Technical Proposal

Vortex Pressure Regulation Station

Conceptual Design

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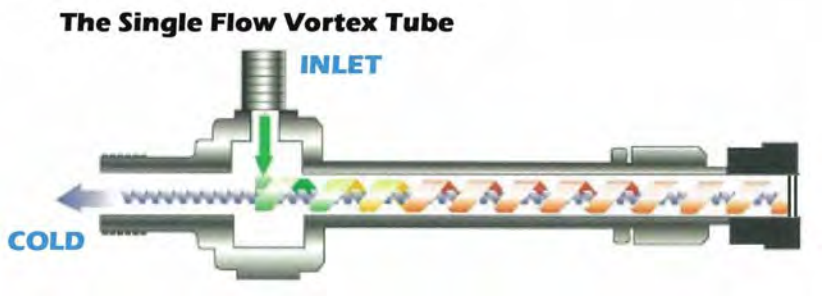
Opportunity

XXX operates a Pressure Regulation Station with inlet gas pressure of 700+ psig, delivery pressure of 54 psi (60psi MAOP) and gas maximal flowrate of 6 Msfh (8 Msfh design capacity). The Station original setup comprised of a single Fisher 627 with a Bruest Heater didn't prevent the PRS regular freezing up. The present two stage pressure regulation didn't substantially improve the situation.
XXX is looking for a solution that eliminates gas freeze up in pressure regulation and simplifies the PRS design and operation.

Solution

Universal Vortex Inc. (UVI's) innovative technology- the Vortex Pressure Regulation is a solution to secure non-freeze pressure reduction of non-preheated gas for delivery at the required pressure and flowrate. The core of the technology is the proprietary self-heating, single flow Vortex Pressure Reducer (VPR), a device that generates heat as an outcome of the routine pressure reduction, has no moving parts, consumes no external man-made energy, produces no emissions, and requires no maintenance.



In the VPR, high pressure gas expands in the unit's tangential nozzle of a fixed size down to the delivery pressure. While in the VPR cylindrical

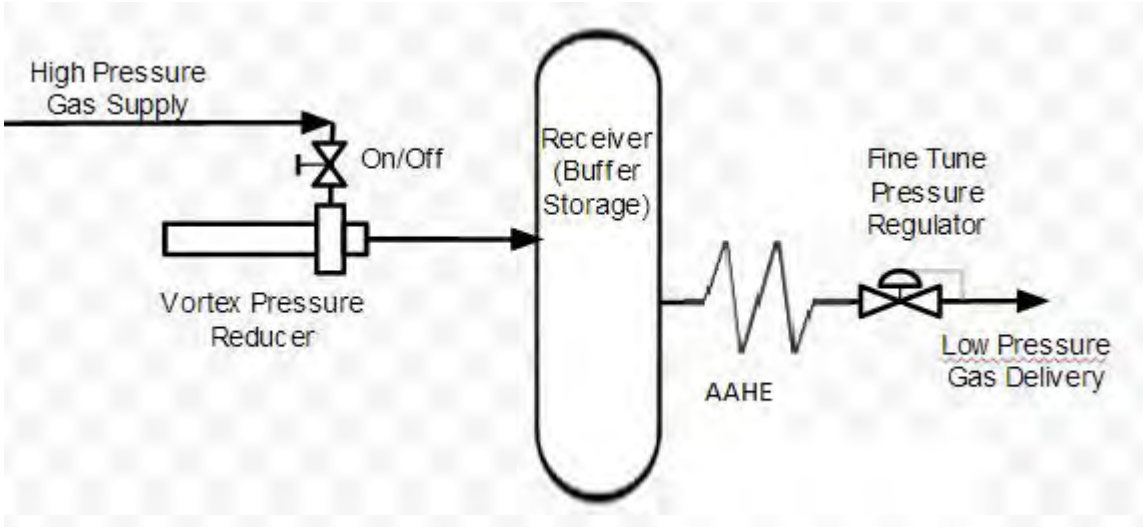
part, the rotating low-pressure gas undergoes energy division (Vortex Phenomenon), forming two currents/flows: cold and hot. The currents coexist in the VPR and exit the unit through a single discharge orifice. Prior to exiting the VPR, the hottest portion of the hot flow is internally directed to warm up the unit's inlet nozzle (proprietary self-heating provision), thus protecting the inlet depressurized flow from freeze up. The vortex cold and the hot flows mixing up at the VPR discharge negate their temperature differences. Therefore, the temperature of the combined flow at the VPR single discharge reflects only a Joule Thomson temperature drop in the expanded gas.

UVI is pleased to submit this technical proposal presenting a conceptual design of a VPRS. This conceptual design has been prepared on the basis of the data available at this time.

VPRS Design

Vortex pressure regulating station VPRS consists of a Vortex Pressure Reducer (VPR) with an upstream 'on/off'' solenoid valve connected to the high pressure pipeline, a buffer receiver (BR) at the VPR discharge, an ambient air heat exchanger (*optional*) and a Fine Tune Pressure Regulator (FTPR) at the BR outlet.

When the on/off valve is opened the full unregulated pressure is applied to VPR. The concept, similar to the use of a receiver in compressor operations, is that the receiver acts as a buffer and a storage of a partially pressure regulated gas between the VPR and the next stage of pressure reduction as presented in the diagram below:



From the flow control stand point a buffer receiver (inter-stage storage) fed through the VPR's fixed, unchangeable (no moving part!) inlet nozzle *allows delivering a variable flow to the end user.*

The following is to be taken into consideration in the BR sizing: Sufficient storage capacity is provided such that the on/off valve does not cycle excessively (e.g. the minimum time between on/off cycles for design may be 20 seconds or more). A consideration in setting this parameter for design is valve life expectancy/cycles per manufacturer specification.

Determining the inter-stage storage capacity is assessed for operating conditions as follows:

- Maximum VPR inlet pressure and with no downstream demand and with VPR delivering its full rate of flow filling the inter-stage storage should exceed the specified minimum on/off valve cycle time.
- Minimum volume of inter-stage storage should be sufficient to maintain the maximum demand without supply from the VPR flow a period of time equal to the specified on/off valve cycle time.

Design Basis

Pipeline gas pressure: 700+ psi; MAOP: 858 psi

Delivery pressure: 54 psi, MAOP 60 psi
Gas flow rate 6 Msfh; maximal design flow 8 Msfh

The VPRS performance

The control logic of the VPRS operations is as follows;

The solenoid valve, based on the pressure in the buffer receiver, will open to make the VPR active. The high pressure pipeline gas introduced through a solenoid valve undergoes a non-freeze pressure reduction in the VPR down to the current pressure in the buffer receiver. Since the design capacity of the specified VPR (roughly 11,500 scfh at 750 psi) will at all times exceed the maximal delivery flow rate, an inter-stage receiver is utilized (like a receiver is used in a compressed air system) to balance supply and demand. The gas pressure in the buffer receiver raises until the receiver is at the high pressure set point (suggested 200 psig or 14.6 bara), whereupon flow is stopped and not started until the receiver is depleted to the low set point (suggested 70 psig or 5.76 bars).

A buffer receiver in the VPRF installation provides for delivering of variable gas flow, thus overcoming the limitation of the VPR's single, non-changeable inlet orifice. To keep the VPR performance smooth the receiver size is to allow for, at least, 20 sec. of non-stop VPR operations in the 'fill in' cycle.

The gas accumulated in the receiver is regulated to the delivery pressure in the fine tune pressure regulator.

A *direct operated pressure regulator* is suggested here to regulate the Buffer Receiver pressure that varies in 70 psig to 200 psig range to the delivery pressure of 60 psi

Sizing the Buffer Receiver:

The suggested 'on/off' pressures allow for a relatively small size of the receiver to satisfy the specified minimum time between on/off cycle. With just 1 m3 (264 gal) volume the receiver's accumulating capacity is 1x (14.6-5.76) = 8.84 nm3 and the time between cycles (8.84/0.092) is 96 sec. Here 0.092 nm3/sec; (194.9scfm) is a specific gas flow rate corresponding to the VPR design capacity of 11,500 scfh at 750 psi.

Thermal Management

The VPR provides a non-freeze pressure reduction so that heating of the gas flow prior to pressure reduction is not required. The pressure regulated gas temperature at the VPR discharge is equal to the inlet gas temperature (e.g. high pressure pipeline gas temperature) less Joule-Thomson temperature drop in the expanding gas. The accumulated gas in the BR is then pressure regulated (maximal gas pressure differential here is 200 psi - 60 psi =140 psi) and is directed into downstream delivery line or (if required), thermally conditioned (post heated) upstream of a Fine Tune PR. There are two possible ways for the pressure regulated gas post heat: in an Ambient Air Heat Exchanger (AAHE) with a standard thermal approach of 10^0F (no man-made energy consumed, a compact design due to the relatively small delivery flow) or in a downstream heater (catalytic, for example).

Specified Self Heating Vortex Pressure Reducer

The application is served by a single VPR (models SG2 internally modified to comply with the specific flow/pressure parameters).

The unit is supplied in a thermal insulating jacket. The overall dimensions of the VPR are: DIA 4'', Length 23''

- Material entirely SS-304
- Hydro test under ASME @ 3,000 psi (204 bar) Pressure certificate will be available
- Connections, NPT: inlet ½'' –M, outlet ½''-F

Scope of Supply

Scope of Universal Vortex Inc. supply includes the technology package comprised of the conceptual design of the VPRS and custom design, manufacturing and supply of Vortex Pressure Reducer to be incorporated into the facility. The conceptual design provides the configuration of the VPRS as well as identifies the major components therein. It shall not include controls, instrumentation, electrical, mechanical or civil works such as may be required for successful project completion.

Previous VPRS installations utilizing the buffer receiver concept

The picture below shows the VPR, a buffer receiver (gray pipe) and an on/off solenoid valve assembly operating in the boiler fuel gas pressure conditioning system at Rock Spring Power Plant, MD, USA.

Feed: pipeline gas @ 600-1,000 psi (41-68 bar) at the ground temperature.

Gas delivery pressure 50-100 psi (3.5-6.8 bar). Gas flow rate is up to 360,000 scfd (425 nm3/HR).

Non-freeze pressure reduction of non-preheated gas. No pressure regulated gas thermal management e.g. no post heat