THE CASE FOR HIGHER INLET PRESSURE AT CNG STATIONS-2012 08 28

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This CNG station gas inlet pressure white paper has been assembled to explain the issues surrounding CNG station utility supply pressure. The paper will identify and quantify the benefits to both the Utility and to the CNG station Owner of using higher inlet pressures at CNG stations.

Please contact Marathon if you wish to pursue the best available option for your facility. Marathon can assist prospective station Owners in evaluating life cycle cost and technical benefits to using elevated inlet pressures.

Background:

Historically, some natural gas utilities have been resistant to providing elevated inlet pressures to CNG stations. In some cases, Utilities have insisted that delivery pressure be limited to a regulated pressure of 5 psig to 10 psig as these are the pressures that they can "guarantee" with their existing system.

In the 1970s and early 1980s, many CNG stations used relatively small compressors which were derived from the high pressure compressed air market. These machines were often mechanically limited to 5 psig to 15 psig inlet pressures and thus there was little or no benefit in having the utility supply higher gas pressures. From the mid-1980s to present time, compressors have tended to become larger as the market has capitalized on the improved economics of the larger stations required for transit, trash collection and large municipal fleets.

These larger compressors are derived from the process or gas compression industries and are capable in some cases of being designed to handle almost any available inlet pressure. In fact, these compressors could be designed to connect to transmission gas lines in excess of 1,000 psig.

How do Gas Transmission and Distribution Systems work?:

Gas is typically transported from the source in gas fields using gas gathering compressors. These compressors take gas well pressure and compress it in to a local gathering pipeline system. These systems typically operate at 300 psig to 1200 psig. (Note that the pressures in this explanation are common but may not be true for each circumstance) Gas is stripped of heavy hydrocarbons and contaminants to levels that are considered “pipeline quality”.

This clean, un-odorized gas is then fed through the gas pipelines that typically operate at pressures up to 1200 psig. Gas is recompressed in the pipeline system periodically to account for pressure losses due to flow through the lines.

When gas arrives at the “City Gate”, a custody transfer from the pipeline to the gas utility occurs. Utilities will typically reduce the pressure from the pipeline pressure to a high utility pressure of 300 psig and odorize the gas. This pressure is used to transport gas to feed various portions of the Utility’s distribution piping.

This pressure is reduced in one to two steps through various portions of the distribution system. Gas lines in many commercial and industrial portions of the distribution piping will operate with a maximum pressure of 60 psig to 100 psig. Some utilities refer to this as medium pressure or intermediate pressure. A 60 psig system will commonly operate in a range of 30 to 50 psig depending on the load on the system—thus, in an extreme “design day” situation with very cold conditions (causing a high heating load), this system may reach its low operating pressure of 30 psig (this is an average value and will vary on each system). It is important to understand that this may not occur every year, it may not occur more than a few days in a cold year and it is typically not a round-the-clock low pressure spike.

Most utility customers cannot tolerate utility delivery pressure fluctuations. The utility addresses this issue by guaranteeing only 10 psig rather than the 30 psig (in this example) that might be in the line. This additional 20 psig gives the utility an operating cushion and accounts for the pressure losses through the pressure reducing regulator at the customer meter set.

Gas utilities who are reluctant to supply higher pressure may explain their reluctance as:

1. A concern for the safety and integrity of the customer’s equipment.
2. The utility is unable to guarantee the supply of gas at the higher pressures.
3. The higher pressures may change over time as additional load is introduced to the system.
4. They have a firm policy to only supply 5 psig or 10 psig—this is all they supply to any customer.

This white paper will address these concerns and explain why it is beneficial to all parties to supply higher pressures to CNG stations and why CNG station loads are different than other conventional utility customers.

Why are CNG Stations Different than Most Customers?:

Most gas customer loads such as heating or fuel gas loads operate at pressures lower than the pressures typically offered by the gas utilities, and therefore, there is no need for, or benefit of, operating at higher gas supply pressures. Other customer loads that might operate at the utility supply pressure such as some boilers require very consistent pressure so it is necessary for the utility to supply consistent pressure.

Small CNG stations that use compressors derived from high pressure air service are typically limited to 5 psig to 15 psig as previously noted. These stations will have only a small benefit from elevated inlet pressure -- there is some benefit to supplying these stations with higher pressure to reduce the size of and pressure loss through the gas dryer.

It is the medium sized and large compressors, typically about 75 hp and upward that can be selected to use higher inlet pressures. In most cases these machines can be designed and configured to operate over a range of floating pressure. Using this higher pressure reduces capital cost and operating cost.

Why is Inlet Pressure so Important at CNG Stations?"

Most CNG stations use dryers located on the inlet of the station. The dryer typically is sized to limit the pressure drop across the dryer to 3 psid to 5 psid. If the station is supplied with 10 psig by the utility, this will only leave 5 psig downstream of the dryer. This is very low pressure and will typically mean that a 5 stage compressor is required, or that a booster compressor is required to raise the pressure at the inlet to the station. Thus, there is a cost penalty for either a booster compressor, or for a larger dryer (so it can operate at lower pressure) and an additional stage of compression.

If the gas utility is prepared to supply 10 psig guaranteed pressure. They are reaching this pressure by regulating a higher pressure source down. In many cases, the higher pressure system feeding the site would be operating at a maximum of 60 psig—with an actual operating range of 30 to 60 psig. (These are common values and may not be true at a specific site). Therefore, if the station is designed to handle a floating pressure, the utility can supply the station with an average pressure of 40 psig. This would mean that the station would have an average 35 psig downstream of the dryer, and on a worst case day, the station would have 25 psig downstream of the dryer at the compressor inlet.

Apart from the quantifiable benefits to higher inlet pressures, there are additional benefits that are hard to quantify. A station supplied with higher inlet pressure has less complication, it will tend to operate more reliably and it will consume a smaller footprint on site.

Example:

The table below describes an example of a large cascade fill station project under two common inlet pressure conditions: unregulated gas in a 30 to 50 psig range and regulated gas at 10 psig. The size of the station corresponds to a large municipal fleet under a cascade fast fill arrangement.

The costs used are typical as of the date of this white paper but may become dated over time. It is for this reason that the reader is encouraged to focus on the relative costs of the two scenarios and not on the absolute costs.

Based on this analysis, there is a life cycle cost benefit of approximately $500,000 to using the higher, unregulated utility pressure. This is obviously a very significant cost benefit and it will be even greater for larger stations, larger annual throughputs (the author used a low daily hour usage to be conservative) or if there is higher inlet pressure available (there are a number of CNG stations served with inlet pressures of 100 to 500 psig.)

Environmental Impact-In this example, the gas utility will be regulating 42 psig (average) gas to 10 psig and the CNG station will be recompressing this gas--the energy required to provide this recompression is wasted. This will result in a **20 percent increase in power consumption**. This will add approximately **1.1 million pounds of unnecessary CO_2 emissions** over the 20 year life of the station. As was the case with the cost, this savings in CO_2 emissions will be even more pronounced for larger stations, larger annual throughputs (the author used a low daily hour usage to be conservative) or if there is even higher inlet pressure available than the 42 psig used in this example.

Floating Pressure Example--2012 08 28		Regulated Service	Unregulated Service
Gas Utility Design Pressure (psig)		60	60
Gas Utility Maximum Expected Pressure (psig)		50	50
Gas Utility Minimum Expected Pressure (psig)		30	30
Gas Utility Typical Expected Pressure (psig)		42	42
Gas Utility Typical Delivery Pressure (psig)		**10**	**42**
Required Station Flow (scfm)		500	500
Number of Compressors		2	2
Number of Boosters (Redundancy is required)	The approach used in this example is to provide a booster ahead of the CNG dryer--this allows the dryer and CNG compressors to be reduced in size. This booster will raise the inlet pressure from 10 psig to approximately 100 psig.	2	0
Annual station throughput in GGE	4 Hours per day & 260 days/year	260,000	260,000
Capital Costs:			
Booster Compressors (total for 2)	Two required for redundancy.	$ 160,000	
Low Pressure Buffer	Required only with booster operation	$ 10,000	
CNG Dryer	As noted above, the CNG dryer is smaller with the regulated service because there is a booster installed ahead of the dryer.	$ 60,000	$ 80,000
CNG Compressors (total for 2)	As noted above, the CNG compressor is smaller with the regulated service because there is a booster installed ahead of the dryer.	$ 440,000	$ 460,000
Cascade Storage	Assumed 35000 scf	$ 100,000	$ 100,000
Dispensers and Miscellaneous Controls	Two dual hose dispensers plus ESD and priority panel	$ 100,000	$ 100,000
Subtotal Equipment Costs:		$ 870,000	$ 740,000
Installation Cost Adder assuming a factor of:	1.0	$ 870,000	$ 740,000
Total Installed Capital Cost for each Scenario		**$ 1,740,000**	**$ 1,480,000**

			Regulated Service	Unregulated Service
Operating Costs:				
Booster Compressor hp--each			100	
CNG Compressor hp--each			200	250
Maximum kW			249	207
Annual kWh			251,887	216,386
Assumed cost per kW of demand costs	$	10.00		
Assumed cost per kWh of energy costs	$	0.10		
Year 1 Power Costs			*$ 55,029*	*$ 46,505*
Assumed maintenance cost per GGE:			$ 0.33	$ 0.30
Year 1 Station Maintenance Cost			*$ 85,800*	*$ 78,000*
Net Present Value of Costs:				
Assumed discount factor (percent)	6.00%			
Assumed inflation factor (percent)	3.00%			
Assumed station life in years	20			
Capital Cost Totals			$ 1,740,000	$ 1,480,000
Net Present Value of Electrical Cost for Life of Station			$ 825,342	$ 697,504
Net Present Value of Maintenance Cost for Life of Station			$ 1,281,473	$ 1,169,874
Total Net Present Value of Capital and Operating Costs			**$ 3,846,814**	**$ 3,347,377**
Net Present Value of Additional Capital and Operating Cost over the Station Life.			**$ 499,437**	
Estimated Carbon Emissions from Power Generation--Assumed to be a Mid Western power plant. Carbon emissions per kWh in pounds of CO2. Carbon Dioxide Emissions from the Generation of Electric Power in the United States-July 2000 Department of Energy/Environmental Protection Agency	1.6		8,060,391	6,924,354
Additional CO2 emissions over station life.			**1,136,037**	**pounds**

What About the Utility's Issues?:--i.e. What is the Benefit to the Utility in Modifying their Standards?

1. Medium to large CNG stations provide the gas utility with a large year round load. If the utility wishes to encourage local CNG projects, this is a no cost means by which to assist the market. In fact, there are savings to the utility as the unregulated meter set is smaller and simpler than the conventional set which requires regulators, relief valves and larger piping.
2. Medium to large CNG stations can be, and are, designed to operate over a floating range of suction pressures. The machinery is designed to handle the operating conditions safely at both extremes and the equipment is well instrumented to shut down should a fault arise.
3. Safety is sometimes mentioned as a possible concern. The minimum design pressure downstream of the utility meter is typically much higher than the utility supply pressure—for example, a station with a 60 psig service will be equipped with a 150 psig dryer. All equipment is designed and fabricated in accordance with ASME Section VIII and ASME B31.3—both very high design standards and these standards exceed normal fuel gas piping requirements. It is arguably safer for the utility to supply unregulated (higher) pressure since, with no regulator or relief valve required at the utility service, there is no risk of failure of these components.
4. Future loads from other new customers—the utility may have a need to allow for additional loads on their system by other new customers. These additional loads would reduce line pressure; however, **the CNG compressor station can be designed to operate with this wider range** of potential service pressures, so this should not be a design limitation.
5. Lastly, utilities are sometimes concerned about the effect the station may have on the utility system during peak usage days. In fact, providing unregulated gas to the CNG station will help the utility cope with this high demand—utilities are often unaware of this benefit:
   a. CNG stations use reciprocating compressors. These "positive displacement" machines always take in a fixed volume of gas in each revolution at the available pressure. If the compressor is supplied with floating pressure from the utility and the pressure is low at the time (for example on a very cold day), then the compressor flow rate (in scfm) is reduced because the gas is less dense. Therefore, on that cold day when the utility pressure is low because of high demand, the compressor inherently reduces its scfm flow rate, which is beneficial to the utility. It is worth noting that compressors are usually sized at the average or typical gas utility pressure not at the minimum.

b. Conversely, if the utility is supplying the station with a regulated pressure, the station will always take in the same fixed volume at the same pressure—therefore, the compressor will not reduce its flow even though the utility pressure is dropping and the system is operating at capacity. Under this scenario, the station does not reduce its flow and therefore it does not assist the utility in copying with the high demand.

What is the Current North American CNG Industry Practice?:

Since the mid-1980s, the CNG industry has embraced the use of floating suction where it is available. In parts of the country where significant CNG station population exists, utilities have been very accommodating in supplying unregulated gas pressure for the past 20 years. It is quite common to have stations operating in a range of up to 60 psig, 150 psig and higher. The author has experience with stations of up to 600 psig utility supply pressure.

Summary:

Based on industry experience, there are no safety advantages for the utility or station Owner to using lower, regulated, utility service pressure gas. Utilities benefit from supplying higher unregulated service pressures by reducing the cost of the meter set and by the inherent feature of floating inlet CNG stations that reduce flow during low service pressure events.

There are significant capital and operating cost benefits for the station Owner related to the use of higher inlet pressures, and this higher pressure will also provide a significant reduction in carbon emissions due to reduced power consumption.

Station Owners and their gas utilities should explore the availability and applicability of floating service pressures. In many cases, there may be relatively low pressure at the station location, however, it may be possible to pay to have higher pressure gas brought to the site—this is often a financially and environmentally sound investment. Marathon is available to act as a technical and financial consultant to assist the stakeholders in evaluating the economics of this issue.

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