Project Name: Vermont Gas Systems 5/25/2016

Location: Burlington, VT Rev. 1

Prepared for: Vermont Gas Systems

Prepared by: Mott MacDonald

Purpose:

Mott MacDonald has prepared the stress calculations included herein for Vermont Gas Systems, to ensure the pipeline's integrity under loading without compaction of backfill. The stress calculations were performed per API 1102, using various combinations of soil type and depth of cover to confirm that 90% compaction will not be necessary.

Knowns:

- Class 3 Location, Design Factor of 0.5
- 12.75 inch OD
- 0.312 inch WT
- API-5L Electric Resistance Welded
- Grade X-65
- MAOP of 1440 psi
- Design Wheel Load HS-20 + 15%

Results:

A summary table has been provided below. The stress calculations show that under all soil types, paired with 3', 4', and 5' of cover, the pipeline passes all stress checks (Hoop, Effective, Girth Weld, and Longitudinal Weld). In conclusion, Mott MacDonald recommends a minimum depth of cover of 4 feet. Although 3 feet of cover is sufficient under the given loading, a one foot buffer would help ensure that even if settlement were to occur, the pipeline would remain safe and operational.

API 1102 STRESS CALCULATION RESULTS			
	Calculated Effective Stress (psi)		
Soil type	3' Cover	4' Cover	5' Cover
Soft to medium clays and silts with high plasticities	31,239	31,437	31,234
Soft to medium clays and silts with low/medium plasticities	31,180	31,370	31,159
Loose sands and gravels	30,360	30,550	30,427
Stiff to very stiff clays and silts	30,216	30,366	30,193
Medium dense sands and gravels	30,278	30,453	30,318
Dense to very dense sands and gravels	29,422	29,554	29,437
ALLOWABLE EFFECTIVE STRESS (psi)	**32,500**		
Note: 1. Calculated girth weld and longitudinal weld stress values were less than the allowable (Girth: 6,000 psi & Long. Welds: 11,500 psi).			

Mott MacDonald

Calculation cover sheet

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

Computer Applications Used:	
Title:	Version Date:
PIPELINE TOOLBOX	2013

Scopes for Checking Manual and Computer Generated Calculations:

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

Sheets Checked: *	**Calculations by:**			**Checked By:**		
	Name:	Signature:	Date:	Name:	Signature:	Date:
18/18	K. KIBBE	Kelsey Kibbe	5/25/16	J. WOJNAS	JW	5/25/16

**If an Excel spreadsheet or other computer file has been checked and has not been attached, enter the name, date and full file path or PiMS location of the file that was checked. (PiMS nickname or short link from Properties – General could also be useful.)*

a) Basic Design Information or Source and Reference:

> Design Info. per Mike Reagan's discussions with client
> API 1102 for design factors and procedure

b) Identify documents/technical records where output will be used:

> calculations summary provided to client

Approved by Project Manager:	**Signature:** ..... **Print name:** Joseph WOJNAS	**Date:** 5/25/16

Distribution: Original to project file

Step

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

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade: X65	
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class: API 5L Electric Resistance Welded	
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type:	Soft to medium clays and silts with high plasticities
E' - Modulus of Soil Reaction [ksi]	0.2
Er - Resilient Modulus [ksi]	5.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	3
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4

Pavement Type: None

Impact Factor Method: ASCE - Highway

Safety Factor Applied: API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423	Maximum Circumferential Stress [psi]	34,305
Allowable Hoop Stress [psi]	32,500	Maximum Longitudinal Stress [psi]	12,239
Stiffness Factor for Earth Load Circumferential Stress	2,196	Maximum Radial Stress [psi]	-1,440
Burial Factor for Earth Load Circumferential Stress	0.83	Total Effective Stress [psi]	31,239
Excavation Factor for Earth Load Circumferential Stress	0.83	Allowable Effective Stress [psi]	32,500
Circumferential Stress from Earth Load [psi]	1,331		
Impact Factor	1.50		
Highway Stiffness Factor for Cyclic Circumferential	16.60		
Highway Geometry Factor for Cyclic Circumferential	1.22		
Cyclic Circumferential Stress [psi]	4,271		
Highway Stiffness Factor for Cyclic Longitudinal Stress	13.20		
Highway Geometry Factor for Cyclic Longitudinal Stress	1.16		
Cyclic Longitudinal Stress [psi]	3,229		

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	31,239	32,500	PASS
Girth Welds	3,229	6,000	PASS
Long. Welds	4,271	11,500	PASS

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

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

Prepared By Kelsey Kibbe	Approved By	Revision: 13.0.1

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

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade: X65	
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class: API 5L Electric Resistance Welded	
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type:	Soft to medium clays and silts with high plasticities
E' - Modulus of Soil Reaction [ksi]	0.2
Er - Resilient Modulus [ksi]	5.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	4
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4

Pavement Type: None

Impact Factor Method: ASCE - Highway

Safety Factor Applied: API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423	Maximum Circumferential Stress [psi]	34,529
Allowable Hoop Stress [psi]	32,500	Maximum Longitudinal Stress [psi]	12,306
Stiffness Factor for Earth Load Circumferential Stress	2,196	Maximum Radial Stress [psi]	-1,440
Burial Factor for Earth Load Circumferential Stress	0.97	Total Effective Stress [psi]	31,437
Excavation Factor for Earth Load Circumferential Stress	0.83	Allowable Effective Stress [psi]	32,500
Circumferential Stress from Earth Load [psi]	1,555		
Impact Factor	1.50		
Highway Stiffness Factor for Cyclic Circumferential	16.60		
Highway Geometry Factor for Cyclic Circumferential	1.22		
Cyclic Circumferential Stress [psi]	4,271		
Highway Stiffness Factor for Cyclic Longitudinal Stress	13.20		
Highway Geometry Factor for Cyclic Longitudinal Stress	1.16		
Cyclic Longitudinal Stress [psi]	3,229		

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	31,437	32,500	PASS
Girth Welds	3,229	6,000	PASS
Long. Welds	4,271	11,500	PASS

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

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

Prepared By Kelsey Kibbe	Approved By	Revision: 13.0.1

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

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade: X65	
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class: API 5L Electric Resistance Welded	
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type:	Soft to medium clays and silts with high plasticities
E' - Modulus of Soil Reaction [ksi]	0.2
Er - Resilient Modulus [ksi]	5.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	5
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4

Pavement Type: None

Impact Factor Method: ASCE - Highway

Safety Factor Applied: API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423
Allowable Hoop Stress [psi]	32,500
Stiffness Factor for Earth Load Circumferential Stress	2,196
Burial Factor for Earth Load Circumferential Stress	1.08
Excavation Factor for Earth Load Circumferential Stress	0.83
Circumferential Stress from Earth Load [psi]	1,732
Impact Factor	1.50
Highway Stiffness Factor for Cyclic Circumferential	16.60
Highway Geometry Factor for Cyclic Circumferential	1.10
Cyclic Circumferential Stress [psi]	3,850
Highway Stiffness Factor for Cyclic Longitudinal Stress	13.20
Highway Geometry Factor for Cyclic Longitudinal Stress	1.08
Cyclic Longitudinal Stress [psi]	3,006

Maximum Circumferential Stress [psi]	34,285
Maximum Longitudinal Stress [psi]	12,136
Maximum Radial Stress [psi]	-1,440
Total Effective Stress [psi]	31,234
Allowable Effective Stress [psi]	32,500

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	31,234	32,500	PASS
Girth Welds	3,006	6,000	PASS
Long. Welds	3,850	11,500	PASS

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

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

Prepared By Kelsey Kibbe	Approved By	Revision: 13.0.1

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

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade: X65	
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class: API 5L Electric Resistance Welded	
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type:	Soft to medium clays and silts with low/medium plasticities
E' - Modulus of Soil Reaction [ksi]	0.5
Er - Resilient Modulus [ksi]	5.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	3
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4

Pavement Type: None

Impact Factor Method: ASCE - Highway

Safety Factor Applied: API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423
Allowable Hoop Stress [psi]	32,500
Stiffness Factor for Earth Load Circumferential Stress	2,088
Burial Factor for Earth Load Circumferential Stress	0.83
Excavation Factor for Earth Load Circumferential Stress	0.83
Circumferential Stress from Earth Load [psi]	1,265
Impact Factor	1.50
Highway Stiffness Factor for Cyclic Circumferential	16.60
Highway Geometry Factor for Cyclic Circumferential	1.22
Cyclic Circumferential Stress [psi]	4,271
Highway Stiffness Factor for Cyclic Longitudinal Stress	13.20
Highway Geometry Factor for Cyclic Longitudinal Stress	1.16
Cyclic Longitudinal Stress [psi]	3,229

Maximum Circumferential Stress [psi]	34,239
Maximum Longitudinal Stress [psi]	12,219
Maximum Radial Stress [psi]	-1,440
Total Effective Stress [psi]	31,180
Allowable Effective Stress [psi]	32,500

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	31,180	32,500	PASS
Girth Welds	3,229	6,000	PASS
Long. Welds	4,271	11,500	PASS

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

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

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

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade: X65	
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class: API 5L Electric Resistance Welded	
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type:	Soft to medium clays and silts with low/medium plasticities
E' - Modulus of Soil Reaction [ksi]	0.5
Er - Resilient Modulus [ksi]	5.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	4
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4

Pavement Type: None

Impact Factor Method: ASCE - Highway

Safety Factor Applied: API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423
Allowable Hoop Stress [psi]	32,500
Stiffness Factor for Earth Load Circumferential Stress	2,088
Burial Factor for Earth Load Circumferential Stress	0.97
Excavation Factor for Earth Load Circumferential Stress	0.83
Circumferential Stress from Earth Load [psi]	1,479
Impact Factor	1.50
Highway Stiffness Factor for Cyclic Circumferential	16.60
Highway Geometry Factor for Cyclic Circumferential	1.22
Cyclic Circumferential Stress [psi]	4,271
Highway Stiffness Factor for Cyclic Longitudinal Stress	13.20
Highway Geometry Factor for Cyclic Longitudinal Stress	1.16
Cyclic Longitudinal Stress [psi]	3,229

Maximum Circumferential Stress [psi]	34,453
Maximum Longitudinal Stress [psi]	12,284
Maximum Radial Stress [psi]	-1,440
Total Effective Stress [psi]	31,370
Allowable Effective Stress [psi]	32,500

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	31,370	32,500	PASS
Girth Welds	3,229	6,000	PASS
Long. Welds	4,271	11,500	PASS

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

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

Prepared By Kelsey Kibbe	Approved By	Revision: 13.0.1

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

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade: X65	
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class: API 5L Electric Resistance Welded	
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type:	Soft to medium clays and silts with low/medium plasticities
E' - Modulus of Soil Reaction [ksi]	0.5
Er - Resilient Modulus [ksi]	5.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	5
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4

Pavement Type: None

Impact Factor Method: ASCE - Highway

Safety Factor Applied: API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423
Allowable Hoop Stress [psi]	32,500
Stiffness Factor for Earth Load Circumferential Stress	2,088
Burial Factor for Earth Load Circumferential Stress	1.08
Excavation Factor for Earth Load Circumferential Stress	0.83
Circumferential Stress from Earth Load [psi]	1,647
Impact Factor	1.50
Highway Stiffness Factor for Cyclic Circumferential	16.60
Highway Geometry Factor for Cyclic Circumferential	1.10
Cyclic Circumferential Stress [psi]	3,850
Highway Stiffness Factor for Cyclic Longitudinal Stress	13.20
Highway Geometry Factor for Cyclic Longitudinal Stress	1.08
Cyclic Longitudinal Stress [psi]	3,006

Maximum Circumferential Stress [psi]	34,200
Maximum Longitudinal Stress [psi]	12,111
Maximum Radial Stress [psi]	-1,440
Total Effective Stress [psi]	31,159
Allowable Effective Stress [psi]	32,500

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	31,159	32,500	PASS
Girth Welds	3,006	6,000	PASS
Long. Welds	3,850	11,500	PASS

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

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

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

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade: X65	
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class: API 5L Electric Resistance Welded	
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type: Loose sands and gravels

E' - Modulus of Soil Reaction [ksi]	0.5
Er - Resilient Modulus [ksi]	10.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	3
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4

Pavement Type: None

Impact Factor Method: ASCE - Highway

Safety Factor Applied: API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423	Maximum Circumferential Stress [psi]	33,209
Allowable Hoop Stress [psi]	32,500	Maximum Longitudinal Stress [psi]	11,265
Stiffness Factor for Earth Load Circumferential Stress	2,088	Maximum Radial Stress [psi]	-1,440
Burial Factor for Earth Load Circumferential Stress	0.83	Total Effective Stress [psi]	30,360
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		
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		

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	30,360	32,500	PASS
Girth Welds	2,275	6,000	PASS
Long. Welds	3,241	11,500	PASS

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

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

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

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade: X65	
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class: API 5L Electric Resistance Welded	
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type: Loose sands and gravels

E' - Modulus of Soil Reaction [ksi]	0.5
Er - Resilient Modulus [ksi]	10.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	4
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4

Pavement Type: None

Impact Factor Method: ASCE - Highway

Safety Factor Applied: API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423
Allowable Hoop Stress [psi]	32,500
Stiffness Factor for Earth Load Circumferential Stress	2,088
Burial Factor for Earth Load Circumferential Stress	0.97
Excavation Factor for Earth Load Circumferential Stress	0.83
Circumferential Stress from Earth Load [psi]	1,479
Impact Factor	1.50
Highway Stiffness Factor for Cyclic Circumferential	12.60
Highway Geometry Factor for Cyclic Circumferential	1.22
Cyclic Circumferential Stress [psi]	3,241
Highway Stiffness Factor for Cyclic Longitudinal Stress	9.30
Highway Geometry Factor for Cyclic Longitudinal Stress	1.16
Cyclic Longitudinal Stress [psi]	2,275

Maximum Circumferential Stress [psi]	33,423
Maximum Longitudinal Stress [psi]	11,330
Maximum Radial Stress [psi]	-1,440
Total Effective Stress [psi]	30,550
Allowable Effective Stress [psi]	32,500

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	30,550	32,500	PASS
Girth Welds	2,275	6,000	PASS
Long. Welds	3,241	11,500	PASS

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

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

Prepared By Kelsey Kibbe	Approved By	Revision: 13.0.1

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

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade: X65	
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class: API 5L Electric Resistance Welded	
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type: Loose sands and gravels

E' - Modulus of Soil Reaction [ksi]	0.5
Er - Resilient Modulus [ksi]	10.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	5
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4

Pavement Type: None

Impact Factor Method: ASCE - Highway

Safety Factor Applied: API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423
Allowable Hoop Stress [psi]	32,500
Stiffness Factor for Earth Load Circumferential Stress	2,088
Burial Factor for Earth Load Circumferential Stress	1.08
Excavation Factor for Earth Load Circumferential Stress	0.83
Circumferential Stress from Earth Load [psi]	1,647
Impact Factor	1.50
Highway Stiffness Factor for Cyclic Circumferential	12.60
Highway Geometry Factor for Cyclic Circumferential	1.10
Cyclic Circumferential Stress [psi]	2,923
Highway Stiffness Factor for Cyclic Longitudinal Stress	9.30
Highway Geometry Factor for Cyclic Longitudinal Stress	1.08
Cyclic Longitudinal Stress [psi]	2,118

Maximum Circumferential Stress [psi]	33,273
Maximum Longitudinal Stress [psi]	11,223
Maximum Radial Stress [psi]	-1,440
Total Effective Stress [psi]	30,427
Allowable Effective Stress [psi]	32,500

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	30,427	32,500	PASS
Girth Welds	2,118	6,000	PASS
Long. Welds	2,923	11,500	PASS

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

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

Prepared By Kelsey Kibbe	Approved By	Revision: 13.0.1

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

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade: X65	
Specified Minimum Yield Stress	65,000
Design Factqr	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class: API 5L Electric Resistance Welded	
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type: Stiff to very stiff clays and silts

E' - Modulus of Soil Reaction [ksi]	1.0
Er - Resilient Modulus [ksi]	10.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	3
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4

Pavement Type: None

Impact Factor Method: ASCE - Highway

Safety Factor Applied: API 1102 Procedure

RESULTS

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

Maximum Circumferential Stress [psi]	33,046
Maximum Longitudinal Stress [psi]	11,216
Maximum Radial Stress [psi]	-1,440
Total Effective Stress [psi]	30,216
Allowable Effective Stress [psi]	32,500

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

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

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

Prepared By Kelsey Kibbe	Approved By	Revision: 13.0.1

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

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade: X65	
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class: API 5L Electric Resistance Welded	
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type: Stiff to very stiff clays and silts

E' - Modulus of Soil Reaction [ksi]	1.0
Er - Resilient Modulus [ksi]	10.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	4
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4

Pavement Type: None

Impact Factor Method: ASCE - Highway

Safety Factor Applied: API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423	Maximum Circumferential Stress [psi]	33,215
Allowable Hoop Stress [psi]	32,500	Maximum Longitudinal Stress [psi]	11,267
Stiffness Factor for Earth Load Circumferential Stress	1,934	Maximum Radial Stress [psi]	-1,440
Burial Factor for Earth Load Circumferential Stress	0.90	Total Effective Stress [psi]	30,366
Excavation Factor for Earth Load Circumferential Stress	0.83	Allowable Effective Stress [psi]	32,500
Circumferential Stress from Earth Load [psi]	1,271		
Impact Factor	1.50		
Highway Stiffness Factor for Cyclic Circumferential	12.60		
Highway Geometry Factor for Cyclic Circumferential	1.22		
Cyclic Circumferential Stress [psi]	3,241		
Highway Stiffness Factor for Cyclic Longitudinal Stress	9.30		
Highway Geometry Factor for Cyclic Longitudinal Stress	1.16		
Cyclic Longitudinal Stress [psi]	2,275		

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	30,366	32,500	PASS
Girth Welds	2,275	6,000	PASS
Long. Welds	3,241	11,500	PASS

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

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

Prepared By Kelsey Kibbe	Approved By	Revision: 13.0.1

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

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade: X65	
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class: API 5L Electric Resistance Welded	
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type: Stiff to very stiff clays and silts

E' - Modulus of Soil Reaction [ksi]	1.0
Er - Resilient Modulus [ksi]	10.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	5
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4

Pavement Type: None

Impact Factor Method: ASCE - Highway

Safety Factor Applied: API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423
Allowable Hoop Stress [psi]	32,500
Stiffness Factor for Earth Load Circumferential Stress	1,934
Burial Factor for Earth Load Circumferential Stress	0.98
Excavation Factor for Earth Load Circumferential Stress	0.83
Circumferential Stress from Earth Load [psi]	1,384
Impact Factor	1.50
Highway Stiffness Factor for Cyclic Circumferential	12.60
Highway Geometry Factor for Cyclic Circumferential	1.10
Cyclic Circumferential Stress [psi]	2,923
Highway Stiffness Factor for Cyclic Longitudinal Stress	9.30
Highway Geometry Factor for Cyclic Longitudinal Stress	1.08
Cyclic Longitudinal Stress [psi]	2,118

Maximum Circumferential Stress [psi]	33,010
Maximum Longitudinal Stress [psi]	11,144
Maximum Radial Stress [psi]	-1,440
Total Effective Stress [psi]	30,193
Allowable Effective Stress [psi]	32,500

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	30,193	32,500	PASS
Girth Welds	2,118	6,000	PASS
Long. Welds	2,923	11,500	PASS

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

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

Prepared By Kelsey Kibbe	Approved By	Revision: 13.0.1

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

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade: X65	
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class: API 5L Electric Resistance Welded	
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type: Medium dense sands and gravels

E' - Modulus of Soil Reaction [ksi]	1.0
Er - Resilient Modulus [ksi]	10.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	3
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4

Pavement Type: None

Impact Factor Method: ASCE - Highway

Safety Factor Applied: API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423
Allowable Hoop Stress [psi]	32,500
Stiffness Factor for Earth Load Circumferential Stress	1,934
Burial Factor for Earth Load Circumferential Stress	0.83
Excavation Factor for Earth Load Circumferential Stress	0.83
Circumferential Stress from Earth Load [psi]	1,172
Impact Factor	1.50
Highway Stiffness Factor for Cyclic Circumferential	12.60
Highway Geometry Factor for Cyclic Circumferential	1.22
Cyclic Circumferential Stress [psi]	3,241
Highway Stiffness Factor for Cyclic Longitudinal Stress	9.30
Highway Geometry Factor for Cyclic Longitudinal Stress	1.16
Cyclic Longitudinal Stress [psi]	2,275

Maximum Circumferential Stress [psi]	33,116
Maximum Longitudinal Stress [psi]	11,238
Maximum Radial Stress [psi]	-1,440
Total Effective Stress [psi]	30,278
Allowable Effective Stress [psi]	32,500

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	30,278	32,500	PASS
Girth Welds	2,275	6,000	PASS
Long. Welds	3,241	11,500	PASS

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

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

Prepared By Kelsey Kibbe	Approved By	Revision: 13.0.1

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

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade: X65	
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class: API 5L Electric Resistance Welded	
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type: Medium dense sands and gravels

E' - Modulus of Soil Reaction [ksi]	1.0
Er - Resilient Modulus [ksi]	10.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	4
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4

Pavement Type: None

Impact Factor Method: ASCE - Highway

Safety Factor Applied: API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423	Maximum Circumferential Stress [psi]	33,314
Allowable Hoop Stress [psi]	32,500	Maximum Longitudinal Stress [psi]	11,297
Stiffness Factor for Earth Load Circumferential Stress	1,934	Maximum Radial Stress [psi]	-1,440
Burial Factor for Earth Load Circumferential Stress	0.97	Total Effective Stress [psi]	30,453
Excavation Factor for Earth Load Circumferential Stress	0.83	Allowable Effective Stress [psi]	32,500
Circumferential Stress from Earth Load [psi]	1,370		
Impact Factor	1.50		
Highway Stiffness Factor for Cyclic Circumferential	12.60		
Highway Geometry Factor for Cyclic Circumferential	1.22		
Cyclic Circumferential Stress [psi]	3,241		
Highway Stiffness Factor for Cyclic Longitudinal Stress	9.30		
Highway Geometry Factor for Cyclic Longitudinal Stress	1.16		
Cyclic Longitudinal Stress [psi]	2,275		

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	30,453	32,500	PASS
Girth Welds	2,275	6,000	PASS
Long. Welds	3,241	11,500	PASS

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

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

Prepared By Kelsey Kibbe	Approved By	Revision: 13.0.1

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

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade: X65	
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class: API 5L Electric Resistance Welded	
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type: Medium dense sands and gravels

E' - Modulus of Soil Reaction [ksi]	1.0
Er - Resilient Modulus [ksi]	10.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	5
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4

Pavement Type: None

Impact Factor Method: ASCE - Highway

Safety Factor Applied: API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423	Maximum Circumferential Stress [psi]	33,151
Allowable Hoop Stress [psi]	32,500	Maximum Longitudinal Stress [psi]	11,186
Stiffness Factor for Earth Load Circumferential Stress	1,934	Maximum Radial Stress [psi]	-1,440
Burial Factor for Earth Load Circumferential Stress	1.08	Total Effective Stress [psi]	30,318
Excavation Factor for Earth Load Circumferential Stress	0.83	Allowable Effective Stress [psi]	32,500
Circumferential Stress from Earth Load [psi]	1,525		
Impact Factor	1.50		
Highway Stiffness Factor for Cyclic Circumferential	12.60		
Highway Geometry Factor for Cyclic Circumferential	1.10		
Cyclic Circumferential Stress [psi]	2,923		
Highway Stiffness Factor for Cyclic Longitudinal Stress	9.30		
Highway Geometry Factor for Cyclic Longitudinal Stress	1.08		
Cyclic Longitudinal Stress [psi]	2,118		

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	30,318	32,500	PASS
Girth Welds	2,118	6,000	PASS
Long. Welds	2,923	11,500	PASS

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

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

Prepared By Kelsey Kibbe	Approved By	Revision: 13.0.1

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

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade: X65	
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class: API 5L Electric Resistance Welded	
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type: Dense to very dense sands and gravels

E' - Modulus of Soil Reaction [ksi]	2.0
Er - Resilient Modulus [ksi]	20.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	3
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4

Pavement Type: None

Impact Factor Method: ASCE - Highway

Safety Factor Applied: API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423
Allowable Hoop Stress [psi]	32,500
Stiffness Factor for Earth Load Circumferential Stress	1,693
Burial Factor for Earth Load Circumferential Stress	0.78
Excavation Factor for Earth Load Circumferential Stress	0.83
Circumferential Stress from Earth Load [psi]	964
Impact Factor	1.50
Highway Stiffness Factor for Cyclic Circumferential	9.30
Highway Geometry Factor for Cyclic Circumferential	1.22
Cyclic Circumferential Stress [psi]	2,393
Highway Stiffness Factor for Cyclic Longitudinal Stress	6.20
Highway Geometry Factor for Cyclic Longitudinal Stress	1.16
Cyclic Longitudinal Stress [psi]	1,517

Maximum Circumferential Stress [psi]	32,060
Maximum Longitudinal Stress [psi]	10,417
Maximum Radial Stress [psi]	-1,440
Total Effective Stress [psi]	29,422
Allowable Effective Stress [psi]	32,500

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	29,422	32,500	PASS
Girth Welds	1,517	6,000	PASS
Long. Welds	2,393	11,500	PASS

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

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

Prepared By Kelsey Kibbe	Approved By	Revision: 13.0.1

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

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade: X65	
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class: API 5L Electric Resistance Welded	
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type: Dense to very dense sands and gravels

E' - Modulus of Soil Reaction [ksi]	2.0
Er - Resilient Modulus [ksi]	20.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	4
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4

Pavement Type: None

Impact Factor Method: ASCE - Highway

Safety Factor Applied: API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423	Maximum Circumferential Stress [psi]	32,209
Allowable Hoop Stress [psi]	32,500	Maximum Longitudinal Stress [psi]	10,462
Stiffness Factor for Earth Load Circumferential Stress	1,693	Maximum Radial Stress [psi]	-1,440
Burial Factor for Earth Load Circumferential Stress	0.90	Total Effective Stress [psi]	29,554
Excavation Factor for Earth Load Circumferential Stress	0.83	Allowable Effective Stress [psi]	32,500
Circumferential Stress from Earth Load [psi]	1,113		
Impact Factor	1.50		
Highway Stiffness Factor for Cyclic Circumferential	9.30		
Highway Geometry Factor for Cyclic Circumferential	1.22		
Cyclic Circumferential Stress [psi]	2,393		
Highway Stiffness Factor for Cyclic Longitudinal Stress	6.20		
Highway Geometry Factor for Cyclic Longitudinal Stress	1.16		
Cyclic Longitudinal Stress [psi]	1,517		

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	29,554	32,500	PASS
Girth Welds	1,517	6,000	PASS
Long. Welds	2,393	11,500	PASS

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

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

Prepared By Kelsey Kibbe	Approved By	Revision: 13.0.1

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

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade: X65	
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class: API 5L Electric Resistance Welded	
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type: Dense to very dense sands and gravels

E' - Modulus of Soil Reaction [ksi]	2.0
Er - Resilient Modulus [ksi]	20.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	5
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4

Pavement Type: None

Impact Factor Method: ASCE - Highway

Safety Factor Applied: API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423
Allowable Hoop Stress [psi]	32,500
Stiffness Factor for Earth Load Circumferential Stress	1,693
Burial Factor for Earth Load Circumferential Stress	0.98
Excavation Factor for Earth Load Circumferential Stress	0.83
Circumferential Stress from Earth Load [psi]	1,211
Impact Factor	1.50
Highway Stiffness Factor for Cyclic Circumferential	9.30
Highway Geometry Factor for Cyclic Circumferential	1.10
Cyclic Circumferential Stress [psi]	2,157
Highway Stiffness Factor for Cyclic Longitudinal Stress	6.20
Highway Geometry Factor for Cyclic Longitudinal Stress	1.08
Cyclic Longitudinal Stress [psi]	1,412

Maximum Circumferential Stress [psi]	32,071
Maximum Longitudinal Stress [psi]	10,386
Maximum Radial Stress [psi]	-1,440
Total Effective Stress [psi]	29,437
Allowable Effective Stress [psi]	32,500

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	29,437	32,500	PASS
Girth Welds	1,412	6,000	PASS
Long. Welds	2,157	11,500	PASS

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

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

Prepared By Kelsey Kibbe	Approved By	Revision: 13.0.1