

CGA Energy Nexus & Annual Technical Conference 2024

Fuelling the Future

S&C 101 Station Design Theory

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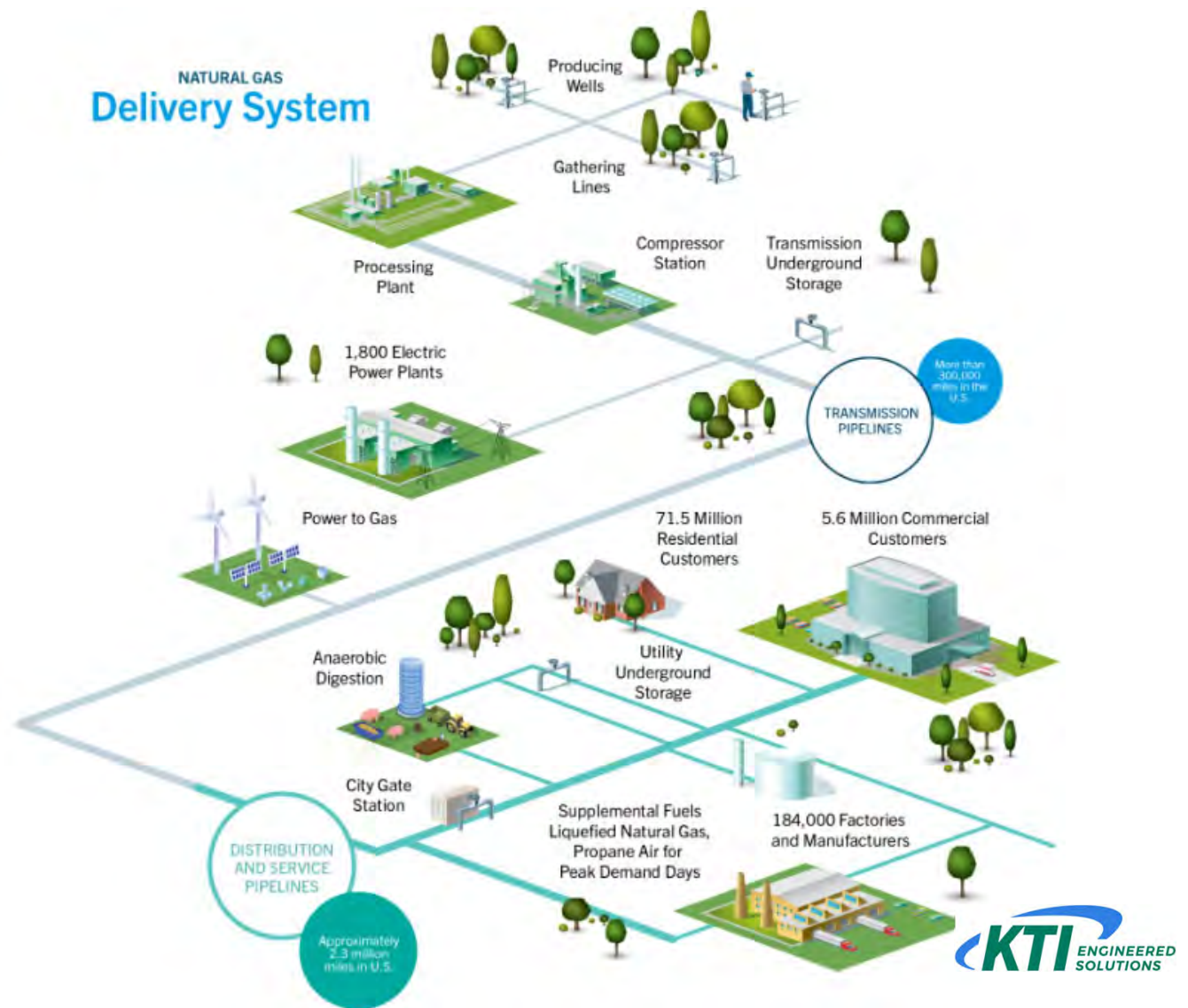
October 7–10, 2024 | Toronto, ON | #CGATEchnicalConference #CGAEnergyNexus #FuellingTheFuture

Agenda

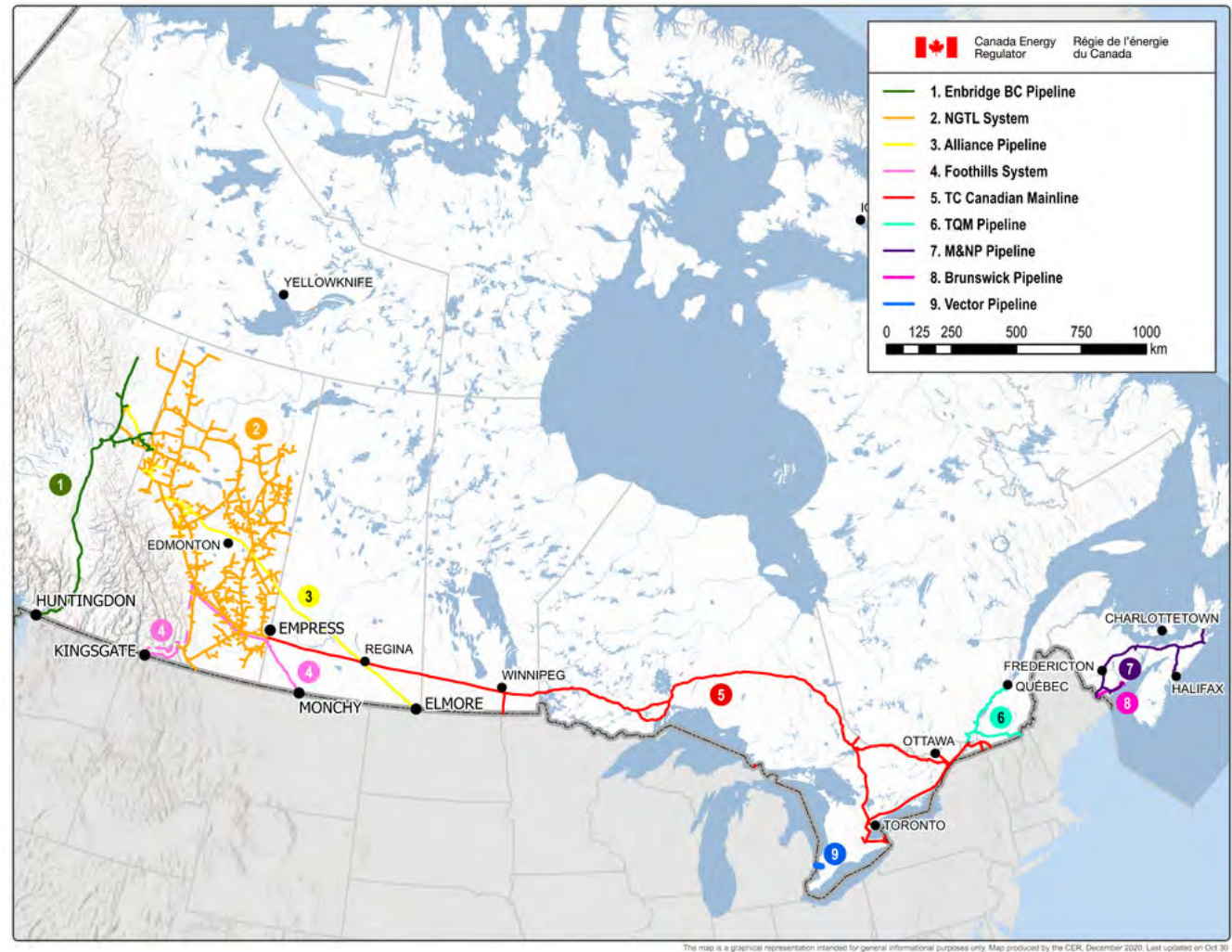
- Natural Gas Delivery System
 - Station Types
- Codes
- Station Design Inputs
- Design
 - Pipe, Valves and Fittings
 - Regulation
 - Gas Preheat
 - Measurement
 - Odourization
- Design Drawings
- Decarbonization
 - H₂
 - RNG



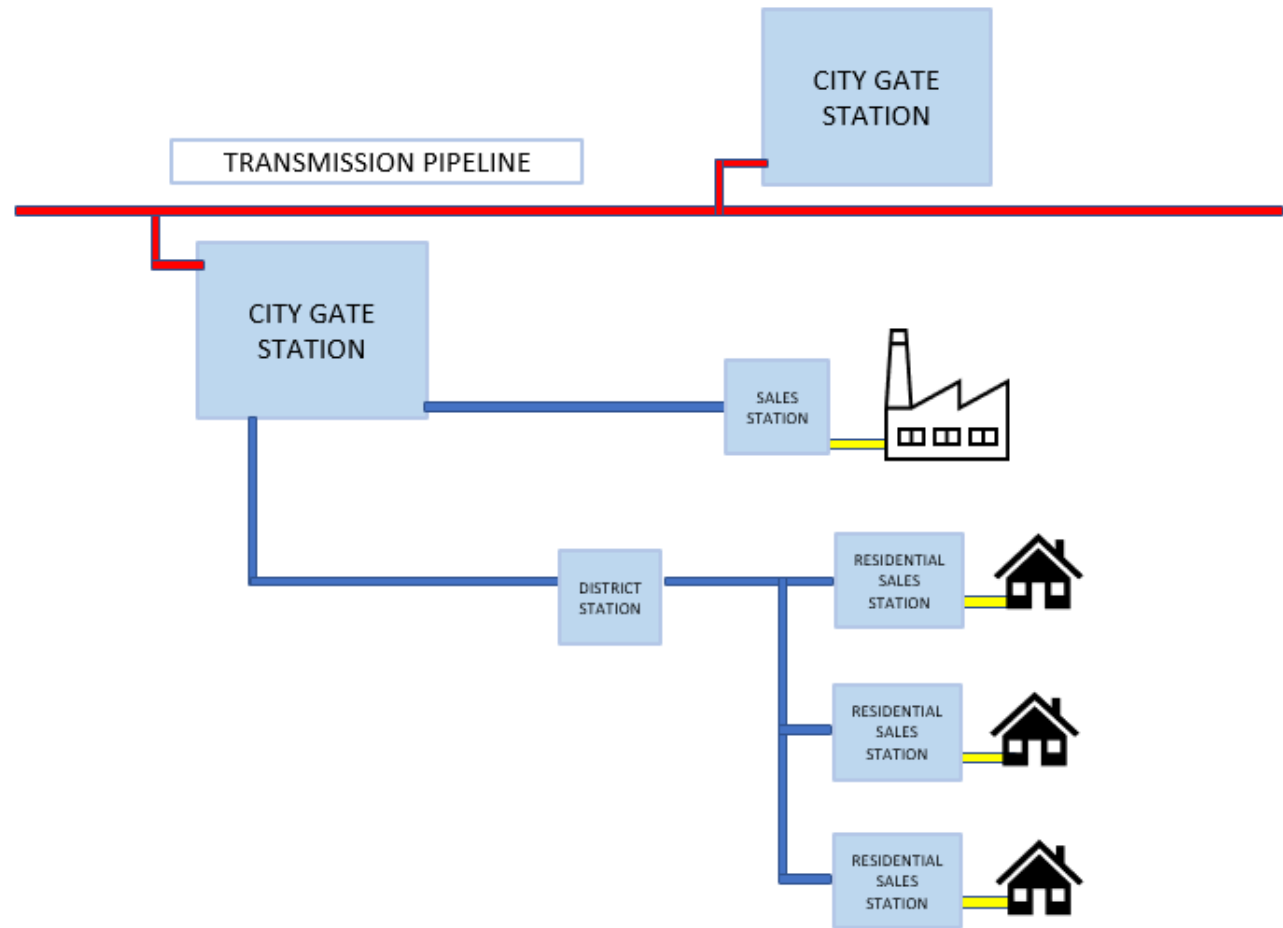
Natural Gas Delivery System



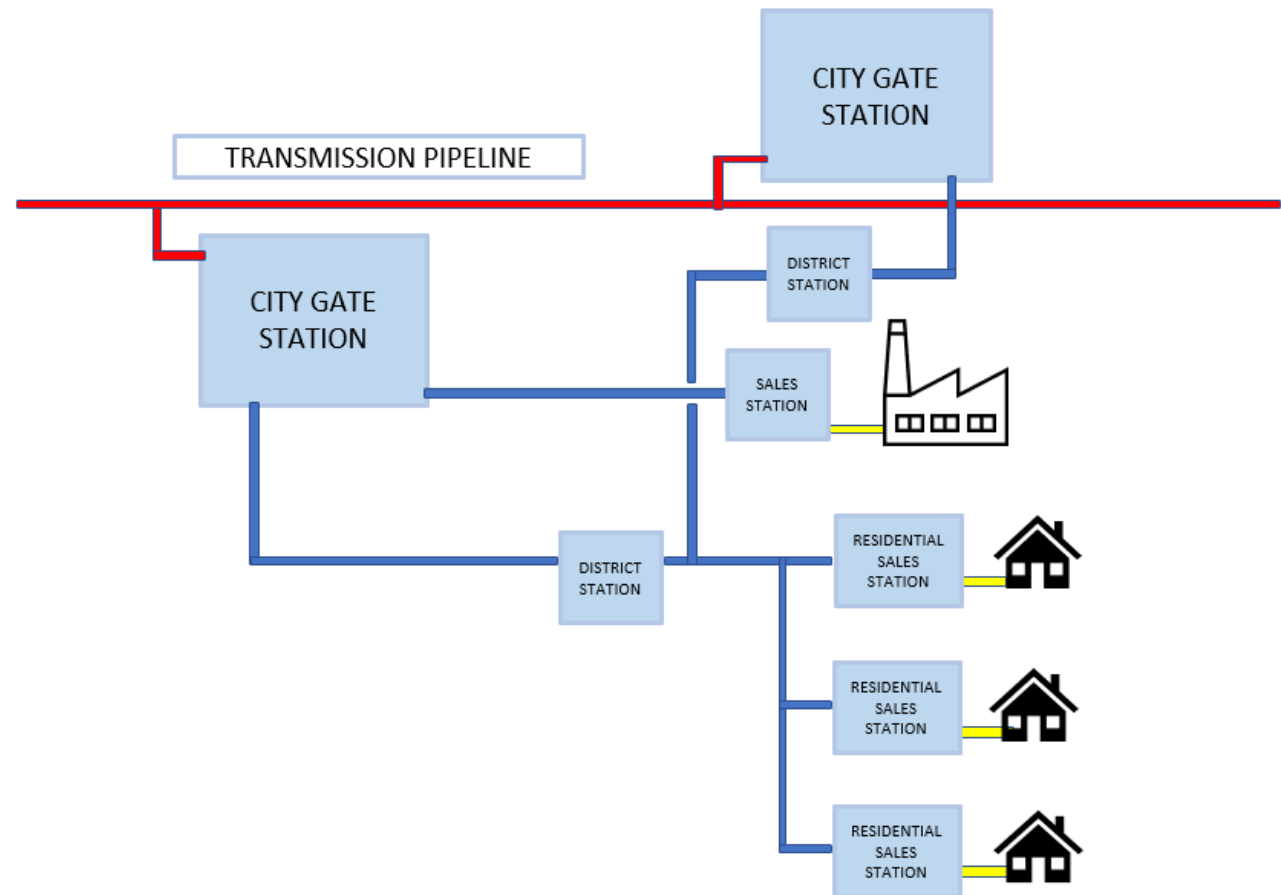
Gas Transmission Pipelines



Gas Distribution System



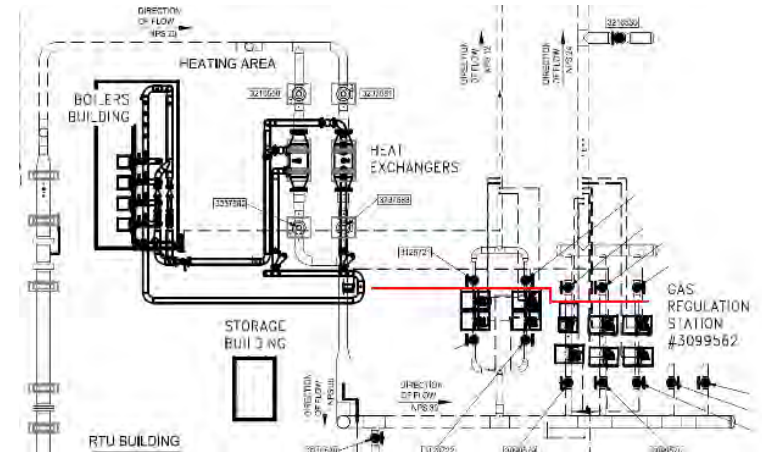
Gas Distribution System



City Gate Station

Custody transfer (delivery point) from transmission to distribution system

- 800-2000 psig inlet to 50-500 psig outlet
- Filter/separators
- Metering
- Gas Preheat
- Regulation
- Odourization
- Sweet Dry Natural Gas

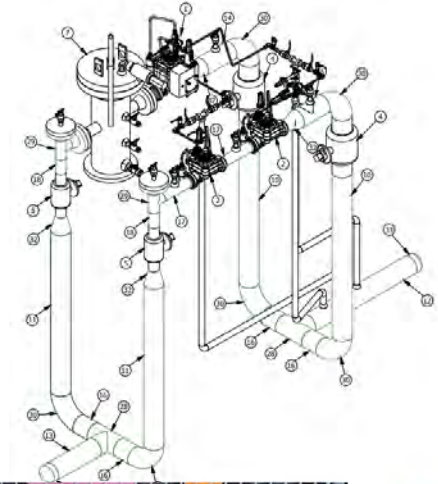


District Station

Pressure Let-Down Stations

100-500 psig inlet to 5-50 psig outlet

- Filtration
- Regulation
- Heating
- No Odourization

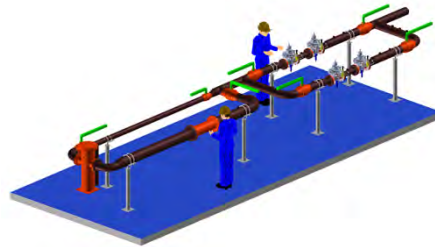


District Station

- Residential Growth
- Station Capacity Growth
- Metering needs
- Gas Preheat
- Traffic Protection



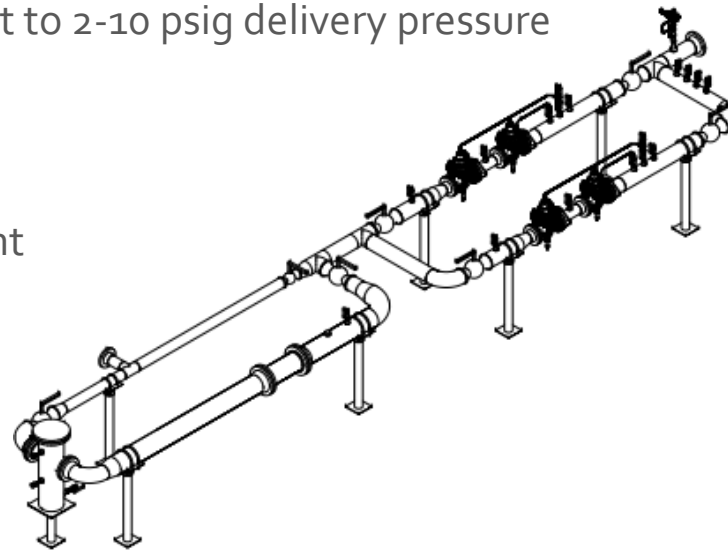
Sales Stations



Large Industrial Customers

5-200 psig inlet to 2-10 psig delivery pressure

- Filtration
- Regulation
- Measurement



ISO VIEW



Sales Stations

Residential and Small Industrial Customers

5-200 psig inlet to Inches of H₂O-2 psig delivery pressure

- Regulation (integral monitor)
- Measurement (Smart Meters)

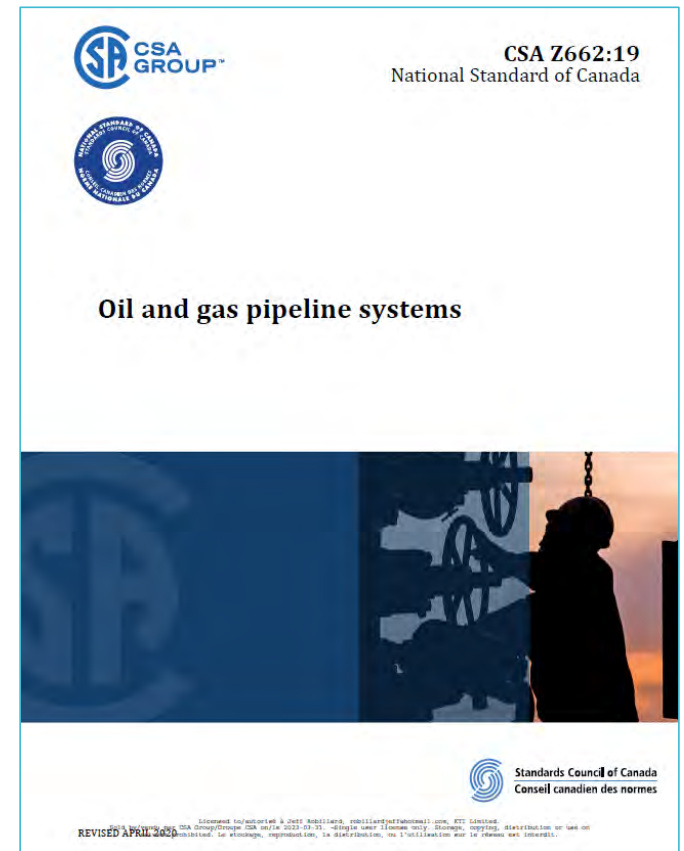


KTI ENGINEERED SOLUTIONS

Codes Z662-19

This Standard covers the design, construction, operation, maintenance, deactivation, and abandonment of oil and gas industry pipeline systems that convey

- a) liquid hydrocarbons, including crude oil, multiphase fluids, condensate, liquid petroleum products, natural gas liquids, and liquefied petroleum gas;
- b) oilfield water;
- c) oilfield steam;
- d) liquid or dense phase carbon dioxide; or
- e) gas.



Codes

CSA CODES

- CSA B51-14
 - Boiler, Pressure Vessel, and Piping Code
- B149-15
 - Natural Gas and Propane Installation Code
- C22.1-18
 - Canadian Electrical Code, Part 1
- Z245.1-18
 - Steel Pipe
- Z245.11-17
 - Steel Fittings
- Z245.12-17
 - Steel Flanges
- Z245.15-17
 - Steel Valves

ASME CODES

- B31.8-2018
 - Gas Transmission and Distribution Piping Systems
- Boiler and Pressure Vessel Code, 2017
 - Section VIII: Pressure Vessels
- B31.3
 - Process Piping
- B16.11-2016
 - Forged Fittings, Socket-Welding and Treaded
- B16.5-2017
 - Pipe Flanges and Flanged Fittings
- B16.34-2017
 - Valves Flanged, Threaded and Welding End

CSA Z245.15

Standard requirements The following information shall be included in the purchase order for valves:

- (a) CSA Standard designation and year of publication (Z245.15-17);
- (b) quantity;
- (c) type and pattern of valve (see Clauses 1.1 and 5.1);
- (d) nominal valve size (see Clauses 1.2.1 and 10);
- (e) category (see Clause 1.2.3);
- (f) end configuration (see Clauses 1.3 and 5.4);
- (g) nominal pressure class (see Clauses 1.2.2 and 5.2.1 and Table 1);
- (h) minimum and maximum design temperatures (see Clause 5.2.1);
- (i) for weld-end valves, matching pipe specified wall thickness and grade and the inside diameter of the butt welding end (see Clause 5.4.2);
- (j) for wafer-type valves, the matching flange (see Clause 5.4.3)
- (k) test temperature for Category II (see Clause 8.4.1.5);
- (l) for flanged-end valves, required bore size;
- (m) packaging and shipping instructions; and
- (n) required delivery date.

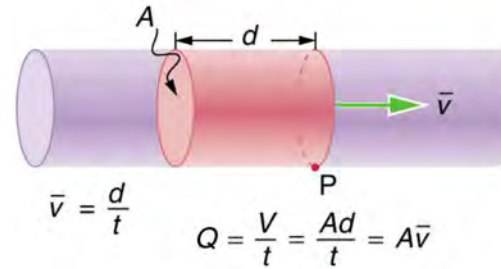
CSA Z245.15-17, QTY 1, BALL VALVE, FULL PORT, 114.3 MM, CAT II (-29°C), RFWN, PN50 (300#), -29°C to 120°C, 102.3 MM BORE

Design Inputs

- Fluid (Sweet Dry Natural Gas)
- Max/Min Flowrate
 - Forecast
- Max/Min Inlet Pressure
- Max/Min Outlet Pressure
- Max/Min Operating Pressure
- Max/Min Temperatures
- Location
 - Spacing
 - Local codes (Building, Fire)



Pipe Size

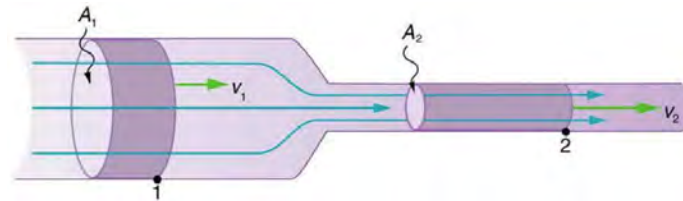


- Max Flow (design input) determines velocities
- Size pipe for max velocity
 - Specific to the operating company
 - 20/30/45 m/s (60/100/150 ft/s)
- Consideration for vibration/noise causing stress on piping and fittings

Pipe Size

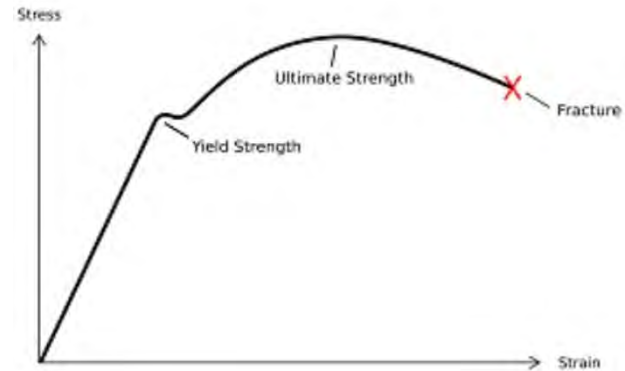
What is the velocity of 1000Mcf/h at 100 psig, 60°F in NPS 4, Sch Std?

- $V = Q/A$
 - Q is at actual conditions not standard
- $V = \frac{748.7QT}{d^2P \times 520}$ (Pipeline Rules of Thumb Handbook, McAllister, c 2002)
- $V = \frac{(748.7)(1000)(60+420)}{(4.5-.237-.237)^2(100)(520)}$
- $V = 461 \frac{ft}{s} = (141 \frac{m}{s})$
- NPS 6, Sch Std, $V = 204 \frac{ft}{s} = 62(\frac{m}{s})$
- NPS 8, Sch Std, $V = 117 \frac{ft}{s} = 36(\frac{m}{s})$



Pipe, Fittings

- Barlow's Equation
- $P = \frac{2tS}{D}$, or $S = \frac{PD}{2t}$
 - P – Pressure
 - t – Wall thickness
 - S – Allowable Stress
 - D – Diameter
- SMYS – Specified Minimum Yield Strength (Grade)
 - MPa or ksi
 - Grade 448 MPa (65 ksi), 359 MPa (52 ksi), 290 Mpa (42 ksi), etc.
- Design to 30% SMYS



Pipe, Fittings

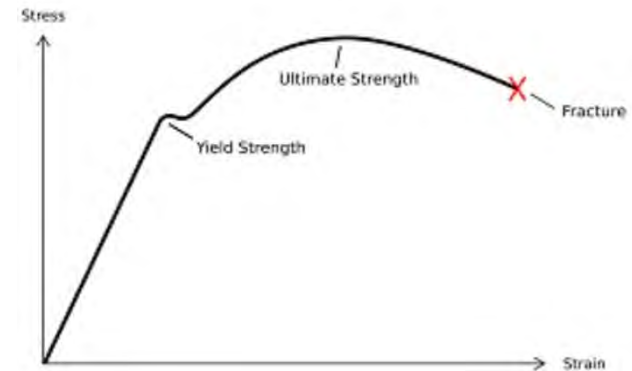
Design to 30% SMYS

NPS 8, Sch Std, 1000 psi (6895 Kpa)

Gr. 359 (52 ksi)

- $S = \frac{PD}{2t}$
- $S = \frac{1000(8.625 - 0.322 - 0.322)}{2(.322)}$
- $S = 12,392 \text{ psi}$
- $\%SMYS = \left(\frac{12,392 \text{ psi}}{52,068 \text{ psi}} \right) = 24\%$

219.1 mm OD, 12.7 mm WT, Gr 359, Cat I, CSA Z245.1

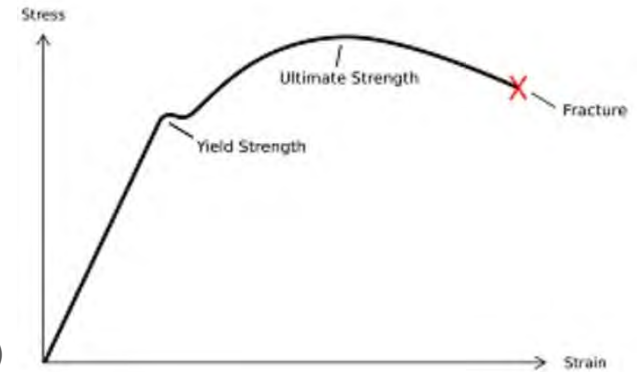


Pipe, Fittings

- Design Pressure

- $P = \frac{2tS}{D} \times F \times L \times J \times T$

- F – Design Factor (0.8)
- L – Location Factor (0.5)
- J – Joining Factor (1.0 welded steel)
- T – Temperature Factor (1.0 up to 120°C)



- $P = \frac{2tS}{D} (0.8)(0.5)(1.0)(1.0)$

- $P = \frac{2(0.322)(52000)}{2(8.625-0.322-0.322)} (0.8)(0.5)(1.0)(1.0)$

- $P = 839 \text{ psig} (5,784 \text{ kPa}) < 1000 \text{ psig} (6,895 \text{ kPa})$

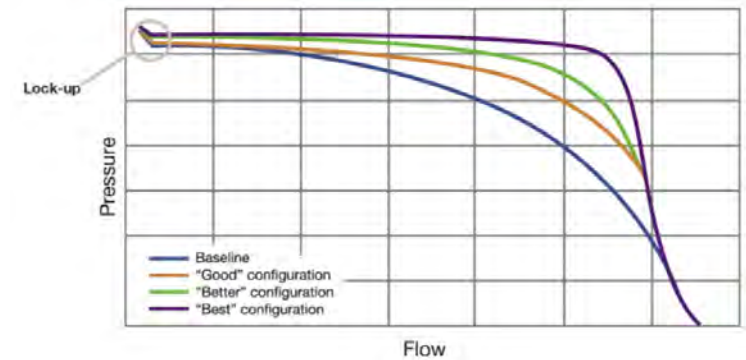
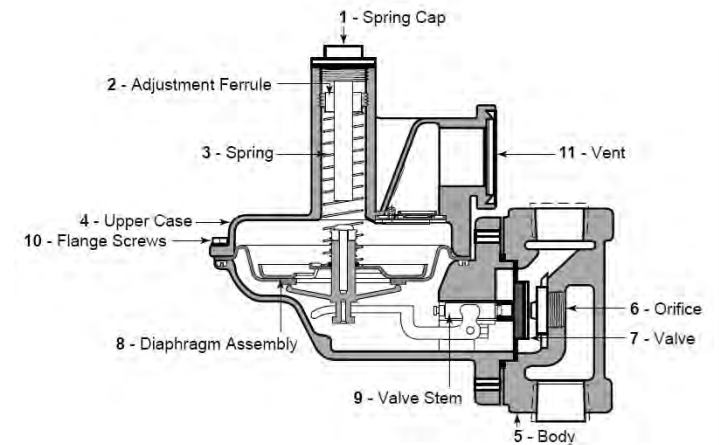
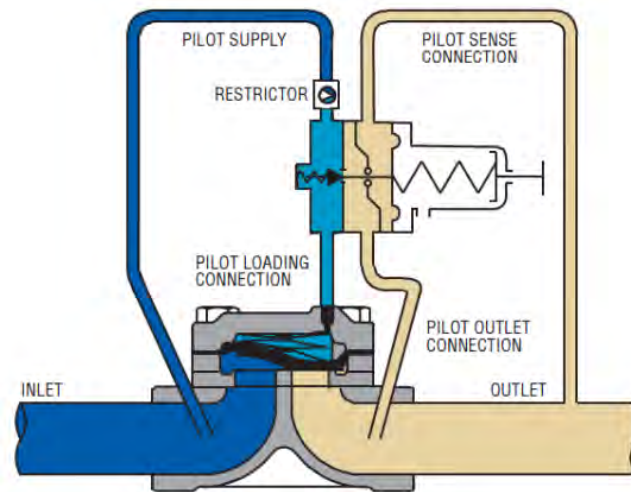
- Use Sch 80

- $P = \frac{2(0.5)(52000)}{2(8.625-0.5-0.5)} (0.4)$

- $P = 1,363 \text{ psig} (9,397 \text{ kPa})$

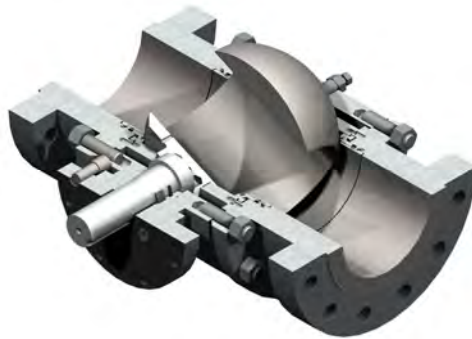
Pressure Regulation

- Direct Operating Regulators
- Pilot Operated Regulators
 - Flexible Element
 - Plug and Stem



Pressure Regulation

- Control Valves
 - Power gas/Electric Actuated
 - Digital Positioners
 - Control Pressure and Flow
 - Noise Attenuation
 - Turndown and capacity
 - Globe or Ball Valve



FPCV-T0



QTCV-T1



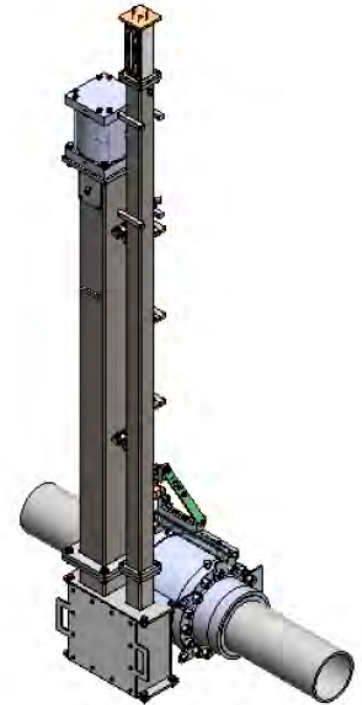
QTCV-T2



QTCV-T3



QTCV-T4



Pressure Regulation

Size for low and high end capacity and noise

- Min Flow (Controllability)
 - Min Inlet Pressure
 - Min ΔP
 - Min Design Flow
- Capacity
 - Min Inlet Pressure
 - Max ΔP
 - Max Design Flow
- Noise
 - Max Inlet Pressure
 - Max ΔP
 - Max Design Flow

Service Conditions	Sizing Conditions	Units	Min	Max	Noise	Min inlet
	Inlet Pressure	psi g	175	138	175	100
	Outlet Pressure	psi g	45	45	45	45
	Flow Rate	sm ³ /h	283	3500	3500	3500
	Temperature	deg C	5	5	5	5
	Interstage Pressure	psi g				
	Vapor Pressure	psi a				
	Relief Valve Set Point	psi g				
	Calculated Capacity	Cg	40.05	623.4	495.3	862.9
	Recommended Capacity	Cg	40.05	623.4	495.3	862.9
	Flow Type					
	Max Flow (Volume)	sm ³ /h	7983	6344	7983	4583
	Noise level at 1m	dBA	58.73	73.94	76.52	70.83
		dBA	58.73	73.94	76.52	70.83
	Velocity at Outlet	ft/s	31.3	387.1	387.1	387.1
	Downstream Velocity	ft/s	7.725	95.54	95.54	95.54
	Tube Expansion Factor					
	% Travel		3.544	55.17	43.83	76.36
	Outlet Temperature	deg C	0.1852	1.555	0.1852	2.963
	Required Relief Capacity					

Pressure Regulation

Independent Pressure Control and Overpressure Protection Devices

- Slamshut
- Operator/Monitor (2 Regs or control valves in series)
- Full Capacity Relief
- Tertiary Safety Device
 - Alarm monitoring
 - Slamshut
 - Token Relief



Gas Preheat

Joule Thompson Effect

- ΔP of 690 kPa (100 psi) = ΔT of 3-4 °C (6-8 °F)
- Temperature drops from gas expansion
- Potential to compromise regulator operation

Gas Preheat Systems

Sized for max flow and max pressure differential

- Potential to oversize a system



Gas Preheat

Boiler and Heat Exchanger

- Redundancy
- Expansion for additional boilers
- Controls and programming



Glycol Bath Line Heater

- Glycol Management
- Tune the heater for efficiency (above 80%)
- Simple operations



Gas Preheat

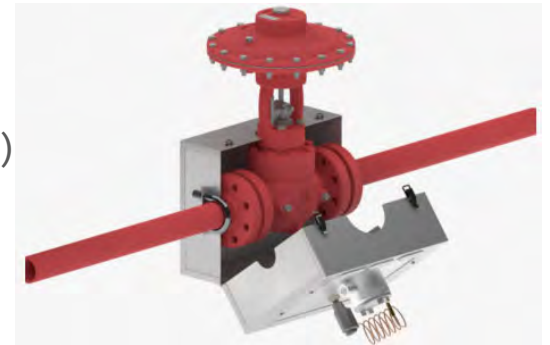
Vacuum Boiler

- Redundancy
- Expansion for additional boilers
- Efficiency at operational flowrates



Catalytic Heaters

- Tune the heater for efficiency (above 80%)
- Scalable in size



Measurement

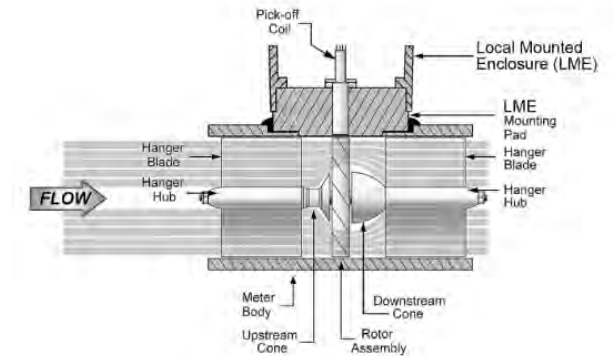
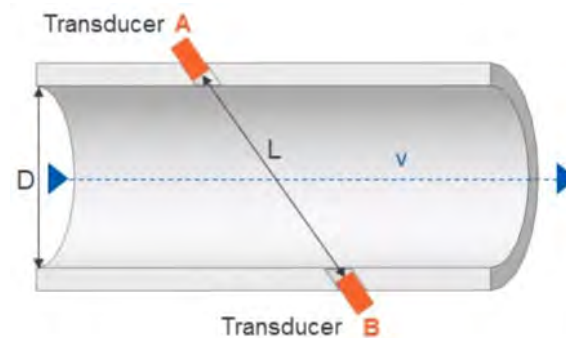
Custody Transfer – Measurement Canada Certification

- Pressure and Temperature Compensation
- Upstream and downstream pipe runs
- Flow conditioning

Ultrasonic Meters

Turbine Meters

Diaphragm Metering



Measurement

Check Metering (not Custody Transfer)

- Validation of network flows
- Unaccounted for gas loss
- Odourizing rates

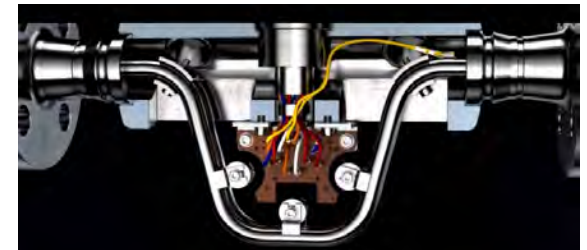
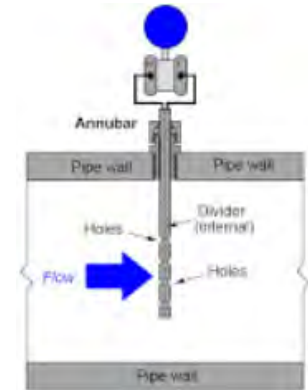
Ultrasonic Meters

Diaphragm Metering

Coriolis Metering

Turbine Meters

Pitot Tube Meters



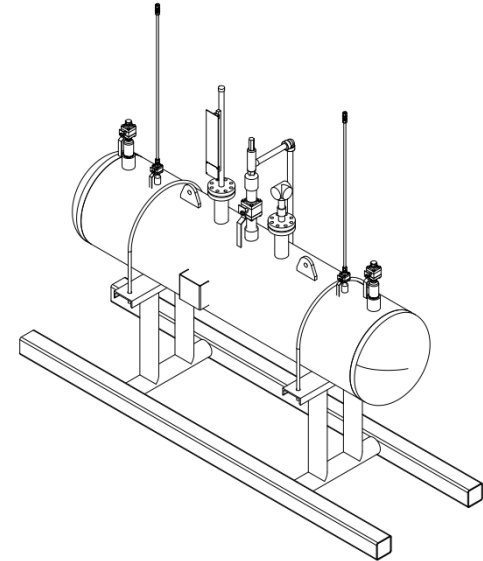
Odourization

- PD pump injection systems
 - Precise Measurement
 - Pump designed for flow conditions
 - Customizable
 - Wide range of gas flows
- YZ Injection Systems
 - Complete package
 - Alarms
 - Controllers

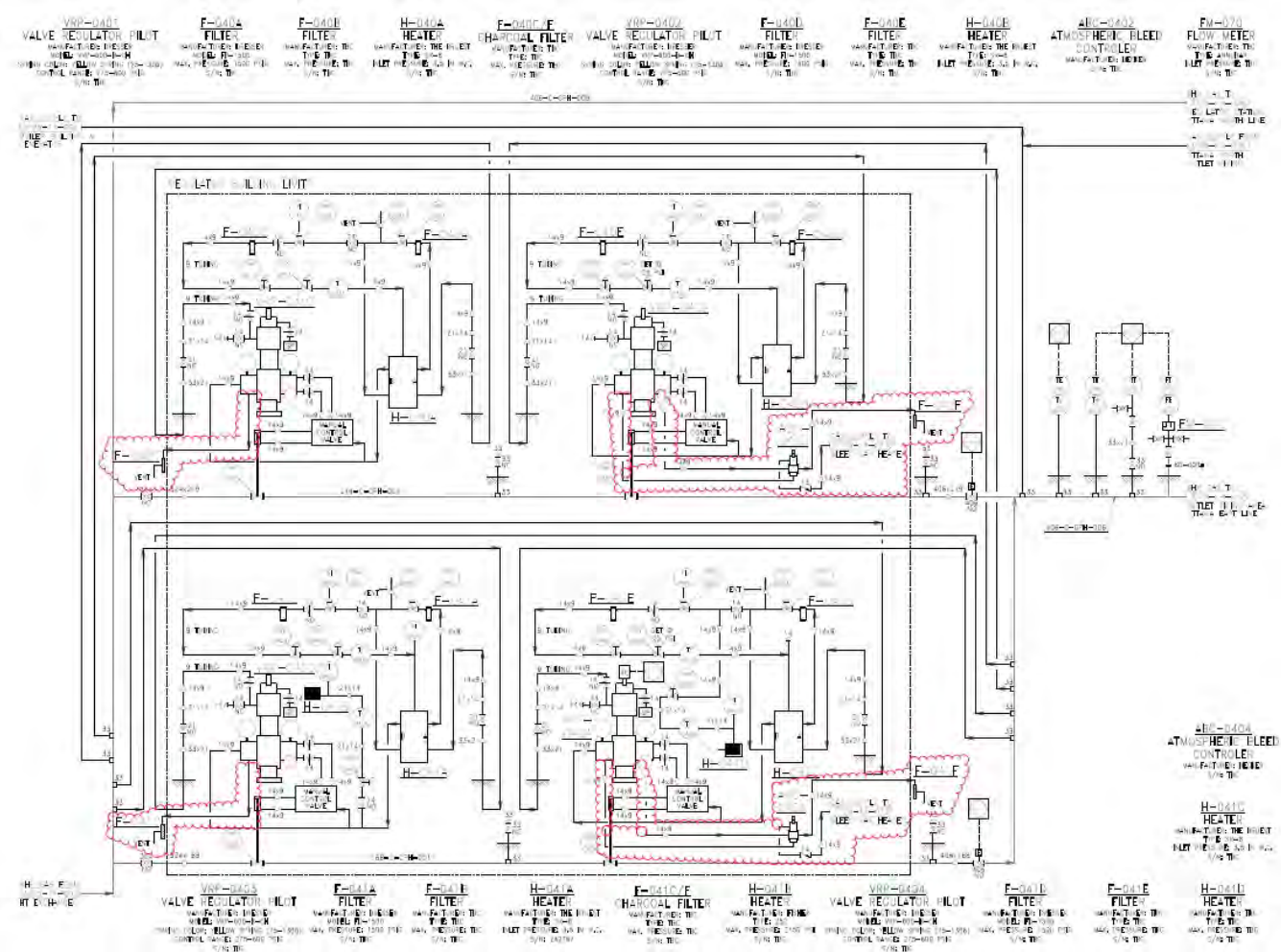


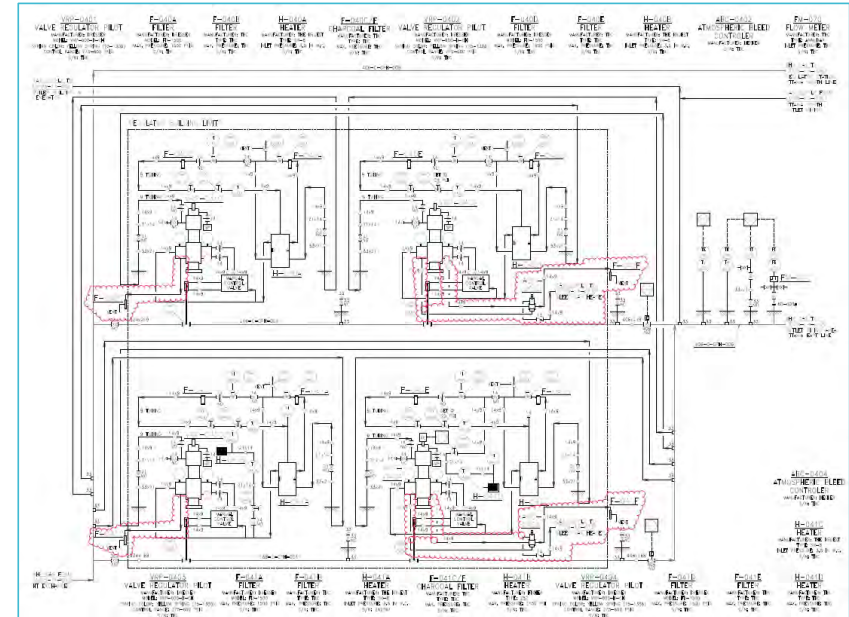
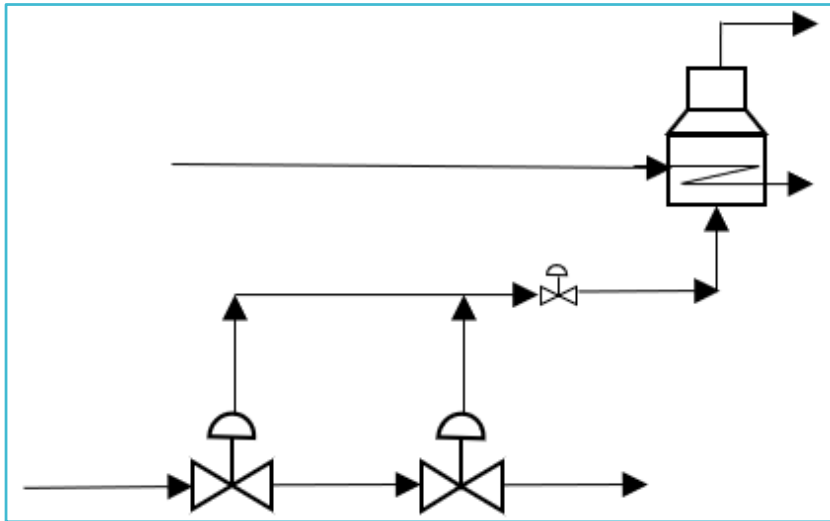
Odourization

- Bypass Systems
 - Measurement limitations
 - Reduced Control of odourant rates
 - Cost effective
 - High pressure bulk storage



P&IDs



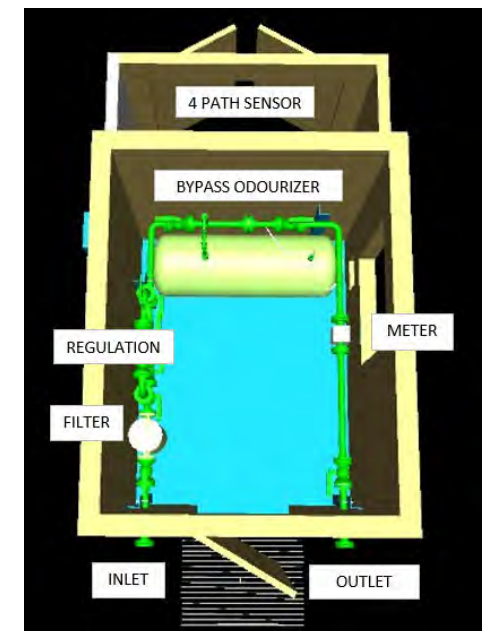
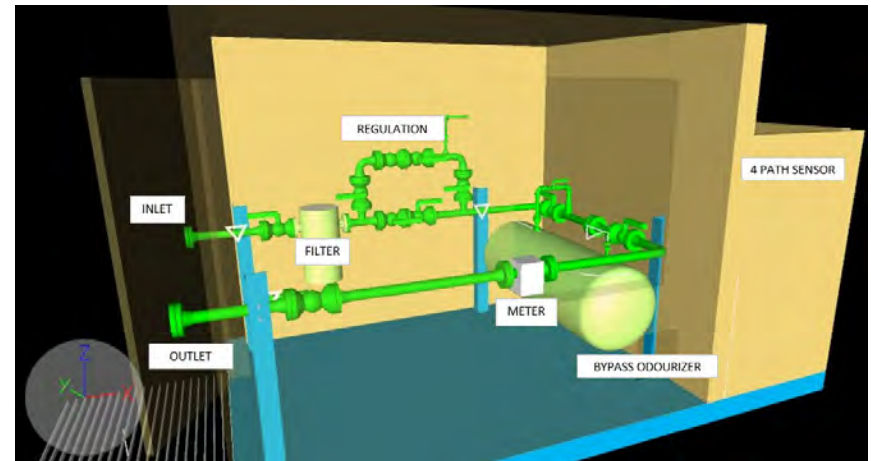


PFD v P&IDs

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Decarbonization

- RNG Station
 - Biofuel
 - Gas Quality
 - (H_2S , H_2O , CO_2 , O_2)
 - Measurement
 - Gas entry into network
- H₂ blending
 - Hydrogen Stress Cracking
 - Manufacturer verification of H₂ tolerance



Questions...

