13.20Highway Geometry Factor for Cyclic Longitudinal Stress1.16Cyclic Longitudinal Stress [psi]3,229	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Ci Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor	mferential Stress Circumferential Stress Load [psi]	32,500 2,088 0.83 0.83 1,265 1.50	Maximum Lor Maximum Rad Total Effective Allowable Effe Stress [psi] Hoop	ngitudinal Si dial Stress [ps ective Stress Calculated 29,423	tress [psi] [psi] i] s [psi] Allowable 32,500	12,21 -1,44 31,18 32,50 PASS/FA PASS
Highway Geometry Factor for Cyclic Longitudinal Stress 1.16 Cyclic Longitudinal Stress [psi] 3,229	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Ci Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycli	mferential Stress Circumferential Stress Load [psi] c Circumferential	32,500 2,088 0.83 0.83 1,265 1.50 16.60	Maximum Lor Maximum Rad Total Effective Allowable Effe Stress [psi] Hoop Effective	ngitudinal Si dial Stress [ps ective Stress Calculated 29,423 31,180	tress [psi] [psi] i] s [psi] Allowable 32,500 32,500	12,21 -1,44 31,18 32,50 PASS/FA PASS PASS
Cyclic Longitudinal Stress [psi] 3,229	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Cir Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycli Highway Geometry Factor for Cycli	mferential Stress Circumferential Stress Load [psi] c Circumferential clic Circumferential	32,500 2,088 0.83 0.83 1,265 1.50 16.60 1.22	Maximum Lor Maximum Rad Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds	ngitudinal Si dial Stress [ps ective Stress Calculated 29,423 31,180 3,229	tress [psi] [psi] i] s [psi] Allowable 32,500 32,500 6,000	12,21 -1,440 31,18 32,50 PASS/FA PASS PASS PASS
	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Ci Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycli Highway Geometry Factor for Cycli Cyclic Circumferential Stress [psi]	mferential Stress Circumferential Stress Load [psi] c Circumferential clic Circumferential	32,500 2,088 0.83 1,265 1.50 16.60 1.22 4,271	Maximum Lor Maximum Rad Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds	ngitudinal Si dial Stress [ps ective Stress Calculated 29,423 31,180 3,229	tress [psi] [psi] i] s [psi] Allowable 32,500 32,500 6,000	12,21 -1,44 31,18 32,50 PASS/FA PASS PASS PASS
Notes: Open cut construction, calculations run using HS-20 loading + 15%	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Ci Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycli Cyclic Circumferential Stress [psi] Highway Stiffness Factor for Cycli	mferential Stress Circumferential Stress Load [psi] c Circumferential clic Circumferential	32,500 2,088 0.83 1,265 1.50 16.60 1.22 4,271 13.20	Maximum Lor Maximum Rad Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds	ngitudinal Si dial Stress [ps ective Stress Calculated 29,423 31,180 3,229	tress [psi] [psi] i] s [psi] Allowable 32,500 32,500 6,000	12,21 -1,440 31,18 32,50 PASS/FA PASS PASS PASS
	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Cir Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycli Highway Geometry Factor for Cycli Highway Stiffness Factor for Cycli Highway Stiffness Factor for Cycli	mferential Stress Circumferential Stress Load [psi] c Circumferential clic Circumferential	32,500 2,088 0.83 1,265 1.50 16.60 1.22 4,271 13.20 1.16	Maximum Lor Maximum Rad Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds	ngitudinal Si dial Stress [ps ective Stress Calculated 29,423 31,180 3,229	tress [psi] [psi] i] s [psi] Allowable 32,500 32,500 6,000	12,21 -1,44 31,18 32,50 PASS/FA PASS PASS PASS

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

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

Prepared By Kelsey Kibbe	Approved By
--------------------------	-------------

Revision: 13.0.1

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

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

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

0

Approved By

Revision: 13.0.1

API 1102 - Gas Pipeline Crossing Highway PIPE AND OPERATIONAL DATA: SITE AND INSTALLATION DATA: Operating Pressure [psi] 1440 Soil Type: Loces sands and gravels Location Class: 3 E' - Modulus of Soil Reaction [ksi] 0.5 Operating Temperature [°F] 60.0 Er - Resilient Modulus [ksi] 10.0 Pipe Outside Diameter [in] 12.75 Average Unit Weight of Soil [lb/ft³] 120.00 Pipe Grade: X65 Bored Diameter [in] 12.75 Specified Minimum Yield Stress 65,000 InstallationTemperature [°F] 60.0 Design Factor 0.50 Design Wheel Load from Single Axle [kips] 18.4 Longitudinal Joint Factor 1.00 Pavement Type: None Impact Factor Method: ASCE - Highway Young's Modulus for Steel 0.30 Coefficient of Thermal Expansion [per"F] 0.0000065 Safety Factor Applied: API 1102 Procedure RESULTS 29,423 Maximum Circumferential Stress [psi] 33,27 Allowable Hoop Stress [psi] 29,423 Maximum Longitudinal Stress [psi] 11,22 Stiffness Factor for Earth Load Circumferential Stress 2,08 Maximum Radial Stress [psi] 1,44 Buri	Location Burlington, VT		Date 5/24/20	16			
Operating Pressure [psi] 1440 Soil Type: Locas and gravels Location Class: 3 E' - Modulus of Soil Reaction [ksi] 0.5 Operating Temperature [°F] 60.0 Er - Resilient Modulus [ksi] 10.0 Pipe Outside Diameter [in] 12.75 Average Unit Weight of Soil [lb/ft³] 120.00 Pipe Grade: X65 Bored Diameter [in] 12.75 Specified Minimum Yield Stress 65.000 InstallationTemperature [°F] 60.0 Design Factor 0.50 Design Wheel Load from Single Axle [kips] 18.4 Longitudinal Joint Factor 1.0 Design Wheel Load from Tandem Axles [kips] 18.4 Temperature Derating Factor 1.000 Pavement Type: None Impact Factor Method: ASCE - Highway Young's Modulus for Steel 0.30 Coefficient of Thermal Expansion [per°F] 0.0000065 RESULTS 32,500 Maximum Circumferential Stress [psi] 33,27 Allowable Hoop Stress [psi] 29,423 Maximum Circumferential Stress [psi] 31,22 Stiffness Factor for Earth Load Circumferential Stress 2,088 Maximum Calualitated Allowable PASS/FA Burial Factor for Earth Load Circumferential Stress 0.83		e Crossing High	way				
Location Class: 3 E' - Modulus of Soil Reaction [ksi] 0.5 Operating Temperature [°F] 60.0 Er - Resilient Modulus [ksi] 10.0 Pipe Outside Diameter [in] 12.75 Average Unit Weight of Soil [lb/ft ^a] 120.00 Pipe Wall Thickness [in] 0.312 Pipe Depth [ft] 5 Pipe Grade: X65 Bored Diameter [in] 12.75 Specified Minimum Yield Stress 65,000 InstallationTemperature [°F] 60.0 Design Factor 0.50 Design Wheel Load from Single Axle [kips] 18.4 Longitudinal Joint Factor 1.0 Design Wheel Load from Tandem Axles [kips] 18.4 Temperature Derating Factor 1.000 Pavement Type: None Impact Factor Method: ASCE - Highway Young's Modulus for Steel 0.30 Coefficient of Thermal Expansion [per*F] 0.000065 Safety Factor Applied: API 1102 Procedure RESULTS Hoop Stress [psi] 32,500 Maximum Longitudinal Stress [psi] 33,27 Allowable Hoop Stress [psi] 29,423 Maximum Longitudinal Stress [psi] 34,42 Burial Factor for Earth Load Circumferential Stress 0.83 Allowable Effective Stress [psi] 30,42	PIPE AND OPERATIONAL DATA		SITE A	ND INSTALLA	TION DATA:		
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Operating Pressure [psi]	1440	Soil Ty	pe: Loose sa	ands and gra	ivels	
Operating Temperature [°F]60.0Er - Resilient Modulus [ksi]10.0Pipe Outside Diameter [in]12.75Average Unit Weight of Soil [lb/ft ^a]120.00Pipe Wall Thickness [in]0.312Pipe Depth [ft]5Pipe Grade:X65Bored Diameter [in]12.75Specified Minimum Yield Stress65,000InstallationTemperature [°F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel0.30Safety Factor Applied: API 1102 ProcedureRESULTS29,423Maximum Circumferential Stress [psi]31,27Allowable Hoop Stress [psi]29,423Maximum Radial Stress [psi]11,22Stiffness Factor for Earth Load Circumferential Stress2,088Maximum Radial Stress [psi]34,42Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]30,42Excavation Factor for Earth Load Circumferential1.647Impact Factor1.50Effective 30,42732,500Ingate Factor1.50Stress [psi]2,942332,500PASSEffective 30,42732,500PASSCircumferential Stress [psi]1.647Impact Factor1.50Effective 30,42732,500PASSHighway Geometry Factor for Cyclic Circumferential1.60Stress [psi]2,9423 <td>Location Class:</td> <td>3</td> <td>E' - Mo</td> <td>dulus of Soil Re</td> <td>eaction [ksi]</td> <td></td> <td>0.5</td>	Location Class:	3	E' - Mo	dulus of Soil Re	eaction [ksi]		0.5
Pipe Outside Diameter [in]12.75Average Unit Weight of Soil [lb/ft ^{an}]120.00Pipe Wall Thickness [in]0.312Pipe Depth [ft]5Pipe Grade:X65Bored Diameter [in]12.75Specified Minimum Yield Stress65,000Installation Temperature ["F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel [ksi]30,000Safety Factor Applied:API 1102 ProcedurePoisson's Ratio for Steel0.30Safety Factor Applied:API 1102 ProcedureRESULTS29,423Maximum Circumferential Stress [psi]11,22Movable Hoop Stress [psi]29,423Maximum Radial Stress [psi]11,22Stiffness Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]30,42Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]30,42Circumferential Stress form Earth Load Circumferential1.647Hoop29,423Azimum Radial Stress [psi]32,500Highway Stiffness Factor for Cyclic Circumferential1.647Impact Factor1.50Stress [psi]22,500PASSCyclic Circumferential1.60Effective30,42732,500PASSStress [psi]2,92311,500PASSCyclic Circumferential1	Operating Temperature [°F]	60.0					
Pipe Wall Thickness [in]0.312Pipe Depth [ft]5Pipe Grade::X65Bored Diameter [in]12.75Specified Minimum Yield Stress65,000InstallationTemperature [°F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel [ksi]30,00030Coefficient of Thermal Expansion [per°F]0.0000065Pipe Stress [psi]29,423Maximum Circumferential Stress [psi]33.27Allowable Hoop Stress [psi]29,423Maximum Longitudinal Stress [psi]11.22Stiffness Factor for Earth Load Circumferential Stress2,088Maximum Radial Stress [psi]30.42Excavation Factor or Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]30.42Circumferential Stress from Earth Load Circumferential1.647Hoop29,42332,500PASSHighway Stiffness Factor for Cyclic Circumferential1.647Hoop29,42332,500PASSHighway Geometry Factor for Cyclic Circumferential1.00Effective 30,42732,500PASSKiffness Factor for Cyclic Circumferential1.00Effective 30,42732,500PASSHighway Geometry Factor for Cyclic Corcumferential1.01Girth Welds 2,1186,000PASSCyclic Circumferential Stress [psi]2,9231,500 <td>Pipe Outside Diameter [in]</td> <td>12.75</td> <td></td> <td></td> <td></td> <td></td> <td></td>	Pipe Outside Diameter [in]	12.75					
Pipe Grade:X65Bored Diameter [in]12.75Specified Minimum Yield Stress65,000InstallationTemperature [°F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel [ksi]30,00030.000Safety Factor Applied:API 1102 ProcedureRESULTS0.30Safety Factor Applied:API 1102 Procedure11.22RESULTS29,423Maximum Circumferential Stress [psi]33,27Allowable Hoop Stress [psi]32,500Maximum Longitudinal Stress [psi]11.42Stiffness Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]30,42Linautor Factor1.50Stress [psi]32,500PASSHighway Stiffness Factor for Cyclic Circumferential1.50Stress [psi]32,500Highway Stiffness Factor for Cyclic Circumferential1.50Stress [psi]29,42332,500Highway Stiffness Factor for Cyclic Circumferential1.50Stress [psi]30,427Highway Geometry Factor for Cyclic Circumferential1.10Girth Weids 2,1186,000Cyclic Circumferential Stress [psi]2,92311,500PASSHighway Geometry Factor for Cyclic Longitudinal Stress9.30Highway Geometry Factor for Cyclic Longitudinal Stress9.30Highway Geometry Factor for Cyclic Lo	Pipe Wall Thickness [in]	0.312	-	-			
Specified Minimum Yield Stress65,000InstallationTemperature ["F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel [ksi]30,00030,000Safety Factor Applied: API 1102 ProcedurePoisson's Ratio for Steel0.30Coefficient of Thermal Expansion [per"F]0.0000065RESULTS100029,423Maximum Circumferential Stress [psi]11,22Hoop Stress [psi]29,423Maximum Longitudinal Stress [psi]11,22Stiffness Factor for Earth Load Circumferential Stress2,088Maximum Radial Stress [psi]1,44Burial Factor1.6471.6471.647Impact Factor1.50Stress [psi]29,42332,500Highway Stiffness Factor for Cyclic Circumferential1.6471.6029,42332,500Highway Geometry Factor for Cyclic Circumferential1.6471.6029,42332,500PASSHighway Stiffness Factor for Cyclic Circumferential1.10Stress [psi]Calculated Allowable PASS/FAHighway Geometry Factor for Cyclic Longitudinal Stress9.3011,500PASSLinghway Stiffness Factor for Cyclic Longitudinal Stress9.3011,500PASSLinghway Geometry Factor for Cyclic Longitudinal Stress9.3011,500PASSLinghway Geometry Factor for Cyclic Long	Pipe Grade: X65						-
Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayPipe Class:API 5L Electric Resistance WeldedImpact Factor Method: ASCE - HighwayImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel0.30Safety Factor Applied: API 1102 ProcedureCoefficient of Thermal Expansion [per*F]0.0000065Safety Factor Applied: API 1102 ProcedureRESULTS29,423Maximum Circumferential Stress [psi]33,27Allowable Hoop Stress [psi]29,423Maximum Longitudinal Stress [psi]11,22Stiffness Factor for Earth Load Circumferential Stress0.88Maximum Radial Stress [psi]-1,44Burial Factor1.50Stress [psi]32,5009A23Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load Circumferential1.647Impact Factor1.50Impact Factor1.50Stress [psi]29,42332,500Highway Geometry Factor for Cyclic Circumferential1.00Effective 30,42732,500Cyclic Circumferential Stress9.30Impact Factor1.00Impact FactorHighway Geometry Factor for Cyclic Longitudinal Stress9.30Impact Factor1.08Highway Geometry Factor for Cyclic Longitudinal Stress9.30Impact FactorImpact FactorHighway Geometry Factor	Specified Minimum Yield Stress	65,000			re [°F]		
Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel0.30Safety Factor Applied: API 1102 ProcedurePoisson's Ratio for Steel0.30Safety Factor Applied: API 1102 ProcedureRESULTS4000 Stress [psi]29,423Maximum Circumferential Stress [psi]11,22Hoop Stress [psi]29,423Maximum Longitudinal Stress [psi]11,22Stiffness Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]30,42Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load Circumferential1.647Impact Factor1.50Stress [psi]22,42332,500Highway Stiffness Factor for Cyclic Circumferential1.260Hoop29,42332,500PASSHighway Geometry Factor for Cyclic Circumferential1.00Girth Weids 2,1186,000PASSCyclic Circumferential Stress [psi]2,92311,500PASSHighway Geometry Factor for Cyclic Longitudinal Stress9.301.08Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress [psi]2,1181.08Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress [psi]2,1181.08Cyclic Longitudinal Stress	Design Factor	0.50				xle [kins]	
Temperature Derating Factor1.000Pavement Type: NonePipe Class:API 5L Electric Resistance WeldedImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel [ksi]30,000Safety Factor Method: ASCE - HighwayPoisson's Ratio for Steel0.30Safety Factor Applied: API 1102 ProcedureCoefficient of Thermal Expansion [per°F]0.0000065Safety Factor Applied: API 1102 ProcedureRESULTS4000 Stress [psi]29,423Maximum Circumferential Stress [psi]33,27Allowable Hoop Stress [psi]32,500Maximum Longitudinal Stress [psi]11,22Stiffness Factor for Earth Load Circumferential Stress2,088Maximum Radial Stress [psi]1,44Burial Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]30,422Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load [psi]1,6471.6471.647Impact Factor1.50Stress [psi]Calculated Allowable PASS/FAHighway Geometry Factor for Cyclic Circumferential1.10Girth Welds 2,1186,000Cyclic Circumferential Stress [psi]2,92311,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.301.082,92311,500Highway Geometry Factor for Cyclic Longitudinal Stress9.301.082,1182,118Cyclic Longitudinal Stress [psi]2,1182,1182,1182,118	Longitudinal Joint Factor	1.0	-		-		
Pipe Class:API 5L Electric Resistance Welded Joung's Modulus for Steel [ksi]30,000 30,000Poisson's Ratio for Steel0.30 Coefficient of Thermal Expansion [per*F]0.0000065RESULTSSafety Factor Applied:API 1102 ProcedureHoop Stress [psi]29,423Maximum Circumferential Stress [psi]33,27Allowable Hoop Stress [psi]32,500Maximum Longitudinal Stress [psi]11,22Stiffness Factor for Earth Load Circumferential Stress2,088Maximum Radial Stress [psi]-1,44Burial Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]30,42Circumferential Stress from Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load [psi]1,647Impact Factor1.50Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential1.047Impact 30,600PASSEffective 30,42732,500PASSCyclic Circumferential Stress [psi]2,9231.647Impact 30,600PASSEffective 30,42732,500PASSHighway Stiffness Factor for Cyclic Circumferential1.10Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Longitudinal Stress9.30Impact Stress [psi]1.48Highway Geometry Factor for Cyclic Longitudinal Stress9.30Impact Stress [psi]1.08Highway Stiffness Factor for Cyclic Longitudinal Stress9.30Impact Stress [psi]1.08 <tr<tr>Highway Geometry Fact</tr<tr>	Temperature Derating Factor	1.000	•			i olioo [ilii]	
Young's Modulus for Steel [ksi] 30,000 Poisson's Ratio for Steel 0.30 Coefficient of Thermal Expansion [per*F] 0.0000065 RESULTS 29,423 Hoop Stress [psi] 29,423 Allowable Hoop Stress [psi] 32,500 Maximum Longitudinal Stress [psi] 11,22 Stiffness Factor for Earth Load Circumferential Stress 2,088 Maximum Radial Stress [psi] -1,444 Burial Factor for Earth Load Circumferential Stress 1.08 Circumferential Stress from Earth Load Circumferential Stress 0.83 Allowable Effective Stress [psi] 32,500 Circumferential Stress from Earth Load [psi] 1,647 Impact Factor 1.50 Stress [psi] Calculated Allowable PASS/FA Highway Stiffness Factor for Cyclic Circumferential 12.60 Hoop 29,423 32,500 PASS Highway Stiffness Factor for Cyclic Circumferential 1.10 Girth Weids 2,118 6,000 PASS Cyclic Circumferential Stress [psi] 2,923 11,500 PASS Highway Stiffness Factor for Cyclic Longitudinal Stress 9.30 Into Neids 2,923 11,500 PASS Hi	Pipe Class: API 5L Electric Re	esistance Welded		• •		nhway	
Coefficient of Thermal Expansion [per°F] 0.0000065Safety Factor Applied: API 1102 ProcedureRESULTSHoop Stress [psi]29,423Maximum Circumferential Stress [psi]33,27Allowable Hoop Stress [psi]32,500Maximum Longitudinal Stress [psi]11,22Stiffness Factor for Earth Load Circumferential Stress2,088Maximum Radial Stress [psi]-1,44Burial Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]30,42Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load [psi]1,6471.0671.067Impact Factor1.50Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential12.60Effective 30,42732,500Highway Geometry Factor for Cyclic Corcumferential1.10Girth Welds 2,1186,000PASSCyclic Circumferential Stress [psi]2,92311,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.301.08Cyclic Longitudinal Stress9.30Highway Geometry Factor for Cyclic Longitudinal Stress1.082,118Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress [psi]2,1182,1181.00PASS	Young's Modulus for Steel [ksi]	30,000	mpao			gintay	
RESULTSHoop Stress [psi]29,423Maximum Circumferential Stress [psi]33,27Allowable Hoop Stress [psi]32,500Maximum Longitudinal Stress [psi]11,22Stiffness Factor for Earth Load Circumferential Stress2,088Maximum Radial Stress [psi]-1,44Burial Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]30,42Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load [psi]1,6471.6471.647Impact Factor1.50Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential12.60Hoop29,42332,500Highway Geometry Factor for Cyclic Circumferential1.10Girth Welds 2,1186,000PASSCyclic Circumferential Stress [psi]2,92311,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.301.08Cyclic Longitudinal Stress [psi]2,1182,118	Poisson's Ratio for Steel	0.30					
Hoop Stress [psi]29,423Maximum Circumferential Stress [psi]33,27Allowable Hoop Stress [psi]32,500Maximum Longitudinal Stress [psi]11,22Stiffness Factor for Earth Load Circumferential Stress2,088Maximum Radial Stress [psi]-1,44Burial Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]30,42Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load [psi]1,647111Impact Factor1.50Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential12.60Iffective30,42732,500Highway Geometry Factor for Cyclic Circumferential1.10Girth Welds2,1186,000PASSCyclic Circumferential Stress [psi]2,92311,500PASSSHighway Stiffness Factor for Cyclic Longitudinal Stress9.30Allowable Stress [psi]1.08Highway Geometry Factor for Cyclic Longitudinal Stress1.08Curcumferential Stress [psi]1.08Cyclic Longitudinal Stress [psi]2,1181.08Curcumferential Stress [psi]1.08Cyclic Longitudinal Stress [psi]2,1181.08Curcumferential Stress [psi]1.08	Coefficient of Thermal Expansion	[per°F] 0.0000065	Safety	Factor Applied:	API 1102	Procedur	re
Hoop Stress [psi]29,423Maximum Circumferential Stress [psi]33,27Allowable Hoop Stress [psi]32,500Maximum Longitudinal Stress [psi]11,22Stiffness Factor for Earth Load Circumferential Stress2,088Maximum Radial Stress [psi]-1,44Burial Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]30,42Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load [psi]1,647151Impact Factor1.50Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential12.6011Highway Geometry Factor for Cyclic Circumferential1.10Girth Welds 2,1186,000PASSCyclic Circumferential Stress [psi]2,92311,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.3011Highway Geometry Factor for Cyclic Longitudinal Stress1.081Cyclic Longitudinal Stress [psi]2,11811Cyclic Longitudinal Stress [psi]2,1181							
Allowable Hoop Stress [psi]32,500Maximum Longitudinal Stress [psi]11,22Stiffness Factor for Earth Load Circumferential Stress2,088Maximum Radial Stress [psi]-1,444Burial Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]30,42Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load [psi]1,6471.647Impact Factor1.50Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential12.60Stress [psi]Calculated Allowable PASS/FAHighway Geometry Factor for Cyclic Circumferential1.10Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential1.10Girth Welds 2,1186,000Cyclic Circumferential Stress [psi]2,92311,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.301.08Cyclic Longitudinal Stress [psi]2,1181.08Cyclic Longitudinal Stress [psi]2,1181.08Cyclic Longitudinal Stress [psi]2,1181.08Cyclic Longitudinal Stress [psi]2,118	REQUEID						
Stiffness Factor for Earth Load Circumferential Stress2,088Maximum Radial Stress [psi]-1,44Burial Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]30,42Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,50Circumferential Stress from Earth Load [psi]1,647Impact Factor1.50Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential12.60Hoop29,42332,500Highway Geometry Factor for Cyclic Circumferential1.10Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential1.10Girth Welds2,1186,000Cyclic Circumferential Stress [psi]2,92311,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.301.08Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress [psi]2,1182,1181.081.08Cyclic Longitudinal Stress [psi]2,1181.081.08Cyclic Longitudinal Stress [psi]2,1181.081.08Cyclic Longitudinal Stress [psi]2,1181.081.08Cyclic Longitudinal Stress [psi]2,1181.081.08Cyclic Longitudinal Stress [psi]2,1181.08Cyclic Longitudinal Stress [psi]2,1181.08Cyclic Longitudinal Stress [psi]2,118Cyclic Longitudinal Stress [psi]2,118Cyclic Longitudinal Stress [psi]2,118 <tr< td=""><td></td><td></td><td>29.423</td><td>Maximum Cire</td><td>cumferentiał</td><td>Stress [p</td><td>si] 33,27</td></tr<>			29.423	Maximum Cire	cumferentiał	Stress [p	si] 33,27
Burial Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]30,42Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,50Circumferential Stress from Earth Load [psi]1,647Impact Factor1.50Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential12.60Hoop29,42332,500Highway Geometry Factor for Cyclic Circumferential1.10Girth Welds 2,1186,000PASSCyclic Circumferential Stress [psi]2,92311,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.301.08Highway Geometry Factor for Cyclic Longitudinal Stress1.082,118Cyclic Longitudinal Stress [psi]2,1182,118	Hoop Stress [psi]						-
Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,50Circumferential Stress from Earth Load [psi]1,647Impact Factor1.50Highway Stiffness Factor for Cyclic Circumferential12.60Highway Geometry Factor for Cyclic Circumferential1.10Cyclic Circumferential Stress [psi]2,923Highway Stiffness Factor for Cyclic Longitudinal Stress9.30Highway Geometry Factor for Cyclic Longitudinal Stress9.30Highway Geometry Factor for Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress [psi]2,118	Hoop Stress [psi] Allowable Hoop Stress [psi]	rcumferential Stress	32,500	Maximum Lor	ngitudinal Str	ess [psi]	11,22
Circumferential Stress from Earth Load [psi]1,647Impact Factor1.50Highway Stiffness Factor for Cyclic Circumferential12.60Highway Geometry Factor for Cyclic Circumferential1.10Cyclic Circumferential Stress [psi]2,923Highway Stiffness Factor for Cyclic Longitudinal Stress9.30Highway Geometry Factor for Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress [psi]2,118	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Ci		32,500 2,088	Maximum Lor Maximum Rad	ngitudinal Str dial Stress [p	ress [psi] psi]	-11,22 -1,440
Impact Factor1.50Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential12.60Hoop29,42332,500PASSHighway Geometry Factor for Cyclic Circumferential1.10Effective30,42732,500PASSCyclic Circumferential Stress [psi]2,9231.10Girth Welds2,1186,000PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.309.301.08Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress [psi]2,1182,1182,1181.081.08	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Ci Burial Factor for Earth Load Circu	mferential Stress	32,500 2,088 1.08	Maximum Lor Maximum Rad Total Effective	ngitudinal Str dial Stress [p e Stress [psi]	ress [psi] psi]]	11,22 -1,440 30,42
Highway Stiffness Factor for Cyclic Circumferential12.60Hoop29,42332,500PASSHighway Geometry Factor for Cyclic Circumferential1.10Effective30,42732,500PASSCyclic Circumferential Stress [psi]2,9231.10Girth Welds2,1186,000PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.309.3011,500PASSHighway Geometry Factor for Cyclic Longitudinal Stress1.082,1181.08Cyclic Longitudinal Stress [psi]2,1182,1181.08	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Circu Burial Factor for Earth Load Circu Excavation Factor for Earth Load	mferential Stress Circumferential Stress	32,500 2,088 1.08 0.83	Maximum Lor Maximum Rad Total Effective	ngitudinal Str dial Stress [p e Stress [psi]	ress [psi] psi]]	-1,440 -1,440 30,42
Highway Geometry Factor for Cyclic Circumferential1.10Effective30,42732,500PASSCyclic Circumferential Stress [psi]2,923Girth Welds2,1186,000PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.30JuneJuneJuneHighway Geometry Factor for Cyclic Longitudinal Stress1.082,118JuneJuneCyclic Longitudinal Stress [psi]2,1182,118JuneJune	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Ci Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth	mferential Stress Circumferential Stress	32,500 2,088 1.08 0.83 1,647	Maximum Lor Maximum Rad Total Effective Allowable Effe	ngitudinal Str dial Stress [p e Stress [psi] ective Stress	ress [psi] psi] [[psi]	11,22 -1,440 30,42 32,50
Cyclic Circumferential Stress [psi]2,923Cyclic Longitudinal Stress2,923Cyclic Longitudinal Stress9.30Highway Geometry Factor for Cyclic Longitudinal Stress9.301.08Cyclic Longitudinal Stress [psi]2,118	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Ci Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor	mferential Stress Circumferential Stress Load [psi]	32,500 2,088 1.08 0.83 1,647 1.50	Maximum Lor Maximum Rad Total Effective Allowable Effe Stress [psi] Hoop	ngitudinal Str dial Stress [psi] ective Stress Calculated 29,423	ress [psi] psi] [[psi] Allowable 32,500	11,22 -1,44 30,42 32,50 PASS/FA PASS
Highway Stiffness Factor for Cyclic Longitudinal Stress 9.30 Highway Geometry Factor for Cyclic Longitudinal Stress 1.08 Cyclic Longitudinal Stress [psi] 2,118	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Ci Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycl	mferential Stress Circumferential Stress Load [psi] ic Circumferential	32,500 2,088 1.08 0.83 1,647 1.50 12.60	Maximum Lor Maximum Rad Total Effective Allowable Effe Stress [psi] Hoop Effective	ngitudinal Str dial Stress [psi] ective Stress Calculated 29,423		11,22 -1,44 30,42 32,50 PASS/FA PASS PASS
Highway Geometry Factor for Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress [psi]2,118	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness 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	mferential Stress Circumferential Stress Load [psi] ic Circumferential clic Circumferential	32,500 2,088 1.08 0.83 1,647 1.50 12.60 1.10	Maximum Lor Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds	ngitudinal Str dial Stress [psi] e Stress [psi] ective Stress Calculated / 29,423 30,427 2,118	Allowable 32,500 6,000	11,22 -1,44 30,42 32,50 PASS/FA PASS PASS PASS
Cyclic Longitudinal Stress [psi] 2,118	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness 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]	mferential Stress Circumferential Stress Load [psi] ic Circumferential clic Circumferential	32,500 2,088 1.08 0.83 1,647 1.50 12.60 1.10 2,923	Maximum Lor Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds	ngitudinal Str dial Stress [psi] e Stress [psi] ective Stress Calculated / 29,423 30,427 2,118	Allowable 32,500 6,000	11,22 -1,44 30,42 32,50 PASS/FA PASS PASS PASS
	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Ci Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycl Cyclic Circumferential Stress [psi] Highway Stiffness Factor for Cycl	mferential Stress Circumferential Stress Load [psi] ic Circumferential clic Circumferential ic Longitudinal Stress	32,500 2,088 1.08 0.83 1,647 1.50 12.60 1.10 2,923 9.30	Maximum Lor Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds	ngitudinal Str dial Stress [psi] e Stress [psi] ective Stress Calculated / 29,423 30,427 2,118	Allowable 32,500 6,000	11,22 -1,44 30,42 32,50 PASS/FA PASS PASS PASS
	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness 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	mferential Stress Circumferential Stress Load [psi] ic Circumferential clic Circumferential ic Longitudinal Stress	32,500 2,088 1.08 0.83 1,647 1.50 12.60 1.10 2,923 9.30 1.08	Maximum Lor Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds	ngitudinal Str dial Stress [psi] e Stress [psi] ective Stress Calculated / 29,423 30,427 2,118	Allowable 32,500 6,000	11,22 -1,44 30,42 32,50 PASS/FA PASS PASS PASS
	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness 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 Highway Stiffness Factor for Cycl Highway Stiffness Factor for Cycl Highway Stiffness Factor for Cycl Cyclic Circumferential Stress [psi]	mferential Stress Circumferential Stress Load [psi] ic Circumferential clic Circumferential ic Longitudinal Stress clic Longitudinal Stress	32,500 2,088 1.08 0.83 1,647 1.50 12.60 1.10 2,923 9.30 1.08 2,118 -20 loadin	Maximum Lor Maximum Rad Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds Long. Welds	ngitudinal Str dial Stress [psi] e Stress [psi] ective Stress Calculated / 29,423 30,427 2,118	Allowable 32,500 6,000	11,22 -1,440 30,42 32,50 PASS/FA PASS PASS PASS

÷.

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

API 1102 - Gas Pipeline Crossing Highway

- 1				
	PIPE AND OPERATIONAL DATA:		SITE AND INSTALLATION DATA:	
	Operating Pressure [psi]	1440	Soil Type: Stiff to very stiff clays and silts	
	Location Class:	3	E' - Modulus of Soil Reaction [ksi]	1.0
	Operating Temperature [°F]	60.0	Er - Resilient Modulus [ksi]	10.0
	Pipe Outside Diameter [in]	12.75	Average Unit Weight of Soil [lb/ft³]	120.00
	Pipe Wall Thickness [in]	0.312	Pipe Depth [ft]	3
	Pipe Grade: X65		Bored Diameter [in]	12.75
	Specified Minimum Yield Stress	65,000	InstallationTemperature [°F]	60.0
	Design Factor	0.50	Design Wheel Load from Single Axle [kips]	18.4
	Longitudinal Joint Factor	1.0	Design Wheel Load from Tandem Axles [kips	s] 18.4
	Temperature Derating Factor	1.000	Pavement Type: None	
	Pipe Class: API 5L Electric Resistance Welded		Impact Factor Method: ASCE - Highway	
	Young's Modulus for Steel [ksi]	30,000		
	Poisson's Ratio for Steel	0.30	Out of Easter Anglistic ADI 4400 December	
	Coefficient of Thermal Expansion [per°F] 0.0000065	Safety Factor Applied: API 1102 Procedure	

RESULTS

Hoop Stress [psi]	29,423
Allowable Hoop Stress [psi]	32,500
Stiffness Factor for Earth Load Circumferential Stress	1,934
Burial Factor for Earth Load Circumferential Stress	0.78
Excavation Factor for Earth Load Circumferential Stress	0.83
Circumferential Stress from Earth Load [psi]	1,102
Impact Factor	1.50
Highway Stiffness Factor for Cyclic Circumferential	12.60
Highway Geometry Factor for Cyclic Circumferential	1.22
Cyclic Circumferential Stress [psi]	3,241
Highway Stiffness Factor for Cyclic Longitudinal Stress	9.30
Highway Geometry Factor for Cyclic Longitudinal Stress	1.16
Cyclic Longitudinal Stress [psi]	2,275

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

Stress [psi]	Calculated	Allowable	PASS/FAIL
Ноор	29,423	32,500	PASS
Effective	30,216	32,500	PASS
Girth Welds	2,275	6,000	PASS
Long. Welds	3,241	11,500	PASS

Notes: Open cut construction, calculations run using HS-20 loading + 15%

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

	Prepared By Kelsey Kibbe	Approved By	Revision: 13.0.1	
1				í.

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

Prepared By Kelsey Kibbe

i.

Approved By

Revision: 13.0.1

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

Approved By

Prepared By Kelsey Kibbe

Revision: 13.0.1

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

Pipe Wall Thickness [in]0.312Pipe Depth [ft]4Pipe Grade:X65Bored Diameter [in]12.75Specified Minimum Yield Stress65,000InstallationTemperature [°F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel0.30Safety Factor Applied: API 1102 ProcedureFactor Applied: API 1102 ProcedureRESULTS29,423Maximum Circumferential Stress [psi]33,Allowable Hoop Stress [psi]29,423Maximum Longitudinal Stress [psi]11,Stiffness Factor for Earth Load Circumferential Stress1,934Maximum Radial Stress [psi]-1,4Burial Factor for Earth Load Circumferential Stress0.97Total Effective Stress [psi]30,00	Location Burlington, VT	8	Date 5/24/20	16			
Operating Pressure [psi] 1440 Soil Type: Medium dense sands and gravels Location Class: 3 E' - Modulus of Soil Reaction [ksi] 1.0 Operating Temperature [°F] 60.0 Er - Resilient Modulus [ksi] 10.0 Pipe Outside Diameter [in] 12.75 Average Unit Weight of Soil [lb/ft*] 12.00 Pipe Grade: X65 Bored Diameter [in] 12.75 Specified Minimum Yield Stress 65,000 InstallationTemperature [°F] 60.0 Design Factor 0.50 Design Wheel Load from Single Axle [kips] 18.4 Longitudinal Joint Factor 1.0 Design Wheel Load from Tandem Axles [kips] 18.4 Temperature Derating Factor 1.000 Pavement Type: None Impact Factor Method: ASCE - Highway 18.4 Young's Modulus for Steel 0.30 Coefficient of Thermal Expansion [per*F] 0.000065 Safety Factor Applied: API 1102 Procedure 33, RESULTS 29,423 Maximum Longitudinal Stress [psi] 14,4 Burial Factor for Earth Load Circumferential Stress 0.97 Total Effective Stress [psi] 30, Circumferential Stress from Earth Load Circumferential Stress 0.83 Allowable Effective Stress [API 1102 - Gas Pipeline	e Crossing High	way				
Location Class:3E' - Modulus of Soil Reaction [ksi]1.0Operating Temperature ["F]60.0Er - Resilient Modulus [ksi]10.0Pipe Outside Diameter [in]12.75Average Unit Weight of Soil [lb/ft*]120.00Pipe Wall Thickness [in]0.312Pipe Depth [ft]4Pipe Grade:X65Bored Diameter [in]12.75Specified Minimum Yield Stress65,000Installation Temperature ["F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel0.30Safety Factor Applied:API 1102 ProcedureCoefficient of Thermal Expansion [per"F]0.0000065Safety Factor Applied:API 1102 ProcedureRESULTS1.934Maximum Circumferential Stress [psi]33,Allowable Hoop Stress [psi]29,423Maximum Radial Stress [psi]14,4Burial Factor for Earth Load Circumferential Stress0.97Total Effective Stress [psi]30,00Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Impact Factor1.50Stress [psi]32,500PASSCircumferential Stress from Earth Load [psi]1,370Impact Factor Stress [psi]32,500Impact Factor1.50Stress [psi]22,756,000Highway Geometry Fact	PIPE AND OPERATIONAL DATA		SITE A	ND INSTALLA		A:	
Operating Temperature [°F]60.0Er - Resilient Modulus [ksi]1.0Pipe Outside Diameter [in]12.75Average Unit Weight of Soli [lb/ft³]120.00Pipe Wall Thickness [in]0.312Pipe Depth [ft]4Pipe Grade:X65Bored Diameter [in]12.75Specified Minimum Yield Stress65,000InstallationTemperature [°F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel [ksi]30.00030Coefficient of Thermal Expansion [per°F]0.000065Poisson's Ratio for Steel0.30Safety Factor Applied: API 1102 Procedure11,2RESULTS1.934Maximum Circumferential Stress [psi]11,2Hoop Stress [psi]29,423Maximum Longitudinal Stress [psi]11,2Stiffness Factor for Earth Load Circumferential Stress0.97Total Effective Stress [psi]30,2Excavation Factor1.50Stress [psi]32,500PASS/Highway Stiffness Factor for Cyclic Circumferential1,275Stress [psi]32,500PASS/Highway Geometry Factor for Cyclic Circumferential1,226Stress [psi]32,500PASS/Highway Stiffness Factor for Cyclic Circumferential1,226Stress [psi]32,41111,500Highway Geometry Factor for Cyclic Longitudinal Stress9,30<	Operating Pressure [psi]	1440	Soil Ty	pe: Medium	dense san	ds and gra	ivels
Operating Temperature [°F] 60.0 Er - Resilient Modulus [ksi] 10.0 Pipe Outside Diameter [in] 12.75 Average Unit Weight of Soil [lb/ft"] 12.00 Pipe Wall Thickness [in] 0.312 Pipe Depth [ft] 4 Pipe Grade: X65 Bored Diameter [in] 12.75 Specified Minimum Yield Stress 65,000 Installation Temperature [°F] 60.0 Design Factor 0.50 Design Wheel Load from Single Axle [kips] 18.4 Longitudinal Joint Factor 1.00 Pavement Type: None Impact Factor Axles [kips] 18.4 Pipe Class: API 5L Electric Resistance Welded Impact Factor Applied: API 1102 Procedure Young's Modulus for Steel 0.30 Coefficient of Thermal Expansion [per*F] 0.000065 Safety Factor Applied: API 1102 Procedure 11.4 RESULTS 29,423 Maximum Circumferential Stress [psi] 33. 33. Allowable Hoop Stress [psi] 22,642 Maximum Radial Stress [psi] 14.4 Burial Factor for Earth Load Circumferential Stress 0.97 Total Effective Stress [psi] 30. Exca	Location Class:	3	E' - Mo	dulus of Soil Re	eaction [ksi	i]	1.0
Pipe Outside Diameter [in] 12.75 Average Unit Weight of Soli [lb/ft*] 12.00 Pipe Wall Thickness [in] 0.312 Pipe Depth [ft] 4 Pipe Grade: X65 Bored Diameter [in] 12.75 Specified Minimum Yield Stress 65.000 Installation Temperature ["F] 60.0 Design Factor 0.50 Design Wheel Load from Single Axle [kips] 18.4 Longitudinal Joint Factor 1.0 Design Wheel Load from Tandem Axles [kips] 18.4 Temperature Derating Factor 1.00 Pavement Type: None Impact Factor Method: ASCE - Highway 18.4 Young's Modulus for Steel [ksi] 30.000 Poisson's Ratio for Steel 0.30 Safety Factor Applied: API 1102 Procedure 11.3 RESULTS Safety Factor Applied: API 1102 Procedure 11.4 Burial Factor for Earth Load Circumferential Stress 1.934 Maximum Longitudinal Stress [psi] 33. Allowable Hoop Stress [psi] 1.370 1.370 1.370 1.4 Burial Factor for Earth Load Circumferential Stress 0.83 Allowable Effective Stress [psi] 32.500 PASS Fifted two Stiffness Factor for Cyclic Circumferential 1.370 1	Operating Temperature [°F]	60.0			-	-	10.0
Pipe Wall Thickness [in]0.312Pipe Depth [ft]4Pipe Grade:X65Bored Diameter [in]12.75Specified Minimum Yield Stress65,000InstallationTemperature [°F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel [ksi]30,000Safety Factor Applied:API 1102 ProcedureRESULTS0.30Safety Factor Applied:API 1102 ProcedureReSULTS29,423Maximum Circumferential Stress [psi]33,Allowable Hoop Stress [psi]29,423Maximum Calial Stress [psi]11,Stiffness Factor for Earth Load Circumferential Stress0.97Total Effective Stress [psi]30,Sural Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]30,Circumferential Stress from Earth Load Circumferential Stress0.87Total Effective Stress [psi]32,Impact Factor1.50Stress [psi]32,32,500PASS/FHighway Stiffness Factor for Cyclic Circumferential1.26Hoop29,42332,500PASSCyclic Circumferential Stress [psi]3,24111,500PASSEffective 30,45332,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.30Highway Geometry Factor for Cyclic Longitudinal Stress9.30Highway	Pipe Outside Diameter [in]	12.75				3]	120.00
Pipe Grade:X65Bored Diameter [in]12.75Specified Minimum Yield Stress65,000InstallationTemperature [°F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayPipe Class:API 5L Electric Resistance WeldedImpact Factor Method: ASCE - HighwayImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel0.30Ocoefficient of Thermal Expansion [per °F]0.0000065Safety Factor Applied: API 1102 ProcedureRESULTS29,423Maximum Circumferential Stress [psi]33,Allowable Hoop Stress [psi]32,500Maximum Radial Stress [psi]11,4Stiffness Factor for Earth Load Circumferential Stress0.97Total Effective Stress [psi]30,Stiffness Factor for Earth Load Circumferential Stress0.97Total Effective Stress [psi]30,Circumferential Stress from Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,Circumferential Stress from Earth Load Circumferential1,370Impact Factor1,200Impact Factor1.50Stress [psi]22,500PASSHighway Stiffness Factor for Cyclic Circumferential1,22Girth Welds32,2500PASSCyclic Circumferential Stress [psi]3,24111,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.301,4	Pipe Wall Thickness [in]	0.312		-			4
Specified Minimum Yield Stress65,000Installation Temperature [°F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: None18.4Pipe Class:API 5L Electric Resistance WeldedImpact Factor Method: ASCE - Highway18.4Young's Modulus for Steel0.30Safety Factor Applied:API 1102 ProcedureCoefficient of Thermal Expansion [per°F]0.0000065Safety Factor Applied:API 1102 ProcedureRESULTS29,423Maximum Circumferential Stress [psi]33,Allowable Hoop Stress [psi]29,423Maximum Longitudinal Stress [psi]11,Stiffness Factor for Earth Load Circumferential Stress0.97Total Effective Stress [psi]30,Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,Circumferential Stress from Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,Impact Factor1.50Stress [psi]Calculated Allowable PASS/FHighway Stiffness Factor for Cyclic Circumferential1.22Girth Welds2,275Highway Stiffness Factor for Cyclic Longitudinal Stress9.301.16Highway Geometry Factor for Cyclic Longitudinal Stress9.301.16	Pipe Grade: X65						12.75
Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayPipe Class:API 5L Electric Resistance WeldedImpact Factor Method: ASCE - HighwayImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel0.30Safety Factor Applied: API 1102 ProcedureCoefficient of Thermal Expansion [per°F] 0.0000065Safety Factor Applied: API 1102 ProcedureRESULTS29,423Maximum Circumferential Stress [psi]33,Allowable Hoop Stress [psi]29,423Maximum Longitudinal Stress [psi]11,Stiffness Factor for Earth Load Circumferential Stress0.97Total Effective Stress [psi]30,Burial Factor1.50Stress [psi]32,500PASSCircumferential Stress from Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,Impact Factor1.50Stress [psi]32,500PASSHighway Stiffness Factor for Cyclic Circumferential1.22Girth Welds 2,2756,000PASSCyclic Circumferential Stress [psi]3,24111,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.301.16	Specified Minimum Yield Stress	65,000			re [°F]		60.0
Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayPipe Class:API 5L Electric Resistance WeldedImpact Factor Method: ASCE - HighwayImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel0.30Safety Factor Applied: API 1102 ProcedureCoefficient of Thermal Expansion [per°F]0.0000065Safety Factor Applied: API 1102 ProcedureRESULTS29,423Maximum Circumferential Stress [psi]33,3Allowable Hoop Stress [psi]32,500Maximum Longitudinal Stress [psi]11,4Stiffness Factor for Earth Load Circumferential Stress0.97Total Effective Stress [psi]30,60Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]30,70Impact Factor1.50Stress [psi]Calculated Allowable PASS/FHighway Stiffness Factor for Cyclic Circumferential1.22Girth Welds2.2756,000Highway Stiffness Factor for Cyclic Longitudinal Stress9.309.304.16	Design Factor	0.50				Axle [kips]	18.4
Temperature Derating Factor1.00Pavement Type: NonePipe Class:API 5L Electric Resistance WeldedImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel [ksi]30,000Safety Factor Method: ASCE - HighwayPoisson's Ratio for Steel0.30Safety Factor Applied: API 1102 ProcedureCoefficient of Thermal Expansion [per°F]0.0000065Safety Factor Applied: API 1102 ProcedureRESULTS29,423Maximum Circumferential Stress [psi]33,3Allowable Hoop Stress [psi]29,423Maximum Longitudinal Stress [psi]11,4Stiffness Factor for Earth Load Circumferential Stress1,934Maximum Radial Stress [psi]14,4Burial Factor for Earth Load Circumferential Stress0.97Total Effective Stress [psi]30,0Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,00Impact Factor1.50Stress [psi]23,2500PASSHighway Stiffness Factor for Cyclic Circumferential1.22Girth Welds2,2756,000Highway Stiffness Factor for Cyclic Longitudinal Stress9.309.30Highway Geometry Factor for Cyclic Longitudinal Stress1.16	Longitudinal Joint Factor	1.0	-		-		
Pipe Class:API 5L Electric Resistance Welded Mug's Modulus for Steel [ksi]30,000Poisson's Ratio for Steel0.30Safety Factor Method: ASCE - HighwayCoefficient of Thermal Expansion [per°F]0.0000065Safety Factor Applied: API 1102 ProcedureRESULTS29,423Maximum Circumferential Stress [psi]33,Allowable Hoop Stress [psi]29,423Maximum Longitudinal Stress [psi]11,Stiffness Factor for Earth Load Circumferential Stress1,934Maximum Radial Stress [psi]1,4Burial Factor for Earth Load Circumferential Stress0.97Total Effective Stress [psi]30,0Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,20Impact Factor1.50Stress [psi]Calculated Allowable PASS/FHighway Stiffness Factor for Cyclic Circumferential1.22Girth Welds2,2756,000Highway Stiffness Factor for Cyclic Longitudinal Stress9.301.161.16	Temperature Derating Factor	1.000	Ũ			•	
Young's Modulus for Steel [ksi]30,000Poisson's Ratio for Steel0.30Coefficient of Thermal Expansion [per°F]0.0000065RESULTSSafety Factor Applied: API 1102 ProcedureHoop Stress [psi]29,423Maximum Circumferential Stress [psi]33,3Allowable Hoop Stress [psi]29,423Maximum Longitudinal Stress [psi]11,2Stiffness Factor for Earth Load Circumferential Stress1,934Burial Factor for Earth Load Circumferential Stress0.97Total Effective Stress [psi]30,70Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Impact Factor1.50Highway Stiffness Factor for Cyclic Circumferential1.22Girth Welds2,275Girth Welds2,275Girth Welds3,241Highway Stiffness Factor for Cyclic Longitudinal Stress9.30Highway Geometry Factor for Cyclic Longitudinal Stress9.30	Pipe Class: API 5L Electric Re	esistance Welded		• •		lighway	
Coefficient of Thermal Expansion [per°F] 0.000065Safety Factor Applied:API 1102 ProcedureRESULTSHoop Stress [psi]29,423Maximum Circumferential Stress [psi]33,Allowable Hoop Stress [psi]32,500Maximum Longitudinal Stress [psi]11,Stiffness Factor for Earth Load Circumferential Stress0.97Total Effective Stress [psi]30,Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,Circumferential Stress from Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,Circumferential Stress from Earth Load [psi]1,3701,37032,500PASSHighway Stiffness Factor for Cyclic Circumferential1,260Hoop29,42332,500PASSGirth Welds2,2756,000PASSGirth Welds2,2756,000PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.301.161.161.16	Young's Modulus for Steel [ksi]	30,000				5 ,	
RESULTSHoop Stress [psi]29,423Maximum Circumferential Stress [psi]33,3Allowable Hoop Stress [psi]32,500Maximum Longitudinal Stress [psi]11,3Stiffness Factor for Earth Load Circumferential Stress1,934Maximum Radial Stress [psi]-1,4Burial Factor for Earth Load Circumferential Stress0.97Total Effective Stress [psi]30,6Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,600Circumferential Stress from Earth Load [psi]1,3701,37032,500PASSImpact Factor1.50Stress [psi]Calculated Allowable PASS/FEffective30,45332,500PASSHighway Geometry Factor for Cyclic Circumferential1.22Girth Welds2,2756,000PASSLong. Welds3,24111,500PASSLong. Welds3,24111,500PASSHighway Geometry Factor for Cyclic Longitudinal Stress9.301.163.24111,500PASS	Poisson's Ratio for Steel	0.30					
Hoop Stress [psi]29,423Maximum Circumferential Stress [psi]33,33,33,33,33,33,33,33,33,33,33,33,33,	Coefficient of Thermal Expansion	[per°F] 0.0000065	Safety	Factor Applied:	API 110	2 Procedu	re
Allowable Hoop Stress [psi]32,500Maximum Longitudinal Stress [psi]11,7Stiffness Factor for Earth Load Circumferential Stress1,934Maximum Radial Stress [psi]-1,4Burial Factor for Earth Load Circumferential Stress0.97Total Effective Stress [psi]30,4Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,7Circumferential Stress from Earth Load [psi]1,3701,370Stress [psi]Calculated Allowable PASS/FHighway Stiffness Factor for Cyclic Circumferential12.60Stress [psi]Calculated Allowable PASS/FHighway Geometry Factor for Cyclic Circumferential1.22Girth Welds 2,2756,000PASSCyclic Circumferential Stress [psi]3,24111,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.301.16	RESULTS					Ň	
Stiffness Factor for Earth Load Circumferential Stress1,934Maximum Radial Stress [psi]-1,4Burial Factor for Earth Load Circumferential Stress0.97Total Effective Stress [psi]30,4Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,4Circumferential Stress from Earth Load [psi]1,370Impact Factor1.50Stress [psi]Calculated Allowable PASS/FHighway Stiffness Factor for Cyclic Circumferential12.60Effective30,45332,500PASSHighway Geometry Factor for Cyclic Circumferential1.22Girth Welds2,2756,000PASSCyclic Circumferential Stress [psi]3,24111,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.301.16	Hoop Stress [psi]		29,423	Maximum Cire	cumferentia	al Stress [p	osi] 33,31
Stiffness Factor for Earth Load Circumferential Stress1,934Maximum Radial Stress [psi]-1,4Burial Factor for Earth Load Circumferential Stress0.97Total Effective Stress [psi]30,4Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,4Circumferential Stress from Earth Load [psi]1,3701,370Stress [psi]Calculated Allowable PASS/FHighway Stiffness Factor for Cyclic Circumferential12.60Stress [psi]Calculated Allowable PASS/FHighway Geometry Factor for Cyclic Circumferential1.22Girth Welds 2,2756,000PASSCyclic Circumferential Stress [psi]3,24111,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.301.161.16			32,500	Maximum Lor	ngitudinal S	Stress [psi]	11,29
Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,3Circumferential Stress from Earth Load [psi]1,370Impact Factor1.50Highway Stiffness Factor for Cyclic Circumferential12.60Highway Geometry Factor for Cyclic Circumferential1.22Cyclic Circumferential Stress [psi]3,241Highway Stiffness Factor for Cyclic Longitudinal Stress9.30Highway Geometry Factor for Cyclic Longitudinal Stress9.30Highway Geometry Factor for Cyclic Longitudinal Stress1.16		rcumferential Stress	1,934				-1,44
Circumferential Stress from Earth Load [psi]1,370Impact Factor1.50Highway Stiffness Factor for Cyclic Circumferential12.60Highway Geometry Factor for Cyclic Circumferential1.22Cyclic Circumferential Stress [psi]3,241Highway Stiffness Factor for Cyclic Longitudinal Stress9.30Highway Geometry Factor for Cyclic Longitudinal Stress1.16	Burial Factor for Earth Load Circu	mferential Stress	0.97	Total Effective	e Stress [ps	si]	30,45
Impact Factor1.50Stress [psi]Calculated Allowable PASS/FHighway Stiffness Factor for Cyclic Circumferential12.60Hoop29,42332,500PASSHighway Geometry Factor for Cyclic Circumferential1.22Girth Welds2,2756,000PASSCyclic Circumferential Stress [psi]3,24111,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.301.16	Excavation Factor for Earth Load	Circumferential Stress	0.83	Allowable Effe	ective Stres	ss [psi]	32,50
Highway Stiffness Factor for Cyclic Circumferential12.60Hoop29,42332,500PASSHighway Geometry Factor for Cyclic Circumferential1.22Effective30,45332,500PASSCyclic Circumferential Stress [psi]3,2411.20Girth Welds2,2756,000PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.309.301.16	Circumferential Stress from Earth	Load [psi]	1,370			×	
Highway Stiffness Factor for Cyclic Circumferential12.00Highway Geometry Factor for Cyclic Circumferential1.22Cyclic Circumferential Stress [psi]3,241Highway Stiffness Factor for Cyclic Longitudinal Stress9.30Highway Geometry Factor for Cyclic Longitudinal Stress1.16	Impact Factor		1.50	Stress [psi]	Calculated	Allowable	PASS/FA
Highway Geometry Factor for Cyclic Circumferential1.22Girth Welds2,2756,000PASSCyclic Circumferential Stress [psi]3,241Long. Welds3,24111,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.309.30Highway Geometry Factor for Cyclic Longitudinal Stress1.16		ic Circumferential	12.60				
Cyclic Circumferential Stress [psi]3,241Long. Welds3,24111,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.30Highway Geometry Factor for Cyclic Longitudinal Stress1.16	Highway Stiffness Factor for Cycl	clic Circumferential	1.22				
Highway Geometry Factor for Cyclic Longitudinal Stress 1.16	•						
	Highway Geometry Factor for Cyc		3,241		9	99)	
	Highway Geometry Factor for Cyc Cyclic Circumferential Stress [psi]						
	Highway Geometry Factor for Cyc Cyclic Circumferential Stress [psi] Highway Stiffness Factor for Cycl	ic Longitudinal Stress	9.30				
Notes: Open cut construction, calculations run using HS-20 loading + 15%	Highway Geometry Factor for Cyc Cyclic Circumferential Stress [psi] Highway Stiffness Factor for Cycl Highway Geometry Factor for Cyc	ic Longitudinal Stress	9.30 1.16				
	Highway Geometry Factor for Cyc Cyclic Circumferential Stress [psi] Highway Stiffness Factor for Cycl Highway Geometry Factor for Cyc Cyclic Longitudinal Stress [psi]	ic Longitudinal Stress clic Longitudinal Stress culations run using HS	9.30 1.16 2,275 -20 loadir				

Operating Pressure [psi]1440Soil Type:Medium dense sands and gravesLocation Class:3E' - Modulus of Soil Reaction [ksi]1.0Operating Temperature [°F]60.0Er - Resilient Modulus [ksi]10.0Pipe Outside Diameter [in]12.75Average Unit Weight of Soil [lb/ft³]120.00Pipe Wall Thickness [in]0.312Pipe Depth [ft]5Pipe Grade:X65Bored Diameter [in]12.75Specified Minimum Yield Stress65,000InstallationTemperature [°F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.00Pavement Type: None18.4Temperature Derating Factor1.000Pavement Type: None19.2Pipe Class:API 5L Electric Restance WeldedImpact Factor Method: ASCE - Highway18.4Young's Modulus for Steel [ksi]30,0003036etty Factor Applied: API 1102 ProcedureRESULTS29,423Maximum Circumferential Stress [psi]33,14Allowable Hoop Stress [psi]29,423Maximum Longitudinal Stress [psi]33,14Allowable Hoop Stress [psi]1.934Maximum Radial Stress [psi]11,14Stiffness Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]30,37Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]30,37Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,50 <th>Location Burlington, VT</th> <th></th> <th>Date 5/24/20</th> <th>16</th> <th></th> <th></th>	Location Burlington, VT		Date 5/24/20	16		
Operating Pressure [psi] 1440 Soil Type: Medium dense sands and gravels Location Class: 3 E' - Modulus of Soil Reaction [ksi] 1.0 Operating Temperature [*F] 60.0 Er - Resilient Modulus [ksi] 10.0 Pipe Outside Diameter [in] 12.75 Average Unit Weight of Soil [[b/ft ⁴] 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 Tandem Axles [kips] 18.4 Longitudinal Joint Factor 1.0 Design Wheel Load from Tandem Axles [kips] 18.4 Pipe Class: API 5L Electric Resistance Weided Impact Factor Method: ASCE - Highway 10.4 Young's Modulus for Steel 0.30 Coefficient of Thermal Expansion [per*F] 0.0000Poisson's Ratio for Steel 0.30 Coefficient of Thermal Expansion [per*F] 0.0000065 Safety Factor Applied: API 1102 Procedure RESULTS 29,423 Maximum Circumferential Stress [psi] 1.1,13 Stiffness Factor for Earth Load Circumfer	API 1102 - Gas Pipelin	e Crossing High	way			
Location Class:3E' - Modulus of Soil Reaction [ksi]1.0Operating Temperature (*F)60.0Er - Resilient Modulus [ksi]10.0Pipe Outside Diameter [in]12.75Average Unit Weight of Soil [lb/ft*]120.00Pipe Wall Thickness [in]0.312Pipe Depth [ft]5Pipe Grade:X65Bored Diameter [in]12.75Specified Minimum Yield Stress65,000InstallationTemperature [*F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Congis Modulus for Steel0.30Pavement Type: NoneImpact Factor Applied: ASCE - HighwayYoung's Modulus for Steel0.30Safety Factor Applied: API 1102 ProcedureCoefficient of Thermal Expansion [per*F]0.030Maximum Circumferential Stress [psi]11.10Stiffness Factor for Earth Load Circumferential Stress1.934Maximum Longitudinal Stress [psi]11.44Burial Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32.50Circumferential Stress from Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32.50Impact Factor1.50Stress [psi]22.42332.600PASSCircumferential Stress from Earth Load [psi]1.525Impact Factor for Cyclic Circumferential12.60Hoop 29.422332.600PASSHoop 29.42332.600PASSHighway Geometry Factor for Cyclic Congitudinal S	PIPE AND OPERATIONAL DATA	A:	SITE A	ND INSTALLAT	FION DATA:	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Operating Pressure [psi]	1440	Soil Ty	pe: Medium o	dense sands ar	nd gravels
Operating Temperature [°F]60.0Er - Resilient Modulus [ksi]10.0Pipe Outside Diameter [in]12.75Average Unit Weight of Soil [lb/ft³]120.00Pipe Wall Thickness [in]0.312Pipe Depth [ft]5Pipe Grade:X65Bored Diameter [in]12.75Specified Minimum Yield Stress65,000InstallationTemperature [°F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel0.30Safety Factor Applied: API 1102 ProcedureCoefficient of Thermal Expansion [per°F]0.0000065Safety Factor Applied: API 1102 ProcedureRESULTS29,423Maximum Circumferential Stress [psi]3.16Allowable Hoop Stress [psi]29,423Maximum Radial Stress [psi]11.16Stiffness Factor for Earth Load Circumferential Stress1.98Total Effective Stress [psi]30,03Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]30,37Circumferential Stress from Earth Load [psi]1,525Impact Factor1.50Impact Factor1.50Stress [psi]29,42332,500PASSGirth Weids 2,1186,000PASS/FAHighway Geometry Factor for Cyclic Circumferential1.09Girth Weids 2,1186,000Cyclic Circumferential1.08 <td>Location Class:</td> <td>3</td> <td>E' - Mo</td> <td>dulus of Soil Re</td> <td>action [ksi]</td> <td>1.0</td>	Location Class:	3	E' - Mo	dulus of Soil Re	action [ksi]	1.0
Pipe Outside Diameter [in]12.75Average Unit Weight of Soil [lb/ft³]120.00Pipe Wall Thickness [in]0.312Pipe Depth [ft]5Pipe Grade:X65Bored Diameter [in]12.75Specified Minimum Yield Stress65,000Installation Temperature [°F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel [ksi]30,00030Safety Factor Applied:API 1102 ProcedurePoisson's Ratio for Steel0.30Safety Factor Applied:API 1102 ProcedureRESULTS29,423Maximum Circumferential Stress [psi]33,16Allowable Hoop Stress [psi]32,500Maximum Radial Stress [psi]11,16Stiffness Factor for Earth Load Circumferential Stress1,934Maximum Radial Stress [psi]30,37Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]30,37Excavation Factor for Earth Load Circumferential Stress1.50Stress [psi]32,500PASSImpact Factor1.50Stress [psi]29,423Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential1,525Effective 30,31832,500PassCyclic Circumferential1,505Effective 30,31832,500PASSEnder for Cyclic Circumferential1,06 <td>Operating Temperature [°F]</td> <td>60.0</td> <td></td> <td></td> <td></td> <td>10.0</td>	Operating Temperature [°F]	60.0				10.0
Pipe Wall Thickness [in]0.312Pipe Depth [ft]5Pipe Grade:X65Bored Diameter [in]12.75Specified Minimum Yield Stress65,000Installation Temperature [°F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel [ksi]30,00030Coefficient of Thermal Expansion [per°F]0.000065RESULTSHoop Stress [psi]29,423Maximum Circumferential Stress [psi]33,15Allowable Hoop Stress [psi]29,423Maximum Longitudinal Stress [psi]11,18Stiffness Factor for Earth Load Circumferential Stress1,934Maximum Radial Stress [psi]30,31Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]30,31Excavation Factor for Cyclic Circumferential1,525Impact Factor1.50Iftess [psi]25,00Impact Factor1.50Stress [psi]32,500PASS25,00PASSHighway Stiffness Factor for Cyclic Circumferential1.260Hoop29,42332,500PASSHighway Geometry Factor for Cyclic Circumferential1.10Girth Weids 2,1186,000PASSCyclic Circumferential Stress [psi]2,92311,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.301.08Ca	Pipe Outside Diameter [in]	12.75				120.00
Pipe Grade:X65Bored Diameter [in]12.75Specified Minimum Yield Stress65,000Installation Temperature [°F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel [ksi]30,00030Safety Factor Applied:API 1102 ProcedurePoisson's Ratio for Steel0.30Safety Factor Applied:API 1102 ProcedureCoefficient of Thermal Expansion [per*F]0.000065Safety Factor Applied:API 1102 ProcedureRESULTS29,423Maximum Circumferential Stress [psi]33,15Allowable Hoop Stress [psi]32,500Maximum Radial Stress [psi]-1,44Burial Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]30,30Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Impact Factor1.50Stress [psi]32,500PASSCircumferential Stress from Earth Load [psi]1,525Impact Factor PASSStress [psi]Impact Factor1.50Stress [psi]2,942332,500PASSHighway Geometry Factor for Cyclic Circumferential1.10Effective 30,31832,500PASSCircumferential Stress [psi]2,92311,500PASSImpact 29,42332,500PASSHighway Geomet	Pipe Wall Thickness [in]	0.312	-	-		5
Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel [kig]30,000Safety Factor Method: ASCE - HighwayPoisson's Ratio for Steel0.30Safety Factor Applied: API 1102 ProcedureCoefficient of Thermal Expansion [per°F]0.0000065Safety Factor Applied: API 1102 ProcedureRESULTS1000Yazimum Circumferential Stress [psi]33,15Allowable Hoop Stress [psi]29,423Maximum Circumferential Stress [psi]11,16Stiffness Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]30,31Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500PASS1.50Stress [psi]29,42332,500PASSCircumferential Stress from Earth Load [psi]1,525Impact Factor1.50Impact Factor1.50Stress [psi]29,2232.500PASSHighway Geometry Factor for Cyclic Circumferential1.10Girth Welds 2,91332,500PASSCyclic Circumferential Stress9.301.08Cyclic Longitudinal Stress9.30Highway Geometry Factor for Cyclic Longitudinal Stress9.301.08Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress [psi]2,1181.08Cyclic Longitudinal Stress1.08<	Pipe Grade: X65					12.75
Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]10.4Longitudinal Joint Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayPipe Class:API 5L Electric Resistance WeldedImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel0.30Safety Factor Applied: API 1102 ProcedureCoefficient of Thermal Expansion [per°F]0.0000065Safety Factor Applied: API 1102 ProcedureRESULTS4000 Stress [psi]29,423Maximum Circumferential Stress [psi]Allowable Hoop Stress [psi]29,423Maximum Cogitudinal Stress [psi]Allowable Hoop Stress [psi]32,500Maximum Radial Stress [psi]Stiffness Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]Stiffness Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]Impact Factor1.50Stress [psi]22,423Impact Factor1.50Stress [psi]22,500Impact Factor1.50Stress [psi]22,500Impact Factor1.50Stress [psi]22,500Impact Factor1.50Stress [psi]22,500Highway Stiffness Factor for Cyclic Circumferential1.08Girth Welds 2,118Cyclic Circumferential Stress [psi]2,92311,500Highway Stiffness Factor for Cyclic Longitudinal Stress9.30Highway Stiffness Factor for Cyclic Longitudinal Stress9.30Highway Stiffness Factor for Cyclic Longitudinal Stress9.30Highway Stiffness Factor for	Specified Minimum Yield Stress	65,000	Installa	ationTemperatur	e [°F]	60.0
Temperature Derating Factor1.000Pavement Type: NonePipe Class:API 5L Electric Resistance WeldedImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel0.30Safety Factor Applied:API 1102 ProcedureRESULTS29,423Maximum Circumferential Stress [psi]33,15Hoop Stress [psi]29,423Maximum Circumferential Stress [psi]11,116Stiffness Factor for Earth Load Circumferential Stress1,934Maximum Radial Stress [psi]1,144Burial Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]30,37Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Impact Factor1.50Stress [psi]29,423Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential1.260Stress [psi]29,42311,500Highway Stiffness Factor for Cyclic Circumferential1.08Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential1.08Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Longitudinal Stress9.301.08Cyclic Longitudinal Stress [psi]2.1182.118	Design Factor	0.50	Desigr	Wheel Load fro	om Single Axle	[kips] 18.4
Pipe Class: API 5L Electric Resistance Welded Impact Factor Method: ASCE - Highway Young's Modulus for Steel [ksi] 30,000 Safety Factor Method: ASCE - Highway 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] 29,423 Maximum Circumferential Stress [psi] 33,15 Allowable Hoop Stress [psi] 32,500 Maximum Longitudinal Stress [psi] 11,18 Stiffness Factor for Earth Load Circumferential Stress 1,934 Maximum Radial Stress [psi] 1,44 Burial Factor for Earth Load Circumferential Stress 1,08 Total Effective Stress [psi] 30,37 Excavation Factor for Earth Load Circumferential Stress 0.83 Allowable Effective Stress [psi] 32,500 Impact Factor 1.50 Stress [psi] 29,423 32,500 PASS Impact Factor 1.50 Stress [psi] 29,500 PASS Highway Stiffness Factor for Cyclic Circumferential 1.10 Stress [psi] 29,423 32,500 PASS Highway Geometry Factor for Cyclic Longitudinal Stress 9.30 Hoop 29,423 11,500 PASS <tr< td=""><td>Longitudinal Joint Factor</td><td>1.0</td><td>Desigr</td><td>Wheel Load fro</td><td>om Tandem Ax</td><td>les [kips] 18.4</td></tr<>	Longitudinal Joint Factor	1.0	Desigr	Wheel Load fro	om Tandem Ax	les [kips] 18.4
Young's Modulus for Steel [ksi] 30,000 Poisson's Ratio for Steel 0.30 Coefficient of Thermal Expansion [per°F] 0.0000065 RESULTS 29,423 Hoop Stress [psi] 29,423 Allowable Hoop Stress [psi] 32,500 Maximum Longitudinal Stress [psi] 11,16 Stiffness Factor for Earth Load Circumferential Stress 1,934 Burial Factor for Earth Load Circumferential Stress 1.08 Total Effective Stress [psi] 30,33 Excavation Factor for Earth Load Circumferential Stress 0.83 Allowable Effective Stress [psi] 32,500 Impact Factor 1.50 Stress [psi] 22,9423 Impact Factor 1.50 Impact Factor 1.50 Stress [psi] Calculated Allowable PASS/FA Highway Stiffness Factor for Cyclic Circumferential 12.60 Hoop 29,423 32,500 Cyclic Circumferential Stress [psi] 2,923 Highway Geometry Factor for Cyclic Longitudinal Stress 9.30 Highway Geometry Factor for Cyclic Longitudinal Stress 1.08 Cyclic Longitudinal Stress [psi] 2,118 </td <td>Temperature Derating Factor</td> <td>1.000</td> <td>Paver</td> <td>ent Type: None</td> <td>9</td> <td></td>	Temperature Derating Factor	1.000	Paver	ent Type: None	9	
Poisson's Ratio for Steel0.30Coefficient of Thermal Expansion [per°F] 0.0000065Safety Factor Applied: API 1102 ProcedureRESULTSHoop Stress [psi]29,423Allowable Hoop Stress [psi]32,500Maximum Longitudinal Stress [psi]11,16Stiffness Factor for Earth Load Circumferential Stress1,934Burial Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]30,37Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load Circumferential1,525Impact Factor1.50Highway Stiffness Factor for Cyclic Circumferential12.60Highway Stiffness Factor for Cyclic Circumferential1.10Cyclic Circumferential Stress9.30Highway Stiffness Factor for Cyclic Longitudinal Stress9.30Highway Geometry Factor for Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress9.30Highway Geometry Factor for Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress1.08Hop Longitudinal Stress1.08Highway Geometry Factor for Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress1.08Cyclic Longitu	Pipe Class: API 5L Electric R	esistance Welded	Impac	Factor Method:	ASCE - Highw	vay
Coefficient of Thermal Expansion [per°F] 0.0000065Safety Factor Applied: API 1102 ProcedureRESULTSHoop Stress [psi]29,423Maximum Circumferential Stress [psi]33,16Allowable Hoop Stress [psi]32,500Maximum Longitudinal Stress [psi]11,18Stiffness Factor for Earth Load Circumferential Stress1,934Maximum Radial Stress [psi]1,44Burial Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]30,31Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load [psi]1,525Impact Factor1.50Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential12.60Effective30,31832,500PASSHighway Geometry Factor for Cyclic Circumferential1.10Girth Welds2,1186,000PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.301.08Cyclic Longitudinal Stress9.30Highway Geometry Factor for Cyclic Longitudinal Stress1.082,118Cyclic Longitudinal Stress9.30Highway Geometry Factor for Cyclic Longitudinal Stress1.082,118Cyclic Longitudinal Stress1.08	Young's Modulus for Steel [ksi]	30,000				
RESULTSHoop Stress [psi]29,423Maximum Circumferential Stress [psi]33,15Allowable Hoop Stress [psi]32,500Maximum Longitudinal Stress [psi]11,16Stiffness Factor for Earth Load Circumferential Stress1,934Maximum Radial Stress [psi]-1,44Burial Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]30,31Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load [psi]1,5251.50Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential1.60Stress [psi]Calculated Allowable PASS/FAHighway Geometry Factor for Cyclic Circumferential1.10Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential1.10Stress [psi]Calculated Allowable PASS/FAHighway Geometry Factor for Cyclic Longitudinal Stress9.3011,500PASSHighway Geometry Factor for Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress [psi]2,118Cyclic Longitudinal Stress [psi]2,1181.081.08	Poisson's Ratio for Steel	0.30				
Hoop Stress [psi]29,423Maximum Circumferential Stress [psi]33,16Allowable Hoop Stress [psi]32,500Maximum Longitudinal Stress [psi]11,16Stiffness Factor for Earth Load Circumferential Stress1,934Maximum Radial Stress [psi]-1,44Burial Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]30,31Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,50Circumferential Stress from Earth Load [psi]1,5251,525111,525Impact Factor1.50Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential12.60Hoop29,42332,500Highway Geometry Factor for Cyclic Circumferential1.10Girth Welds 2,1186,000PASSCyclic Circumferential Stress [psi]2,92311,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.301.081.08Cyclic Longitudinal Stress [psi]2,1181.081.08Cyclic Longitudinal Stress [psi]2,1181.081.08Cyclic Longitudinal Stress [psi]2,1181.081.08Cyclic Longitudinal Stress [psi]2,1181.081.08	Coefficient of Thermal Expansion	[per°F] 0.0000065	Safety	Factor Applied:	API 1102 Pro	ocedure
Allowable Hoop Stress [psi]32,500Maximum Longitudinal Stress [psi]11,18Stiffness Factor for Earth Load Circumferential Stress1,934Maximum Radial Stress [psi]-1,44Burial Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]30,31Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load [psi]1,525Impact Factor1.50Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential12.60Effective30,31832,500PASSHighway Geometry Factor for Cyclic Circumferential1.10Girth Welds2,1186,000PASSCyclic Circumferential Stress [psi]2,92311,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.301.08Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress [psi]2,1181.081.081.081.08Cyclic Longitudinal Stress [psi]2,1181.081.081.08Cyclic Longitudinal Stress [psi]2,1181.081.08Cyclic Longitudinal Stress [psi]2,118<						
Stiffness Factor for Earth Load Circumferential Stress1,934Maximum Radial Stress [psi]-1,44Burial Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]30,31Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Circumferential Stress from Earth Load [psi]1,525Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential12.60Hoop29,42332,500Highway Geometry Factor for Cyclic Circumferential1.10Cyclic Circumferential Stress [psi]2,92311,500Cyclic Circumferential Stress [psi]2,92311,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.301.08Cyclic Longitudinal Stress [psi]2,1182,118	RESULTS			181		
Burial Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]30,31Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,50Circumferential Stress from Earth Load [psi]1,525Impact Factor1.50Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential12.60Effective 30,31832,500PASSHighway Geometry Factor for Cyclic Circumferential1.10Girth Welds 2,1186,000PASSCyclic Circumferential Stress [psi]2,92311,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.301.08Cyclic Longitudinal Stress [psi]2,1182,118			29,423	Maximum Circ	cumferential Str	ress [psi] 33,15
Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,50Circumferential Stress from Earth Load [psi]1,525Impact Factor1.50Highway Stiffness Factor for Cyclic Circumferential12.60Highway Geometry Factor for Cyclic Circumferential1.10Cyclic Circumferential Stress [psi]2,923Highway Stiffness Factor for Cyclic Longitudinal Stress9.30Highway Geometry Factor for Cyclic Longitudinal Stress9.30Linghway Geometry Factor for Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress [psi]2,118	Hoop Stress [psi]					
Circumferential Stress from Earth Load [psi]1,525Impact Factor1.50Highway Stiffness Factor for Cyclic Circumferential12.60Highway Geometry Factor for Cyclic Circumferential1.10Cyclic Circumferential Stress [psi]2,923Highway Stiffness Factor for Cyclic Longitudinal Stress9.30Highway Geometry Factor for Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress [psi]2,118	Hoop Stress [psi] Allowable Hoop Stress [psi]	ircumferential Stress	32,500	Maximum Lon	gitudinal Stress	s [psi] 11,18
Impact Factor1.50Stress [psi]Calculated Allowable PASS/FAHighway Stiffness Factor for Cyclic Circumferential12.60Hoop29,42332,500PASSHighway Geometry Factor for Cyclic Circumferential1.10Effective30,31832,500PASSCyclic Circumferential Stress [psi]2,9231.186,000PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.301.08Cyclic Longitudinal Stress [psi]2,118	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C		32,500 1,934	Maximum Lon Maximum Rac	gitudinal Stress dial Stress [psi]	s [psi] 11,18 -1,44
Highway Stiffness Factor for Cyclic Circumferential12.60Highway Geometry Factor for Cyclic Circumferential1.10Cyclic Circumferential Stress [psi]2,923Highway Stiffness Factor for Cyclic Longitudinal Stress9.30Highway Geometry Factor for Cyclic Longitudinal Stress9.30Cyclic Longitudinal Stress [psi]2,118Cyclic Longitudinal Stress [psi]2,118	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C Burial Factor for Earth Load Circu	umferential Stress	32,500 1,934 1.08	Maximum Lon Maximum Rac Total Effective	gitudinal Stress dial Stress [psi] e Stress [psi]	s [psi] 11,18 -1,44 30,31
Highway Stiffness Factor for Cyclic Circumferential12.80Highway Geometry Factor for Cyclic Circumferential1.10Cyclic Circumferential Stress [psi]2,923Highway Stiffness Factor for Cyclic Longitudinal Stress9.30Highway Geometry Factor for Cyclic Longitudinal Stress9.30Cyclic Longitudinal Stress [psi]2,118Cyclic Longitudinal Stress [psi]2,118	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C Burial Factor for Earth Load Circu Excavation Factor for Earth Load	umferential Stress Circumferential Stress	32,500 1,934 1.08 0.83	Maximum Lon Maximum Rac Total Effective	gitudinal Stress dial Stress [psi] e Stress [psi]	s [psi] 11,18 -1,44 30,31
Highway Geometry Factor for Cyclic Circumferential1.10Girth Welds2,1186,000PASSCyclic Circumferential Stress [psi]2,923Long. Welds2,92311,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.30Highway Geometry Factor for Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress [psi]2,118	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth	umferential Stress Circumferential Stress	32,500 1,934 1.08 0.83 1,525	Maximum Lon Maximum Rac Total Effective Allowable Effe Stress [psi]	gitudinal Stress dial Stress [psi] Stress [psi] ective Stress [ps Calculated Allo	s [psi] 11,18 -1,44 30,31 si] 32,50
Cyclic Circumferential Stress [psi]2,923Long. Welds2,92311,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.30Highway Geometry Factor for Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress [psi]2,118	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor	umferential Stress Circumferential Stress n Load [psi]	32,500 1,934 1.08 0.83 1,525 1.50	Maximum Lon Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop	gitudinal Stress dial Stress [psi] Stress [psi] ctive Stress [ps Calculated Allo 29,423 32,	s [psi] 11,18 -1,44 30,31 si] 32,50 wable PASS/FA 500 PASS
Highway Geometry Factor for Cyclic Longitudinal Stress 1.08 Cyclic Longitudinal Stress [psi] 2,118	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycl	umferential Stress Circumferential Stress n Load [psi] lic Circumferential	32,500 1,934 1.08 0.83 1,525 1.50 12.60	Maximum Lon Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop Effective	gitudinal Stress dial Stress [psi] e Stress [psi] ective Stress [ps Calculated Allo 29,423 32, 30,318 32,	s [psi] 11,18 -1,44 30,31 si] 32,50 wable PASS/FA 500 PASS 500 PASS
Cyclic Longitudinal Stress [psi] 2,118	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycl Highway Geometry Factor for Cycl	umferential Stress Circumferential Stress h Load [psi] lic Circumferential clic Circumferential	32,500 1,934 1.08 0.83 1,525 1.50 12.60 1.10	Maximum Lon Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds	gitudinal Stress dial Stress [psi] e Stress [psi] ective Stress [psi Calculated Allo 29,423 32, 30,318 32, 2,118 6,0	s [psi] 11,18 -1,44 30,31 si] 32,50 wable PASS/FA 500 PASS 500 PASS 00 PASS
	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycl Highway Geometry Factor for Cycl	umferential Stress Circumferential Stress Load [psi] lic Circumferential clic Circumferential	32,500 1,934 1.08 0.83 1,525 1.50 12.60 1.10 2,923	Maximum Lon Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds	gitudinal Stress dial Stress [psi] e Stress [psi] ective Stress [psi Calculated Allo 29,423 32, 30,318 32, 2,118 6,0	s [psi] 11,18 -1,44 30,31 si] 32,50 wable PASS/FA 500 PASS 500 PASS 00 PASS
Notes: Open cut construction, calculations run using HS-20 loading + 15%	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cyc Cyclic Circumferential Stress [psi Highway Stiffness Factor for Cyc	umferential Stress Circumferential Stress h Load [psi] lic Circumferential clic Circumferential] lic Longitudinal Stress	32,500 1,934 1.08 0.83 1,525 1.50 12.60 1.10 2,923 9.30	Maximum Lon Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds	gitudinal Stress dial Stress [psi] e Stress [psi] ective Stress [psi Calculated Allo 29,423 32, 30,318 32, 2,118 6,0	s [psi] 11,18 -1,44 30,31 si] 32,50 wable PASS/FA 500 PASS 500 PASS 00 PASS
	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cyc Cyclic Circumferential Stress [psi Highway Stiffness Factor for Cyc Highway Stiffness Factor for Cyc	umferential Stress Circumferential Stress h Load [psi] lic Circumferential clic Circumferential] lic Longitudinal Stress	32,500 1,934 1.08 0.83 1,525 1.50 12.60 1.10 2,923 9.30 1.08	Maximum Lon Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds	gitudinal Stress dial Stress [psi] e Stress [psi] ective Stress [psi Calculated Allo 29,423 32, 30,318 32, 2,118 6,0	s [psi] 11,18 -1,44 30,37 si] 32,50 wable PASS/FA 500 PASS 500 PASS 00 PASS
	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cyc Cyclic Circumferential Stress [psi] Highway Geometry Factor for Cyc Highway Geometry Factor for Cyc	umferential Stress Circumferential Stress h Load [psi] lic Circumferential clic Circumferential] lic Longitudinal Stress clic Longitudinal Stress	32,500 1,934 1.08 0.83 1,525 1.50 12.60 1.10 2,923 9.30 1.08 2,118 -20 loadir	Maximum Lon Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds Long. Welds	gitudinal Stress dial Stress [psi] e Stress [psi] ective Stress [psi Calculated Allo 29,423 32, 30,318 32, 2,118 6,0	s [psi] 11,18 -1,44 30,31 si] 32,50 wable PASS/FA 500 PASS 500 PASS 00 PASS

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

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

ř.

Prepared By Kelsey Kibbe Approved By Revision: 13.0.1

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

Prepared By Kelsey Kibbe	Approved By	Revision: 13.0.1

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

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

Daniel J. Hartman PE | Project Engineer

T +1 (413) 315 2417 F +1 (413) 535 0136 Daniel.Hartman@mottmac.com

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

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

Sent from my iPad

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

Hey John,

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

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

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

Kind Regards,

-Danny

Daniel J. Hartman PE | Project Engineer

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

Hi Daniel

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

Is this something easy to do?

Thanks, John

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

Hey John,

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

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

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

S1 = 49,629 psi

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

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

psi

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

S2 = 18,774.7 psi

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

S3 = -1440

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

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

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

Seff=44,545.85

 $Seff \leq SMYS \times F$

44,545.85≤65,000×(.9)

44,545.85≤58,500 OK

Daniel J. Hartman PE | Project Engineer

T +1 (413) 315 2417 F +1 (413) 535 0136 Daniel.Hartman@mottmac.com

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

Hi Joe

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

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

John,

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

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

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

Thank you

Joe

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

Hi Joe –

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

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

Let me know if you need anything further.

Thanks,

Kelsey E. Kibbe Engineer II, EIT

T +1 (413) 315 2042 C +1 (413) 530 0799 F kelsey.kibbe@mottmac.com

F +1 (413) 535 0136

<image020.png>

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

<VTGas_GPTC Calc_1ftcover.pdf>

Attachment B – Additional CEPA & GPTC Calculations

Results for Surface Loading Calculation

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

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

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

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

GENERAL NOTES:

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

Results for Surface Loading Calculation

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

Vermont Gas Burlington, VT HS20+15%

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

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

GENERAL NOTES:

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

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

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

PIPE AND CROSSING DATA:

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

RESULTS OF CALCULATION:

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

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