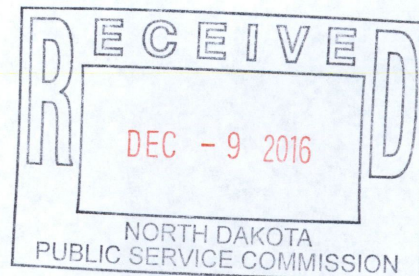




CERTIFIED MAIL 7014 2120 0002 5111 0984  
RETURN RECEIPT REQUESTED

December 7, 2016

Mr. Aaron A. Morman, Manager  
ND Gas Pipeline Safety Program  
600 East Boulevard, Dept. 408  
Bismarck, ND 58505-0480



Re: ONEOK Rockies Midstream, L.L.C.;  
Case No. GS-16-749, Notice of Probable Violation

Mr. Morman:

ONEOK Rockies Midstream, L.L.C. (ORM) is in receipt of your letter of November 18, 2016, and the accompanying Notice of Probable Violation (NOPV). On November 12, you granted our request for a seven (7) day extension of the deadline to respond to the NOPV, so this response is timely submitted. We appreciate your accommodation.

Pursuant to paragraph (a)(2) of the Response Options included in the NOPV, ORM offers the following additional information for your consideration.

The NOPV is the result of an audit performed by an inspector with the North Dakota Public Service Commission (NDPSC) on November 1, 2016. The probable violation states that ORM failed to provide records demonstrating compliance with 49 CFR 192.743, "Pressure limiting and regulating stations; Capacity of relief devices." Pursuant to the regulation, the capacity must be determined at intervals not exceeding fifteen (15) months, but at least once each calendar year, by testing the devices in place or by review and calculations.

The Fort Buford Compressor Station, NW4, Sec. 4, T151N, R103W, McKenzie County, is owned by Northern Natural Gas Company (NNG) and operated by ORM. NNG uses a D7i work order system for scheduling and tracking compliance activities and stores the compliance dates in that system. Each year, NNG personnel verify that relief valve capacity is sufficient to protect the facility based on the annual inspection and testing of the relief valves at Fort Buford.

ONEOK Partners, L.P.  
100 West Fifth Street  
Tulsa, OK 74103  
[www.oneokpartners.com](http://www.oneokpartners.com)

December 7, 2016  
Mr. Aaron Morman

During the NDPSC audit, ORM personnel presented twenty-four (24) inspection and test records from calendar year 2015. It was believed at that time that all of those relief valves were in place to protect MAOP at the station. However, upon receipt of the NOPV, ORM personnel undertook a further review at Fort Buford to verify which valves are currently in service, held discussions with NNG and reviewed the data from the 2016 relief valve inspection and testing reports. As a result of that additional effort, ORM has now determined that only ten (10) relief valves are currently in service and protect the station MAOP and auxiliary piping. The documents showing the annual capacity verification for each of the relief valves are attached.

The remaining pressure relief valves are not in service at this time. They are still inspected and tested, but are considered "stock" valves that could replace an in-service valve if required.

The following is a listing of the relief valves currently in service:

PSV-6280	Station Fuel Gas, capacity checked annually by NNG
PSV-8153	Station Fuel Gas, capacity checked annually by NNG
PSV-6150	Station Fuel Gas, capacity checked annually by NNG
PSV-8156	Station Fuel Gas, capacity checked annually by NNG
PSV-6321	Unit 1 Interstage, capacity checked annually by NNG
PSV-6320	Unit 1 Discharge, capacity checked annually by NNG
PSV-6146	Unit 3 Interstage, capacity checked annually by NNG
PSV-8158 (sn# 85/08958)	Unit 3 Discharge, capacity checked annually by NNG
PSV-6147	Unit 4 Interstage, capacity checked annually by NNG
PSV-6148	Unit 4 Discharge, capacity checked annually by NNG

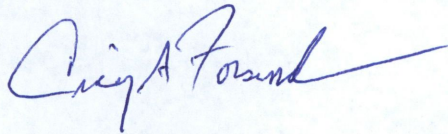
PSV-8166 Inlet Separator relief valve is redundant, the scrubber MAOP is protected by the pipeline over pressure protection at Grasslands Plant.

ORM regrets that the compliance documents provided to the inspector at the audit were not correct and that it caused confusion. We believe that the attached annual capacity verifications for the ten meters in service at Ford Buford should adequately demonstrate compliance with 49 CFR 192.743. Therefore, we request that you consider this additional information as mitigation or elimination of the proposed \$24,000 civil penalty, and that the NOPV be reconsidered.

December 7, 2016  
Mr. Aaron Morman

Thank you. Should you have any questions or need additional information, please contact Rich Chaska at (406) 433-8716.

Respectfully,



Craig A. Forsander  
Vice President  
ONEOK Rockies Midstream Operations  
ONEOK Partners  
896 25<sup>th</sup> St SE  
Sidney, MT 59270

### **Attachment Summary**

#### Station Fuel Gas:

Pages 1 through 7 contain the information for the fuel gas relief valves. For clarification, the fuel gas system pertains to the compressor engines only and associated auxiliary piping. The relief valves are not meant to protect the station MAOPs or other mainline station piping, but are used to protect auxiliary systems noted above. The form shows on page 6 of 7, that the relief valves are compliant, meaning that they will properly protect the engines from over-pressurization. Because the pressures are less than the station MAOP and not meant to protect piping but equipment, there is not a true capacity number generated.

#### Compressor Unit Reliefs

The remaining pages are the compressor unit relief valves. These relief valves, unlike the station fuel gas relief, are designed to protect both the station and gas piping MAOPs. The information, found on page 2 of each of the summaries, is the detail that determines if the relief valve has the proper relief capacity and what is reviewed annually. The specific information is found on the "Totals" line that describes failure capacity, actual capacity and the capacity ratio. In all instances, the actual capacity is greater than the failure capacity and the capacity ratio is greater than 1.0. This means

**ASSEMBLY 100 – STATION FUEL GAS**

**PSV-6280**

**PSV-8153**

**PSV-6150**

**PSV-8156**

**INLET SOURCE: 450 PSIG LOWER THAN INTERSTAGE MAOP: 500 PSIG**

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NORTHERN NATURAL GAS  
Summary Report

PAGE 1

REGION: North TEAM: Fort Buford - Bear Paw FACILITY: ND-003 - FORT BUFORD COMPRESSOR

LEGAL ENTITY: NORTHERN NATURAL GAS COMPANY LEGAL ENTITY ID: 183

PROPERTY CODE: POI: 0

ASSEMBLY: 100 - Station Fuel Gas ASSEMBLY TYPE: Dual Cut w/ Meter

SPECIAL COMMENT:

GAS TYPE: Natural Gas GAS TEMP: 60 F SPECIFIC GRAVITY: .5886 ATMOSPHERIC PRESSURE: 14.700 psi

Total Number of Required Grids: 13 Completed Required Grids: 8 Date Data Entry Complete: Not Complete

DOT REGULATED: INCLUDE DELIVERY Yes OUT OF SERVICE: No COMBINE RISERS & VENTS: No PIPING: No

----- PRESSURES IN PSIG			
Minimum Inlet:	300.000	Firm Entitlement:	.00 MCFD
Inlet Source:	450.000	Min Hours/Day:	33.0
Interstage MAOP:	500.000	Max Hours/Day:	16.0
Reg Out MAOP:	500.000	Reg Max OverPres:	192.000
Jct Out MAOP:	500.000	Jct Pt Max OverPres:	192.000
Delivery:	110.000	Max Relief Set To:	Other
Customer MAOP:	0.000	Customer (or Del) Max Overpres:	121.000
Typical Inlet Pressure:	300.000		
		Firm Entitlement Date:	06/29/2016
		Revised By:	smayer
		Reference No:	
		Assembly Inspection Date:	06/30/2002
		Date Cust MAOP Entered:	
		Cust OPP Equip avail.?	Unknown

----- FIRST CUT REGULATOR DETAIL -----

#	F	SET PT. PSIG	TYPE	SIZE	Coeff/ Mfr Date	COEFF DESCRIPTION	REGULATOR INFO
1	N	140.000	118	5		310 70% PLUG, 2" BODY	

----- FIRST CUT RELIEF VALVE DETAIL -----

#	F	SET PT. PSIG	TYPE	SIZE	PILOT/SPRING	COEFF DESCRIPTION	RELIEF VALVE INFO
---	---	--------------	------	------	--------------	-------------------	-------------------

----- SECOND CUT REGULATOR DETAIL -----

#	F	SET PT. PSIG	TYPE	SIZE	Coeff/ Mfr Date	COEFF DESCRIPTION	REGULATOR INFO
1		110.000	106	14	Cg/CI On or after 1991	630 2" 90-150# 1/2" ORIFICE	SN 18481085

-----SECOND CUT RELIEF VALVE DETAIL-----

SET #	PT. PSIG	TYPE SIZE PILOT/SPRING	COEFF DESCRIPTION	RELIEF VALVE INFO
1	150.000	1920 2	MERCER 8100 1-1/2" & 2" INLET, 3/4" ORIFICE	81-28821109T
2	150.000	401 1	AG 30/230 1x2" D orifice ASME/Restricted lift pop-action pilot	410646
3	150.000	401 1	AG 30/230 1x2" D orifice ASME/Restricted lift pop-action pilot	712194

11/22/2016

NORTHERN NATURAL GAS

PAGE 2

Summary Report

REGION: North TEAM: Fort Buford - Bear Paw FACILITY: ND-003 - FORT BUFORD COMPRESSOR  
 LEGAL ENTITY: NORTHERN NATURAL GAS COMPANY LEGAL ENTITY ID: 183  
 PROPERTY CODE: POI: 0  
 ASSEMBLY: 100 - Station Fuel Gas ASSEMBLY TYPE: Dual Cut w/ Meter

----- Common Fields for All Meters -----

POSITION CODE: U OPERATING PRESSURES: Min: 300 psig  
 METER DESIGN TEMP: 60 F Max: 140 psig

----- METER DETAIL -----

#	TYPE CODE	MANUFACTURER	MODEL	BASE VOL MCFH	Orifice Tap	RUN ID	ORIFICE ID	DIFF PRES ("wc)	Ultrasonic Cd	Coriolis Meter Data	SERIAL/ID NUMBER	MAX WORK PSIG
1	O	Unknown Manufacturer	Unknown Model	Type: F Loc: D	2.066	0.875		100.000				500

Type Code: T-Turbine, O-Orifice, D-Diaphragm, R-Rotary, U-Ultrasonic, F-Dattus-Fluidic Oscillation, S-FlowSic500, C-Coriolis, V-V-Cone

Pos Code: U-Upstream, I-Interstage, Tap Type: P-Pipe Tap, Tap Loc: U-Upstream, \* Out-of-service  
 D-Downstream F-Flange Tap D-Downstream

----- METER VOLUMES LIST -----

11/2015 TO 11/2016 VOLS, MCF/DAY				11/2013 TO 11/2016 VOLS, MCF/DAY			
MIN	MIN DATE	MAX	MAX DATE	MIN	MIN DATE	MAX	MAX DATE

----- METER CAPACITY CHECK -----

MIN HOURLY FLOW 3.03% OF HIST MIN DAY MAX HOURLY FLOW 6.25% OF HIST MAX DAY  
 CAPACITIES IN MCFH: ORIFICE MAX CAPACITY AT 95% DIFF PRESSURE, MIN CAPACITY AT 5% DIFF PRESSURE  
 MIN OPER PSIG: 300.000 MAX OPER PSIG: 140.000

#	TYPE	BETA	- AT MIN PRESSURE -		- AT MAX PRESSURE -		- AT MIN PRESSURE -	
			MIN CAP	MAX CAP	MIN CAP	MAX CAP	BETA=0.2	BETA=0.6
1	O	0.42	8.59	37.41	5.89	25.69	1.88	79.84
	<b>TOTAL</b>		8.59	37.41	5.89	25.69	1.88	79.84
	<b>HISTORY</b>		0.00	0.00	0.00	0.00	0.00	0.00
	<b>HISTORY RATIO</b>		0.00	0.00	0.00	0.00	0.00	0.00
	<b>FIRM ENTITLEMENT</b>			0.00		0.00		0.00
	<b>FIRM RATIO</b>			0.00		0.00		0.00

11/22/2016

NORTHERN NATURAL GAS  
Summary Report

PAGE 3

REGION: North    TEAM: Fort Buford - Bear Paw    FACILITY: ND-003 - FORT BUFORD COMPRESSOR  
 LEGAL ENTITY: NORTHERN NATURAL GAS COMPANY    LEGAL ENTITY ID: 183  
 PROPERTY CODE:    POI: 0  
 ASSEMBLY: 100 - Station Fuel Gas    ASSEMBLY TYPE: Dual Cut w/ Meter

-----RELIEF CAPACITY CHECK-----

<b>Upstream of Regulators:</b>		<b>Heater:</b>		<b>MAOP:</b>		<b>Overpressure:</b>	
Based on Regulator Failure:		Transfer Rate: BTU/Hr Interstage:		500.000		550.000	
Inlet Source:	.000 psig	Efficiency	%	Reg Out MAOP:	500.000	192.000	
Inlet Temp:	60 F	Set Point Temp:	F	Jnct Pt Out MAOP:	500.000	192.000	
<b>Based on Upstream Regulator Failure:</b>		<b>BL &amp; Sta Inlet</b>		<b>Heater &amp; Reg In</b>		<b>Between Regs</b>	
Pressure In:	.000			450.000		.000	
Pressure Out	.000			.000		.000	
OverPres:						550.000	
Temperature	0			60		0	
Z:	0			0		0	
Equivalent D:	.000			1.939		1.939	
Equivalent L:	.000			24.135		36.498	
<b>Regulator</b>		<b>Relief Valve</b>					
Pressure In:	.000	.000	psig				
Pressure Out:	.000		.000 psig				
Float:	.000		psig				
<b>Run #</b>	<b>Failure Capacity (MCFH)</b>	<b>Actual Relief Capacity (MCFH)</b>	<b>Start Opening</b>	<b>Full-open Build-up Pressure (psig)</b>	<b>Build-up Method</b>	<b>Relief Valve Outlet Backpressure Ratio</b>	
Largest Run	0.00						
Min History	0.00						Capacity Ratio
Totals:	0.00	0.00					0.00
<b>Based on Downstream Regulator Failure:</b>		<b>Jnct Pt to Dn Reg</b>		<b>Meter &amp; Station Out</b>			
Pressure In:	.000			.000			
Pressure Out	.000			.000			
OverPres:				192.000	121.000		
Temperature	0			0			
Z:	0			0			
Equivalent D:	1.939			.000			
Equivalent L:	27.517			.000			
<b>Regulator</b>		<b>Relief Valve</b>					
Pressure In:	.000	1.000	psig				
Pressure Out:	.000		2.000 psig				
Float:		1.000	psig				
<b>Run #</b>	<b>Failure Capacity (MCFH)</b>	<b>Actual Relief Capacity (MCFH)</b>	<b>Start Opening</b>	<b>Full-open Build-up Pressure (psig)</b>	<b>Build-up Method</b>	<b>Relief Valve Outlet Backpressure Ratio</b>	
1	.00	.00	7.500	7.500	3	0.0	
2	.00	.00	000	.000	3		
3	.00	.00	000	.000	3		

Largest Run	0.00		
Min History	0.00		
Totals:	0.00	0.00	Capacity Ratio 0.00

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NORTHERN NATURAL GAS  
Summary Report

PAGE 4

**REGION:** North    **TEAM:** Fort Buford - Bear Paw    **FACILITY:** ND-003 - FORT BUFORD COMPRESSOR  
**LEGAL ENTITY:** NORTHERN NATURAL GAS COMPANY    **LEGAL ENTITY ID:** 183  
**PROPERTY CODE:**    **POI:** 0  
**ASSEMBLY:** 100 - Station Fuel Gas    **ASSEMBLY TYPE:** Dual Cut w/ Meter

----- DELIVERY CAPACITY DETAIL -----

Based on Min Operating Conditions							
<b>Heater Input:</b>							
Min Inlet:	300.000	psig	Heater Design Rate:				BTU/hr
Delivery Pressure:	110.000	psig	Heater Efficiency:				%
Atmospheric Pressure:	14.700	psig	Set Point Temp:				F
Max Hours/Day:	16		Sense Location:				
Specific Gravity:	0.5886						
<b>Piping Sections</b>	<b>Sta Inlet</b>	<b>Heater</b>	<b>Reg In</b>	<b>Between Regs</b>	<b>Reg Out</b>	<b>Meter &amp; Sta Out</b>	
Pressure In:	300.000	300.000	300.000	299.733	110.000	110.000	psig
Pressure Out:	300.000	300.000	300.000	299.733	110.000	110.000	psig
Temperature:	60.00	60.00	60.00	59.98	48.56	48.56	F
Z:	0.9531	0.9531	0.9531	0.9531	0.9798	0.9798	
Equivalent D:	0.000	0.000	0.000	0.000	0.000	0.000	inches
Equivalent L:	0.000	0.000	0.000	0.000	0.000	0.000	feet
<b>Delivery Capacity</b>	<b>Regulator (MCFH)</b>	<b>Pressure (psig)</b>	<b>Temp (F)</b>	<b>Max Historic</b>	<b>Firm Entitlement</b>		
Upstream Cut 1	45.50	<b>Into Reg</b>	300.000	60.00			
2		<b>Out of Reg</b>	299.733	59.98	Volume: 0.00	0.00	MCFH
3							
4							
<b>Total - maximum:</b>	<b>45.50</b>	MCFH			<b>Ratio:</b>	<b>0.00</b>	<input checked="" type="checkbox"/> Compliant
<b>Meter Capacity:</b>	<b>37.41</b>	MCFH			<b>Ratios:</b>	<b>0.00</b>	<input checked="" type="checkbox"/> Compliant
<b>Heater Limit Capacity:</b>	N/A					<b>0.00</b>	<input checked="" type="checkbox"/> Compliant
<b>Station Capacity (min of above 3 capacities):</b>	<b>37.41</b>	MCFH			<b>Ratios:</b>	<b>0.00</b>	<input checked="" type="checkbox"/> Compliant
<b>Total Regulator Capacity:</b>	<b>45.50</b>	MCFH			<b>Ratio:</b>	<b>0.00</b>	<input checked="" type="checkbox"/> Compliant
<b>Pressures</b>							
Delivery Pressure - 100 psig					psig	210	<input checked="" type="checkbox"/> Rpt 14
Calc Lowest Acceptable Min Inlet						0	
Exception Lowest Acceptable Min Inlet						1.0	

----- CALCULATION NOTES -----

#	Note Number	Note Message
1	525	Note: Lowest Acceptable Min Inlet Pressure cannot be calculated since there is no Firm Volume
2	504	Note: Piping for upstream meter automatically combined with Station Inlet piping.
3	437	Note: Interstage relief valve not required since Interstage Overpressure >= Inlet Source.
4	586	Note: Method 1 uses Piping Run 1 for DCC.
5	428	Note: No max history/delivery or firm entitlement volumes. No heater sizing or pipe-sizing performed.
6	582	Note: Method 1 uses Regulator Run 1 for DCC.
7	560	Note: Downstream temperature for Heater Limit Capacity assumed to be 40F
8	554	Note: Firm not entered, so Velocity at Firm not calculated
9	553	Note: Max History not entered, so Velocity at Max History not calculated
10	464	Note: Primary Regulator Set Point not equal to delivery pressure. Please verify.
11	38	Note: Required capacity is zero due to working and/or non-working monitor regulators.
12	405	Warning - Outlet pressure is less than the minimum value found in Fisher table.

**ASSEMBLY 1 – COMPRESSOR UNIT 1 INTERSTAGE RELIEF**

**PSV-6321**

11/22/2016

**NORTHERN NATURAL GAS**  
Summary Report

PAGE 1

**REGION:** North    **TEAM:** Fort Buford - Bear Paw    **FACILITY:** ND-003 - FORT BUFORD COMPRESSOR

**LEGAL ENTITY:** NORTHERN NATURAL GAS COMPANY    **LEGAL ENTITY ID:** 183

**PROPERTY CODE:**    **POI:** 0

**ASSEMBLY:** 1 - Compressor Unit #1 Interstage Relief    **ASSEMBLY TYPE:** Relief Only

**SPECIAL COMMENT:** Relief valve is setting on compressor piping. No other piping exist.

**GAS TYPE:** Natural Gas    **GAS TEMP:** 50 F    **SPECIFIC GRAVITY:** .5886    **ATMOSPHERIC PRESSURE:** 14.000 psi

**Total Number of Required Grids:** 2    **Completed Required Grids:** 2    **Date Data Entry Complete:** 6/4/2013

**DOT REGULATED:** Yes    **INCLUDE DELIVERY PIPING:** No    **OUT OF SERVICE:** No    **COMBINE RISERS & VENTS:** Yes

----- PRESSURES IN PSIG -----		----- VOLUMES IN MCFH -----			
<b>INLET SOURCE:</b>	N/A	<b>REQUIRED CAPACITY:</b>	820.75	<b>REVISION DATE:</b>	06/29/2016
<b>MAOP:</b>	1250.000			<b>REVISED BY:</b>	smayer
<b>MAXIMUM RELIEF:</b>	1375.000	<b>RELIEF ON ASME VESSEL:</b>	No	<b>REFERENCE NO:</b>	RELSIZE
<b>MAX RELIEF SET TO:</b>	110% of MAOP				
<b>REQUIRED CAPACITY METHOD:</b>	Generic Horsepower				

----- FIRST CUT RELIEF VALVE DETAIL -----

#	SET PT. PSIG	TYPE SIZE PILOT/SPRING	COEFF DESCRIPTION	RELIEF VALVE INFO
1	1203.000	1920 15	MERCER 9100 H ORIFICE	SN 451705

Based on Failure:		MAOP:	Max Overpressure:
Inlet Source:	N/A	Reg Out MAOP:	1250.000    1375.000
Inlet Temp:	50	ASME Flag	
		<b>Branch Line</b>	<b>Riser</b> <b>Vent</b>
Pressure In:	.000	1269.724	95.912
Pressure Out	0.000	1263.150	0.000
OverPres:	0.000	1375.000	0.000
Temperature	50.00	50.00	-31.16

Z:	0.0000	0.8191	0.9693
Equivalent D:	0.000	1.939	4.026
Equivalent L:	0.000	9.935	322.164

	Regulator	Relief Valve	
Pressure In:	.000	1263.150	psig
Pressure Out:	.000	95.912	psig
Float:	.000		psig

Run #	Failure Capacity (MCFH)	Actual Relief Capacity (MCFH)	Start Opening	Full-open Build-up Pressure (psig)	Build-up Method	Relief Valve Outlet Backpressure Ratio
1	820.75	1563.93	60.150	60.150	3	0.9
Largest Run	<b>820.75</b>					
Min History	<b>0.00</b>					
Totals:	<b>820.75</b>	<b>1563.93</b>				<b>Capacity Ratio 1.91</b>

11/22/2016

**NORTHERN NATURAL GAS  
Summary Report**

PAGE 2

**REGION:** North    **TEAM:** Fort Buford - Bear Paw    **FACILITY:** ND-003 - FORT BUFORD COMPRESSOR  
**LEGAL ENTITY:** NORTHERN NATURAL GAS COMPANY    **LEGAL ENTITY ID:** 183  
**PROPERTY CODE:**    **POI:** 0  
**ASSEMBLY:** 1 - Compressor Unit #1 Interstage Relief    **ASSEMBLY TYPE:** Relief Only

**Generic Horsepower Capacity Calculations**

The calculated capacity of a reciprocating or centrifugal compressor can be estimated using approximate efficiencies, the rated horsepower, operating conditions, and calculated compression ratio.

**Operating conditions and gas properties:**

Max Suction Pressure (Ps): 450 psig + 14.00 = 464.00 psia  
 Max Allowed Overpressure 1375.00 psig + 14.00 = 1389.00 psia  
 (Pd):  
 Atmospheric Pressure (Pa): 14.00 psia  
 Suction Compressibility (Zs): 0.9266  
 Suction Temperature (Ts): 50°F + 460 = 510°R  
 Ratio of Specific Heats (k): 1.30  
 Maximum Rated Horsepower 1060  
 (BHP):


**Estimated Efficiencies:**

Mechanical Efficiencies 95%  
 (Eff):  
 Compressor Cylinder 0.9 for relief valve sizing  
 Efficiency (EC):

**Calculated Compression Ratio:**

 relSizeRptImg  
 = 2.994

**Therefore, the estimated required relief capacity(Qgas) is:**

 relSizeRptImg  
 = 820.75 MCSF/H

where  = 0.231

**ASSEMBLY 1.50 – COMPRESSOR UNIT 1 RELIEF VALVE DISCHARGE**

**PSV-6320**

11/22/2016

**NORTHERN NATURAL GAS**  
**Summary Report**

PAGE 1

**REGION:** North    **TEAM:** Fort Buford - Bear Paw    **FACILITY:** ND-003 - FORT BUFORD COMPRESSOR

**LEGAL ENTITY:** NORTHERN NATURAL GAS COMPANY    **LEGAL ENTITY ID:** 183

**PROPERTY CODE:**    **POI:** 0

**ASSEMBLY:** 1.50 - Compressor Unit #1 Relief Valve Discharge    **ASSEMBLY TYPE:** Relief Only

**SPECIAL COMMENT:** Relief valve is setting on compressor piping. No other piping exist

**GAS TYPE:** Natural Gas    **GAS TEMP:** 50 F    **SPECIFIC GRAVITY:** .5886    **ATMOSPHERIC PRESSURE:** 14.000 psi

**Total Number of Required Grids:** 2    **Completed Required Grids:** 2    **Date Data Entry Complete:** 6/4/2013

**DOT REGULATED:** Yes    **INCLUDE DELIVERY PIPING:** No    **OUT OF SERVICE:** No    **COMBINE RISERS & VENTS:** Yes

----- PRESSURES IN PSIG -----		----- VOLUMES IN MCFH -----			
<b>INLET SOURCE:</b>	N/A	<b>REQUIRED CAPACITY:</b>	620.21	<b>REVISION DATE:</b>	06/29/2016
<b>MAOP:</b>	1440.000	<b>RELIEF ON ASME VESSEL:</b>	No	<b>REVISED BY:</b>	smayer
<b>MAXIMUM RELIEF:</b>	1584.000	<b>MAX RELIEF SET TO:</b>	110% of MAOP	<b>REFERENCE NO:</b>	RELSIZE
<b>REQUIRED CAPACITY METHOD:</b>	Reciprocating Compressors with Curves				

----- FIRST CUT RELIEF VALVE DETAIL -----

#	SET PT. PSIG	TYPE SIZE PILOT/SPRING	COEFF DESCRIPTION	RELIEF VALVE INFO
1	1505.000	1920 15	MERCER 9100 H ORIFICE	1039897

Based on Failure:		MAOP:	Max Overpressure:
Inlet Source:	N/A	Reg Out MAOP: 1440.000	1584.000
Inlet Temp:	50	ASME Flag	
	<b>Branch Line</b>	<b>Riser</b>	<b>Vent</b>
Pressure In:	.000	1583.170	70.671
Pressure Out	0.000	1580.250	0.000
OverPres:	0.000	1584.000	0.000
Temperature	50.00	50.00	-54.84

Z:	0.0000	0.7943	0.9719
Equivalent D:	0.000	1.939	4.026
Equivalent L:	0.000	9.935	349.444

	Regulator	Relief Valve	
Pressure In:	.000	1580.250	psig
Pressure Out:	.000	70.671	psig
Float:	.000		psig

Run #	Failure Capacity (MCFH)	Actual Relief Capacity (MCFH)	Start Opening	Full-open Build-up Pressure (psig)	Build-up Method	Relief Valve Outlet Backpressure Ratio
1	620.21	1982.16	75.250	75.250	3	0.9
Largest Run	<b>620.21</b>					
Min History	<b>0.00</b>					
Totals:	<b>620.21</b>	<b>1982.16</b>				<b>Capacity Ratio 3.20</b>

11/22/2016

NORTHERN NATURAL GAS

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## Summary Report

**REGION:** North    **TEAM:** Fort Buford - Bear Paw    **FACILITY:** ND-003 - FORT BUFORD COMPRESSOR

**LEGAL ENTITY:** NORTHERN NATURAL GAS COMPANY    **LEGAL ENTITY ID:** 183

**PROPERTY CODE:**    **POI:** 0

**ASSEMBLY:** 1.50 - Compressor Unit #1 Relief Valve Discharge    **ASSEMBLY TYPE:** Relief Only

### Reciprocating Compressor with Curves Relief Capacity Calculations

The required capacity for a relief valve is determined by using 110% of rated horsepower from compressor curves, the highest potential suction pressure, and a discharge pressure equal to the maximum allowed overpressure.

#### The parameters for Sample Compressor with Curves include:

Maximum Rated Horsepower 1060 hp  
 (BHP):  
 Max Suction Pressure (Ps): 450 psig + 14.00 = 464.00 psia  
 Max Allowed Overpressure 1584.00 psig + 14.00 = 1598.00 psia  
 (Pd):  
 Atmospheric Pressure (Pa): 14.00 psia

Using an appropriate compressor curve and these parameters, the required flow can be estimated by determining the MMSCFD and BHP at any operating point at the same compression ratio as required for the relief conditions. The rated break horsepower is adjusted by 110% per ES4401 and the conditions on the curve.

To find an operating point that matches the compression ratio, draw a constant ratio line on the curve and locate a point where both horsepower and flow can be easily read from the curve. Below outlines the steps to plot the compression ratio line.

From the above relieving conditions, the compression ratio is:

$$\text{Calculated Compression Ratio (R)} = \frac{P_d}{P_s} = 3.444$$

The compressor curve discharge pressure scale is from 900 (min) to 1400 (max) in psig and the suction pressure scale is from 275 (min) to 525 (max) in psig.

A constant compression ratio line is drawn between these two points on the curve:

Ps = 275 and Pd = 981 to

Ps = 397 and Pd = 1400 to

An operating point on the compression ratio line includes:  
 Horsepower on curve: 940 hp  
 Flow on curve: 12 MMCSF/D

Therefore, the required relief capacity ( $Q_{gas}$ ) at these relieving conditions is

24

$$Q_{gas} = \text{BHP} \times 1.1 \times \frac{\text{Flow on curve}}{\text{BHP on curve}} \times \frac{1000}{12} = 620.21 \text{ MSCF/H}$$

**ASSEMBLY 3 – COMPRESSOR UNIT 3 INTERSTAGE RELIEF**

**PSV-6146**

11/22/2016

**NORTHERN NATURAL GAS  
Summary Report**

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**REGION:** North    **TEAM:** Fort Buford - Bear Paw    **FACILITY:** ND-003 - FORT BUFORD COMPRESSOR

**LEGAL ENTITY:** NORTHERN NATURAL GAS COMPANY    **LEGAL ENTITY ID:** 183

**PROPERTY CODE:**    **POI:** 0

**ASSEMBLY:** 3 - Compressor Unit #3 Interstage Relief    **ASSEMBLY TYPE:** Relief Only

**SPECIAL COMMENT:** Relief valve is setting on compressor piping. No other piping exist

**GAS TYPE:** Natural Gas    **GAS TEMP:** 50 F    **SPECIFIC GRAVITY:** .5886    **ATMOSPHERIC PRESSURE:** 14.000 psi

**Total Number of Required Grids:** 2    **Completed Required Grids:** 2    **Date Data Entry Complete:** 6/4/2013

**DOT REGULATED:** Yes    **INCLUDE DELIVERY PIPING:** No    **OUT OF SERVICE:** No    **COMBINE RISERS & VENTS:** Yes

----- PRESSURES IN PSIG -----		----- VOLUMES IN MCFH -----			
<b>INLET SOURCE:</b>	N/A	<b>REQUIRED CAPACITY:</b>	803.72	<b>REVISION DATE:</b>	06/29/2016
<b>MAOP:</b>	1250.000	<b>RELIEF ON ASME VESSEL:</b>	No	<b>REVISED BY:</b>	smayer
<b>MAXIMUM RELIEF:</b>	1375.000	<b>RELIEF ON ASME VESSEL:</b>	No	<b>REFERENCE NO:</b>	
<b>MAX RELIEF SET TO:</b>	110% of MAOP				
<b>REQUIRED CAPACITY METHOD:</b>	Generic Horsepower				

----- FIRST CUT RELIEF VALVE DETAIL -----

#	SET PT. PSIG	TYPE	SIZE	PILOT/SPRING	COEFF	DESCRIPTION	RELIEF VALVE INFO
1	1199.000	401	3			AG 30/230 1.5x2"&1.5x3" body G orifice ASME Orifice area/Restricted lift Pop- Action pilot	85/02975

Based on Failure:			MAOP:	Max Overpressure:
Inlet Source:	N/A	Reg Out MAOP:	1250.000	1375.000
Inlet Temp:	50	ASME Flag		
		<b>Branch Line</b>	<b>Riser</b>	<b>Vent</b>
Pressure In:	.000	1199.020		141.796

Pressure Out	0.000	1199.000	0.000
OverPres:	0.000	1375.000	0.000
Temperature	50.00	50.00	-22.18
Z:	0.0000	0.8262	0.9591
Equivalent D:	0.000	3.068	3.068
Equivalent L:	0.000	0.320	162.891

	<b>Regulator</b>	<b>Relief Valve</b>	
Pressure In:	.000	1199.000	psig
Pressure Out:	.000	141.796	psig
Float:	.000		psig

<b>Run #</b>	<b>Failure Capacity (MCFH)</b>	<b>Actual Relief Capacity (MCFH)</b>	<b>Start Opening</b>	<b>Full-open Build-up Pressure (psig)</b>	<b>Build-up Method</b>	<b>Relief Valve Outlet Backpressure Ratio</b>
1	803.72	1037.56	.000	.000	3	0.9
Largest Run	<b>803.72</b>					
Min History	<b>0.00</b>					
Totals:	<b>803.72</b>	<b>1037.56</b>				<b>Capacity Ratio</b> <b>1.29</b>

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**NORTHERN NATURAL GAS  
Summary Report**

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**REGION:** North    **TEAM:** Fort Buford - Bear Paw    **FACILITY:** ND-003 - FORT BUFORD COMPRESSOR  
**LEGAL ENTITY:** NORTHERN NATURAL GAS COMPANY    **LEGAL ENTITY ID:** 183  
**PROPERTY CODE:**    **POI:** 0  
**ASSEMBLY:** 3 - Compressor Unit #3 Interstage Relief    **ASSEMBLY TYPE:** Relief Only

**Generic Horsepower Capacity Calculations**

The calculated capacity of a reciprocating or centrifugal compressor can be estimated using approximate efficiencies, the rated horsepower, operating conditions, and calculated compression ratio.

**Operating conditions and gas properties:**

Max Suction Pressure (Ps):  $450 \text{ psig} + 14.00 = 464.00 \text{ psia}$   
 Max Allowed Overpressure  $1375.00 \text{ psig} + 14.00 = 1389.00 \text{ psia}$   
 (Pd):  
 Atmospheric Pressure (Pa):  $14.00 \text{ psia}$   
 Suction Compressibility (Zs):  $0.9266$   
 Suction Temperature (Ts):  $50^\circ\text{F} + 460 = 510^\circ\text{R}$   
 Ratio of Specific Heats (k):  $1.30$   
 Maximum Rated Horsepower  $1038$   
 (BHP):


**Estimated Efficiencies:**

Mechanical Efficiencies  $95\%$   
 (Eff):  
 Compressor Cylinder  $0.9$  for relief valve sizing  
 Efficiency (EC):

**Calculated Compression Ratio:**

  $\text{relSizeRptImg} = 2.994$

Therefore, the estimated required relief capacity ( $Q_{\text{gas}}$ ) is:

  $\text{relSizeRptImg} = 803.72 \text{ MCSF/H}$

where   $= 0.231$

**ASSEMBLY 3.50 – COMPRESSOR UNIT 3 RELIEF VALVE DISCHARGE**

**PSV-8158 (SN# 85/08958)**

11/22/2016

**NORTHERN NATURAL GAS  
Summary Report**

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**REGION:** North    **TEAM:** Fort Buford - Bear Paw    **FACILITY:** ND-003 - FORT BUFORD COMPRESSOR

**LEGAL ENTITY:** NORTHERN NATURAL GAS COMPANY    **LEGAL ENTITY ID:** 183

**PROPERTY CODE:**    **POI:** 0

**ASSEMBLY:** 3.50 - Compressor Unit #3 Relief Valve Discharge    **ASSEMBLY TYPE:** Relief Only

**SPECIAL COMMENT:** Relief valve is setting on compressor piping. No other piping exist

**GAS TYPE:** Natural Gas    **GAS TEMP:** 50 F    **SPECIFIC GRAVITY:** .5886    **ATMOSPHERIC PRESSURE:** 14.000 psi

**Total Number of Required Grids:** 2    **Completed Required Grids:** 2    **Date Data Entry Complete:** 6/4/2013

**DOT REGULATED:** Yes    **INCLUDE DELIVERY PIPING:** No    **OUT OF SERVICE:** No    **COMBINE RISERS & VENTS:** Yes

----- PRESSURES IN PSIG -----		----- VOLUMES IN MCFH -----			
<b>INLET SOURCE:</b>	N/A	<b>REQUIRED CAPACITY:</b>	553.20	<b>REVISION DATE:</b>	06/29/2016
<b>MAOP:</b>	1440.000	<b>RELIEF ON ASME VESSEL:</b>	No	<b>REVISED BY:</b>	smayer
<b>MAXIMUM RELIEF:</b>	1584.000	<b>MAX RELIEF SET TO:</b>	110% of MAOP	<b>REFERENCE NO.:</b>	
<b>REQUIRED CAPACITY METHOD:</b>	Reciprocating Compressors with Curves				

----- **FIRST CUT RELIEF VALVE DETAIL** -----

#	SET PT. PSIG	TYPE SIZE PILOT/SPRING	COEFF DESCRIPTION	RELIEF VALVE INFO
1	1499.000	401 3	AG 30/230 1.5x2"&1.5x3" body G orifice ASME Orifice area/Restricted lift Pop-Action pilot	85/08958

<b>Based on Failure:</b>		<b>MAOP:</b>	<b>Max Overpressure:</b>
Inlet Source:	N/A	Reg Out MAOP:	1440.000    1584.000
Inlet Temp:	50	ASME Flag	
<b>Pressure In:</b>	<b>Branch Line</b>	<b>Riser</b>	<b>Vent</b>
	.000	1499.119	81.924

Pressure Out	0.000	1499.000	0.000
OverPres:	0.000	1584.000	0.000
Temperature	50.00	50.00	-48.13
Z:	0.0000	0.7998	0.9697
Equivalent D:	0.000	1.939	3.068
Equivalent L:	0.000	0.480	135.203

	<b>Regulator</b>	<b>Relief Valve</b>	
Pressure In:	.000	1499.000	psig
Pressure Out:	.000	81.924	psig
Float:	.000		psig

<b>Run #</b>	<b>Failure Capacity (MCFH)</b>	<b>Actual Relief Capacity (MCFH)</b>	<b>Start Opening</b>	<b>Full-open Build-up Pressure (psig)</b>	<b>Build-up Method</b>	<b>Relief Valve Outlet Backpressure Ratio</b>
1	553.20	1315.41	.000	.000	3	0.9
<b>Largest Run</b>	<b>553.20</b>					
<b>Min History</b>	<b>0.00</b>					
<b>Totals:</b>	<b>553.20</b>	<b>1315.41</b>				<b>Capacity Ratio</b> <b>2.38</b>

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**NORTHERN NATURAL GAS**  
**Summary Report**

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**REGION:** North    **TEAM:** Fort Buford - Bear Paw    **FACILITY:** ND-003 - FORT BUFORD COMPRESSOR  
**LEGAL ENTITY:** NORTHERN NATURAL GAS COMPANY    **LEGAL ENTITY ID:** 183  
**PROPERTY CODE:**    **POI:** 0  
**ASSEMBLY:** 3.50 - Compressor Unit #3 Relief Valve Discharge    **ASSEMBLY TYPE:** Relief Only

**Reciprocating Compressor with Curves Relief Capacity Calculations**

The required capacity for a relief valve is determined by using 110% of rated horsepower from compressor curves, the highest potential suction pressure, and a discharge pressure equal to the maximum allowed overpressure.

**The parameters for Sample Compressor with Curves include:**

Maximum Rated Horsepower 1038 hp  
 (BHP):  
 Max Suction Pressure (Ps): 450 psig + 14.00 = 464.00 psia  
 Max Allowed Overpressure 1584.00 psig + 14.00 = 1598.00 psia  
 (Pd):  
 Atmospheric Pressure (Pa): 14.00 psia

Using an appropriate compressor curve and these parameters, the required flow can be estimated by determining the MMSCFD and BHP at any operating point at the same compression ratio as required for the relief conditions. The rated break horsepower is adjusted by 110% per ES4401 and the conditions on the curve.

To find an operating point that matches the compression ratio, draw a constant ratio line on the curve and locate a point where both horsepower and flow can be easily read from the curve. Below outlines the steps to plot the compression ratio line.

**From the above relieving conditions, the compression ratio is:**

**Calculated Compression Ratio (R) =  $\frac{P_d}{P_s}$  = 3.444**

The compressor curve discharge pressure scale is from 900 (min) to 1400 (max) in psig and the suction pressure scale is from 100 (min) to 450 (max) in psig.

A constant compression ratio line is drawn between these two points on the curve:

Ps = 251 and Pd = 900 to  
 Ps = 397 and Pd = 1400 to

An operating point on the compression ratio line includes:  
 Horsepower on curve: 860 hp  
 Flow on curve: 10 MMCSF/D

Therefore, the required relief capacity (Qgas) at these relieving conditions is

24

$$Q_{gas} = \text{BHP} \times 1.1 \times \frac{\text{Flow on curve}}{\text{BHP on curve}} \times \frac{1000}{10} = 553.20 \text{ MSCF/H}$$

**ASSEMBLY 4 – COMPRESSOR UNIT 3 INTERSTAGE RELIEF**

**PSV-6147**

11/22/2016

**NORTHERN NATURAL GAS**  
Summary Report

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**REGION:** North    **TEAM:** Fort Buford - Bear Paw    **FACILITY:** ND-003 - FORT BUFORD COMPRESSOR

**LEGAL ENTITY:** NORTHERN NATURAL GAS COMPANY    **LEGAL ENTITY ID:** 183

**PROPERTY CODE:**    **POI:** 0

**ASSEMBLY:** 4 - Compressor Unit #4 Interstage Relief    **ASSEMBLY TYPE:** Relief Only

**SPECIAL COMMENT:** Relief valve is setting on compressor piping. No other piping exist

**GAS TYPE:** Natural Gas    **GAS TEMP:** 50 F    **SPECIFIC GRAVITY:** .5886    **ATMOSPHERIC PRESSURE:** 14.000 psi

**Total Number of Required Grids:** 2    **Completed Required Grids:** 2    **Date Data Entry Complete:** 6/4/2013

**DOT REGULATED:** Yes    **INCLUDE DELIVERY PIPING:** No    **OUT OF SERVICE:** No    **COMBINE RISERS & VENTS:** Yes

----- PRESSURES IN PSIG -----		----- VOLUMES IN MCFH -----			
<b>INLET SOURCE:</b>	N/A	<b>REQUIRED CAPACITY:</b>	803.72	<b>REVISION DATE:</b>	06/29/2016
<b>MAOP:</b>	1250.000	<b>RELIEF ON ASME VESSEL:</b>	No	<b>REVISED BY:</b>	smayer
<b>MAXIMUM RELIEF:</b>	1375.000	<b>MAX RELIEF SET TO:</b>	110% of MAOP	<b>REFERENCE NO:</b>	
<b>REQUIRED CAPACITY METHOD:</b>	Generic Horsepower				

----- **FIRST CUT RELIEF VALVE DETAIL** -----

#	SET PT. PSIG	TYPE SIZE PILOT/SPRING	COEFF DESCRIPTION	RELIEF VALVE INFO
1	1203.000	401 3	AG 30/230 1.5x2"&1.5x3" body G orifice ASME Orifice area/Restricted lift Pop-Action pilot	85/03466

Based on Failure:			MAOP:	Max Overpressure:
Inlet Source:	N/A	Reg Out MAOP:	1250.000	1375.000
Inlet Temp:	50	ASME Flag		
Pressure In:	.000	<b>Branch Line</b>	<b>Riser</b>	<b>Vent</b>
		1203.069		141.739

Pressure Out	0.000	1203.000	0.000
OverPres:	0.000	1375.000	0.000
Temperature	50.00	50.00	-22.47
Z:	0.0000	0.8258	0.9590
Equivalent D:	0.000	3.068	3.068
Equivalent L:	0.000	1.126	162.891

	<b>Regulator</b>	<b>Relief Valve</b>	
Pressure In:	.000	1203.000	psig
Pressure Out:	.000	141.739	psig
Float:	.000		psig

<b>Run #</b>	<b>Failure Capacity (MCFH)</b>	<b>Actual Relief Capacity (MCFH)</b>	<b>Start Opening</b>	<b>Full-open Build-up Pressure (psig)</b>	<b>Build-up Method</b>	<b>Relief Valve Outlet Backpressure Ratio</b>
1	803.72	1041.25	.000	.000	3	0.9
<b>Largest Run</b>	<b>803.72</b>					
<b>Min History</b>	<b>0.00</b>					
<b>Totals:</b>	<b>803.72</b>	<b>1041.25</b>				<b>Capacity Ratio 1.30</b>

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**NORTHERN NATURAL GAS  
Summary Report**

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**REGION:** North    **TEAM:** Fort Buford - Bear Paw    **FACILITY:** ND-003 - FORT BUFORD COMPRESSOR  
**LEGAL ENTITY:** NORTHERN NATURAL GAS COMPANY    **LEGAL ENTITY ID:** 183  
**PROPERTY CODE:**    **POI:** 0  
**ASSEMBLY:** 4 - Compressor Unit #4 Interstage Relief    **ASSEMBLY TYPE:** Relief Only

**Generic Horsepower Capacity Calculations**

The calculated capacity of a reciprocating or centrifugal compressor can be estimated using approximate efficiencies, the rated horsepower, operating conditions, and calculated compression ratio.

**Operating conditions and gas properties:**

Max Suction Pressure (Ps): 450 psig + 14.00 = 464.00 psia  
 Max Allowed Overpressure 1375.00 psig + 14.00 = 1389.00 psia  
 (Pd):  
 Atmospheric Pressure (Pa): 14.00 psia  
 Suction Compressibility (Zs): 0.9266  
 Suction Temperature (Ts): 50°F + 460 = 510°R  
 Ratio of Specific Heats (k): 1.30  
 Maximum Rated Horsepower 1038  
 (BHP):

**Estimated Efficiencies:**

Mechanical Efficiencies 95%  
 (Eff):  
 Compressor Cylinder 0.9 for relief valve sizing  
 Efficiency (EC):

**Calculated Compression Ratio:**

$$\text{relSizeRptImg} = 2.994$$

**Therefore, the estimated required relief capacity (Qgas) is:**

$$\text{relSizeRptImg} = 803.72 \text{ MCSF/H}$$

where 
$$\text{relSizeRptImg} = 0.231$$

**ASSEMBLY 4.50 – COMPRESSOR UNIT 3 RELIEF VALVE DISCHARGE**

**PSV-6148**

11/22/2016

**NORTHERN NATURAL GAS  
Summary Report**

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**REGION:** North    **TEAM:** Fort Buford - Bear Paw    **FACILITY:** ND-003 - FORT BUFORD COMPRESSOR

**LEGAL ENTITY:** NORTHERN NATURAL GAS COMPANY    **LEGAL ENTITY ID:** 183

**PROPERTY CODE:**    **POI:** 0

**ASSEMBLY:** 4.50 - Compressor Unit #4 Relief Valve Discharge    **ASSEMBLY TYPE:** Relief Only

**SPECIAL COMMENT:** Relief valve is setting on compressor piping. No other piping exist

**GAS TYPE:** Natural Gas    **GAS TEMP:** 50 F    **SPECIFIC GRAVITY:** .5886    **ATMOSPHERIC PRESSURE:** 14.000 psi

**Total Number of Required Grids:** 2    **Completed Required Grids:** 2    **Date Data Entry Complete:** 5/8/2013

**DOT REGULATED:** INCLUDE DELIVERY Yes    **PIPING:** No    **OUT OF SERVICE:** No    **COMBINE RISERS & VENTS:** Yes

----- PRESSURES IN PSIG -----		----- VOLUMES IN MCFH -----			
<b>INLET SOURCE:</b>	N/A	<b>REQUIRED CAPACITY:</b>	553.20	<b>REVISION DATE:</b>	06/29/2016
<b>MAOP:</b>	1440.000	<b>RELIEF ON ASME VESSEL:</b>	No	<b>REVISED BY:</b>	smayer
<b>MAXIMUM RELIEF:</b>	1584.000	<b>MAX RELIEF SET TO:</b>	110% of MAOP	<b>REFERENCE NO:</b>	
<b>REQUIRED CAPACITY METHOD:</b>	Reciprocating Compressors with Curves				

----- **FIRST CUT RELIEF VALVE DETAIL** -----

#	SET PT. PSIG	TYPE	SIZE	PILOT/SPRING	COEFF DESCRIPTION	RELIEF VALVE INFO
1	1504.000	401	3		AG 30/230 1.5x2"&1.5x3" body G orifice ASME Orifice area/Restricted lift Pop-Action pilot	02-67598

Based on Failure:			MAOP:	Max Overpressure:
Inlet Source:	N/A	Reg Out MAOP:	1440.000	1584.000
Inlet Temp:	50	ASME Flag		
Pressure In:	.000	<b>Branch Line</b>	<b>Riser</b>	<b>Vent</b>
		1504.119		78.718

Pressure Out	0.000	1504.000	0.000
OverPres:	0.000	1584.000	0.000
Temperature	50.00	50.00	-48.77
Z:	0.0000	0.7994	0.9706
Equivalent D:	0.000	1.939	3.068
Equivalent L:	0.000	0.480	126.203

	Regulator	Relief Valve	
Pressure In:	.000	1504.000	psig
Pressure Out:	.000	78.718	psig
Float:	.000		psig

Run #	Failure Capacity (MCFH)	Actual Relief Capacity (MCFH)	Start Opening	Full-open Build-up Pressure (psig)	Build-up Method	Relief Valve Outlet Backpressure Ratio
1	553.20	1320.04	.000	.000	3	0.9
Largest Run	<b>553.20</b>					
Min History	<b>0.00</b>					
Totals:	<b>553.20</b>	<b>1320.04</b>				<b>Capacity Ratio 2.39</b>



An operating point on the compression ratio line includes:  
Horsepower on curve: 860 hp  
Flow on curve: 10 MMCSF/D

Therefore, the required relief capacity ( $Q_{gas}$ ) at these relieving conditions is

24

$$Q_{gas} = \text{BHP} \times 1.1 \times \frac{\text{Flow on curve } 1000}{\text{BHP on curve}} \times \frac{1}{24} = 553.20 \text{ MSCF/H}$$