

Portable Gas Compressor Applications

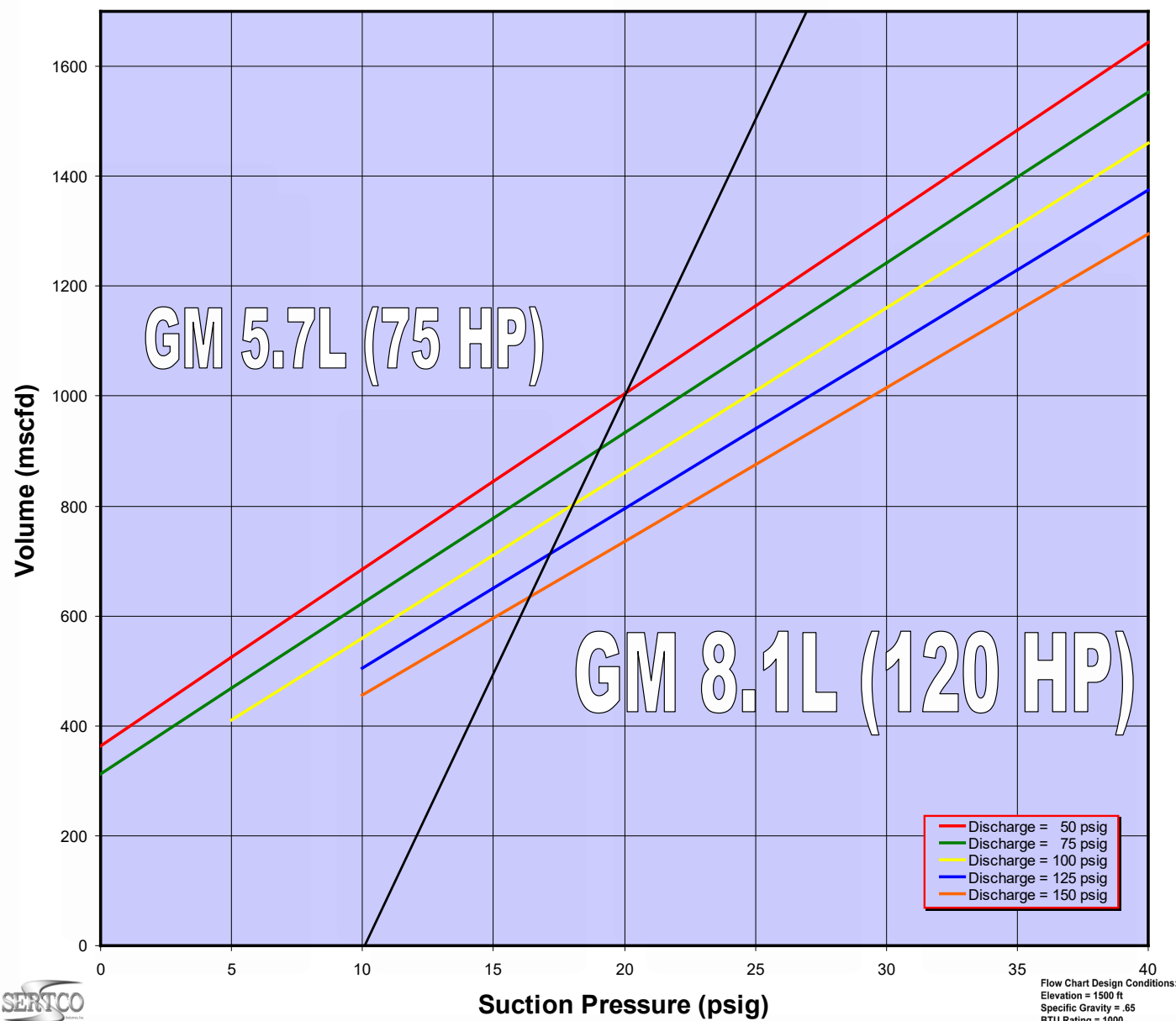
- **Wellhead (Surface) Pressure Reduction**
- **Liquid Loading Relief**
- **Gas Gathering**
- **Casing Pressure Reduction for Enhanced Oil Production**
- **Plunger Lift Coordination**
- **Vapor Recovery**
- **Pigging**



Key Feature Recap

- **GM 5.7 or 8.1 Liter Industrial Power Plant**
- **Flow rates up to 1500 MCFD / 45 MCMD**
- **Discharge pressure up to 150 psig**
- **100 bbl/day fluid handling capability**
- **Low fuel consumption 7 – 15 mcf**
- **High pressure hose connection for ease of installation**
- **Oversized EJW cooler**
- **ASME coded gas aftercooler**
- **Environmentally friendly skid**
- **4.5 gallon engine oil reservoir**
- **4.5 gallon compressor oil reservoir**
- **Lifetime muffler system**
- **Heated ASME coded scrubber/blowcase**
- **Schedule 80 piping throughout**
- **NEMA 4 enclosure with controls and automatic shutdowns**
- **Trailer mount**
- **Make-up system**
- **Dump fluids to tank or discharge even in a vacuum**
- **60-90 day service interval**
- **No site preparation necessary**
- **HOERBIGER VALVES!**

Volume Capacity for Model 350 Package @ 2100 RPM



Surface Pressure Reduction

Lowering the surface pressure of a well by using compression will generally result in:

- **More Production**
- **Prolonged Well Life**
- **Increased Reserves**

This is especially true in zones with:

- **High Porosity**
- **High Permeability**
- **High Initial Flow Rates**
- **Low Decline Rates**
- **High Total Cumulative Production**

Liquid Loading

The most drastic production increases from wellhead compression installations come from wells that are liquid loaded and need some form of artificial lift to bring the fluids to the surface. I have experienced applications where we have increased production from 50 mcf/d before installing a compressor and 750 MCFD after installing the compressor when liquid loading is present.

Most gas streams contain water or condensate. As the well pressure and production rate decline, liquids begin to accumulate in the tubing or flow path. This inability of the produced gas to remove the produced liquids from the wellbore is referred to as **liquid loading**.

Compression is typically the FIRST method of artificial lift.

Liquid Loading

The United States has approximately 400,000 active natural gas wells. Approximately **80%** of these wells suffer from liquid loading issues.

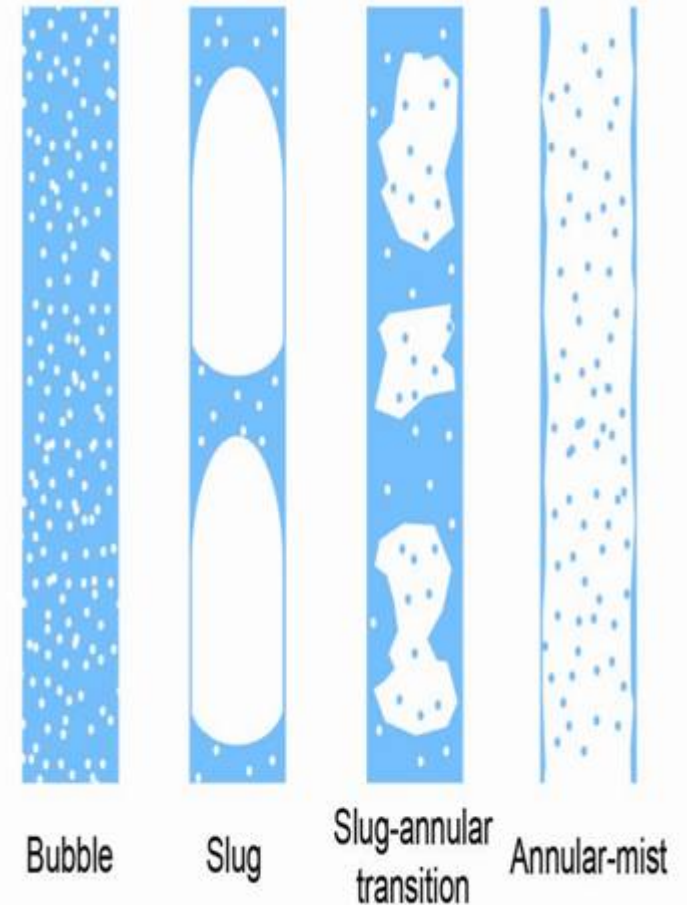
Lowering the surface pressure has two effects, both of which are beneficial for liquid loading problems.

- The flowing bottom hole pressure decreases, increasing the production rate and gas velocity throughout the wellbore.
- The required critical rate to remove liquids decreases because of the reduced pressure.

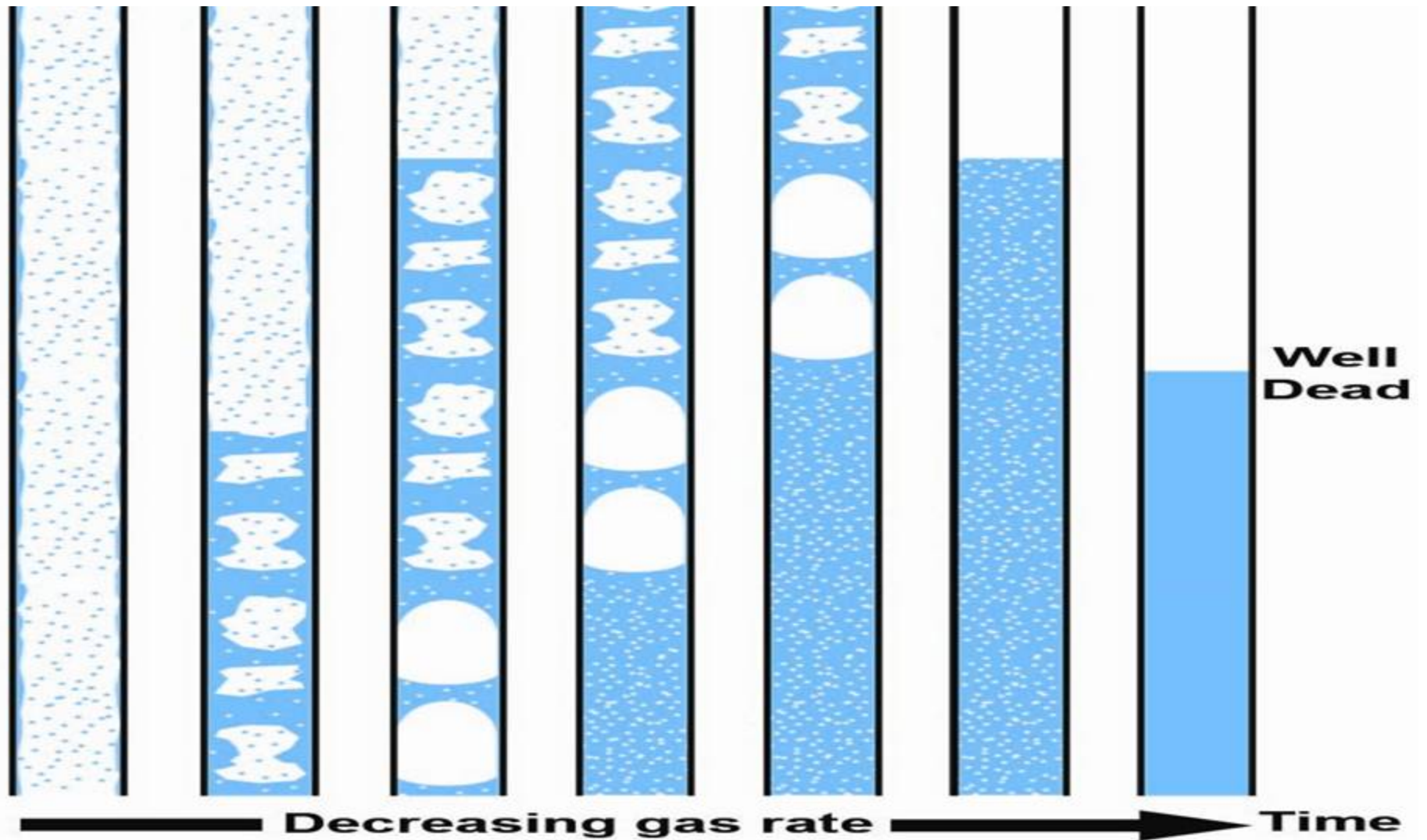
Liquid Loading

Multiphase flow in a gas well

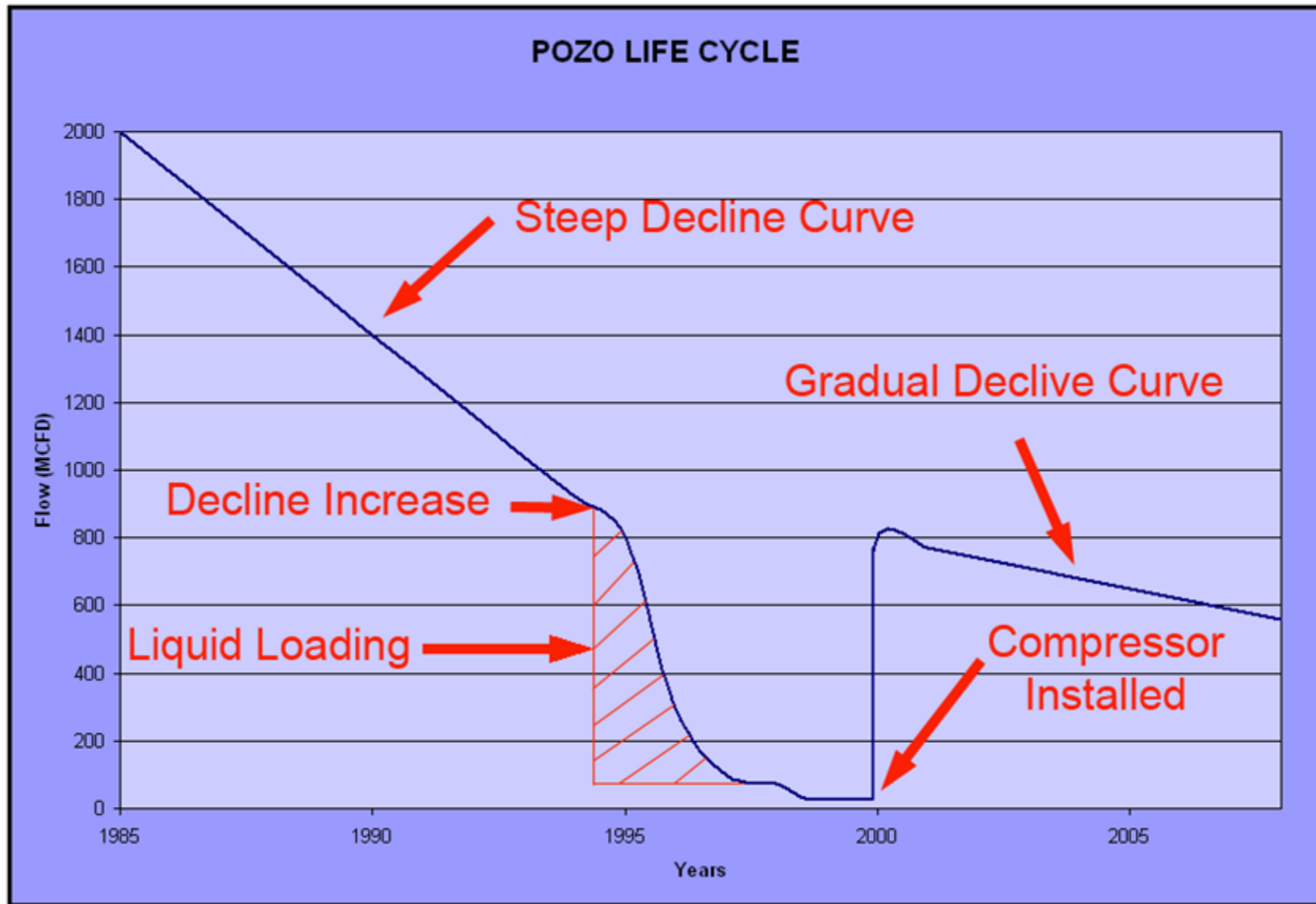
- **Bubble Flow** – The tubing is almost completely filled with liquid. Small bubbles of gas rise up through the liquid.
- **Slug Flow** – Gas bubbles expand as they rise and coalesce into larger bubbles and then slug.
- **Slug-Annular Transition** – The flow changes from continuous liquid to continuous gas phase.
- **Annular-Mist Flow** – Gas phase is continuous and most of the liquid is entrained in the gas as a mist. Flow rate is above critical in this flow phase.



Well Life Cycle



Well Flow Life Cycle



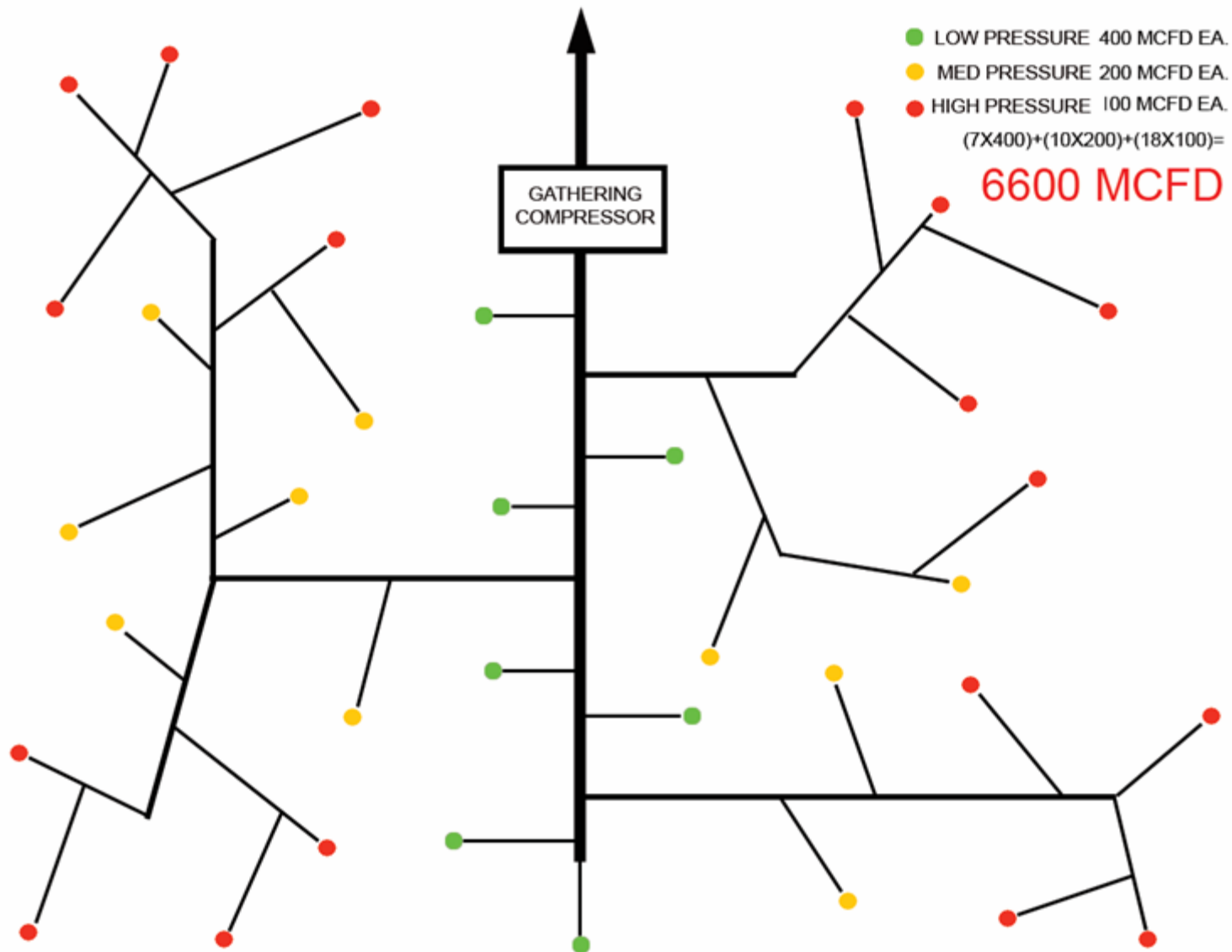
Gas Gathering

- Typically gas gathering is performed with one or more large centralized compressors. This is acceptable for new fields when system pressures are relatively high. As wells deplete and system pressures begin to fall over time, it is necessary to split up the gathering compression and move it closer to the individual wellhead. With that said, we have also been successful in installing multiple units in one location running in parallel. The customers can realize the following benefits from this multi-set concept:
- **Flexibility** – Units can easily be added or subtracted from the system as necessary. Units can also be moved closer to the wellhead as necessary, relieving typical compressor sizing issues.
- **Reliability** – Splitting up the function of one or two units into 6 or 10 units can result in increased run time for several reasons. If one unit breaks down only a fraction of production is lost. If some additional capacity is built into the system virtually 100% uptime can be guaranteed. This is also true when PM time comes. One unit is taken off-line while the speed is increased on the others.
- **Fuel efficiency** – Multiple small compressors often provide sizeable fuel efficiency over larger units. This is especially true when compared with older engines.

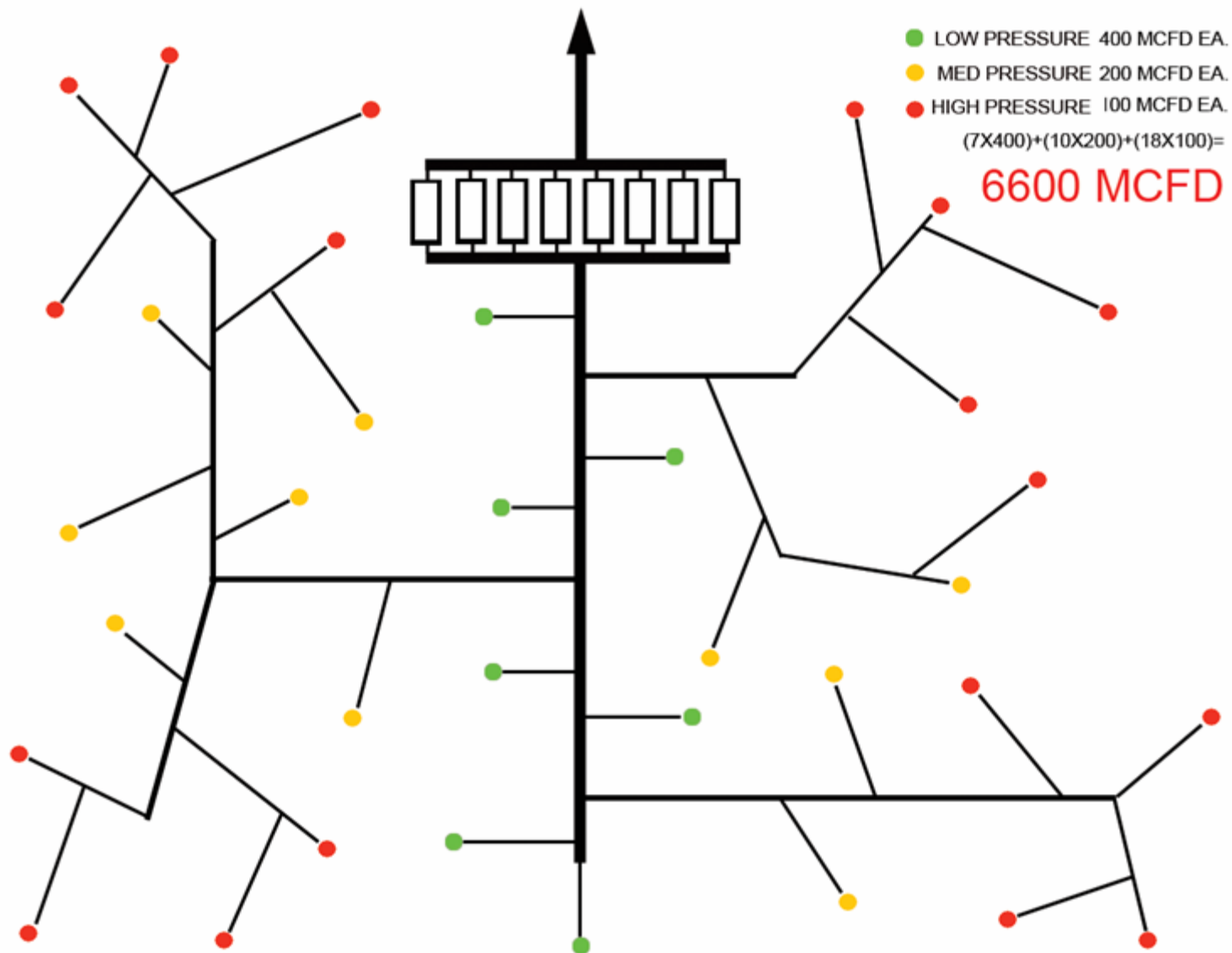
Gas Gathering



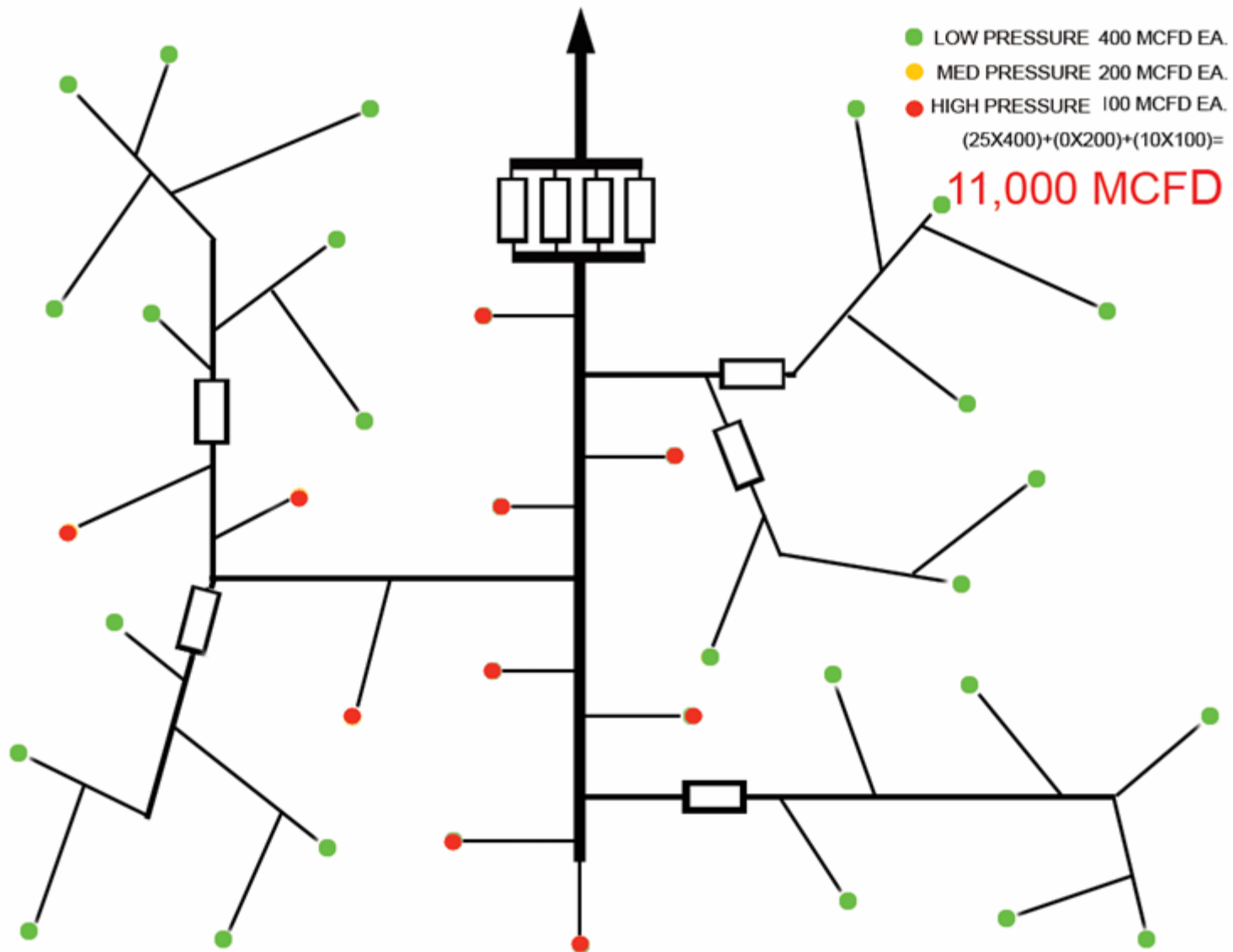
Typical Gas Gathering



Multi-Set Gathering



Integrated Gathering



Gas Gathering Recap

- Wells furthest from gathering station typically are first to benefit from wellhead compression due to pressure drops.
- Down stream compressors also benefit from higher suction pressures associated with wellhead compressors reducing overall system horsepower requirements. This also allows the gathering compressor to extend its useful life before re-sizing or re-staging is necessary.
- Higher system pressures at distant wells lead to reduced flow rates and premature liquid loading. This scenario can be relieved by moving in wellhead compressors closer to the individual wells.
- Other wells in the system without wellhead compressors will suffer due to higher system pressures.
- Also consider the size of flowline and the change in elevations. If a flowline is laid over several hills and valleys it is important to have good compression do to pressure drops in the line.

Casing Pressure Reduction

Oil wells with rod, progressive cavity (PCP) or submersible pumps (ESP) often can achieve increased oil and gas production through casing head pressure reduction. Increases between 2 – 20 bbl/day are common in our Oklahoma applications.



Plunger Coordination

- **Plunger lifts are another form of artificial lift. Compression can expand the usability of plunger lift and applications can benefit greatly from compression.**
- **Conventional plunger applications where shut in periods of greater than 30 minutes are required (shut in is determined based on an average fall time of 200 ft/min/1000 ft) can often benefit from wellhead compression where central compression is not possible at the time. Basically, the lower the tubing pressure or line pressure the more successful a plunger system can be.**



Vapor Recovery

- Automatic RPM adjustment with new PLC and make-up system allow the compressor to maintain constant suction pressure in vapor recovery applications.



Pigging

- Due to the portable nature and high flow rates associated with the trailer mounted compressor, mobile pigging operations may also be a good revenue generating application.



Competition

- **Rotary Screw Compressor**

SCREW ADVANTAGES

- Up to 15 ratios in a single stage
- Many different sizes available

RECIP ADVANTAGES

- Up to 30% less fuel gas required for the same application
- Lower overhaul cost than screw
- Ability to take on higher concentrations of fluids
- Automotive oil vs. costly synthetic

Ganzair LLC Underground storage compressor references

	Suction pressure barg	Discharge pressure barg	Capacity Nm ³ /h	Installed power kW	Year of installation	Remark	Type of compressor	Type of driver
1	50-125	63-185	62000-210000	3700	2022	See the performance chart below	Burckhardt 6HSE	Waukesha 16V275GL
2	45-55	100 -185	7 x 88000	7x5000	2007	See the picture below	Cooper WH76	Wartsila 9L345G
3	37	127 .142	21000 40000	2900	2020		Burckhardt 4HSE	ABB Electric 6,6kV

Performance chart of Nr1 reference.

This is multipurpose unit for different function:

- Fill up the gas storage,
- Booster of existing lower pressure compressors
- During the withdrawal boosting the low Gas storage pressure up to the gas grid pressure

Burkhardt 6HS-E																					
Priority sequence	Case #	Suction Ps (barg)	Suction temperature Ts(°C)	Q (Nm ³ /h)	Discharge pressure (barg) Pd	Compr stages	Compressor Burkhardt 6HS-E (bore 185 mm)										DN 200 pipe				
							6HS-E 185 mm Q (Nm ³ /h)	RPM	Q Nm3/h SACE	Q Nm3/h DA	Pshaft kW SACE	Pshaft kW DA	Pshaft kW SUM	Td oC	Nr of SACE/DA	Nr of first/second st.cylinders	Suction- internal or discharge Temps-	volume on suction side Nm3/sec	speed on the suction side m/sec	volume on disch. side Nm3/sec	speed on disch. m/s
0.97	1	125	+65*	200 000	185	1	210,852	1000	18,248	192,604	290	3,020	3,310	100.5	1/5	6/0	65-100.5-65	29.29	7.40	58.57	10.03
	2	135	+65*	220 000	185	1	239,129	1000	20,504	218,625	275	2,882	3,157	93.9	1/5	6/0	65-93.9-65	33.21	7.78	66.42	11.37
	3	125	+65*	250 000	160	1	256,339	1000	-	256,339	-	2,736	2,736	88.3	0/6	6/0	65-88.3-65	35.60	9.00	71.21	14.08
	4	135	+65*	250 000	160	1	257,723	900	-	257,723	-	2,023	2,023	81.8	0/6	6/0	65-81.8-65	35.79	8.38	71.59	14.16
	5	125	+65*	80 000	185	1	83,212	760	-	83,212	-	1,366	1,366	100.5	0/6	6/0	65-100.5-65	11.56	2.92	23.11	3.96
	6	135	+65*	80 000	160	1	117,539	750	81,745	35,794	655	280	935	81.8	5/1	6/0	65-81.8-65	16.32	3.82	32.65	6.46
II.	7	39	20	50 000	140	2	40,810	1000	-	40,810	-	2,113	2,113	127.0	0/6	3/3	20-55-56-127-65	11.34	9.03	11.34	2.56
	8	55	20	75 000	140	2	63,612	1000	-	63,612	-	2,337	2,337	108.9	0/6	3/3	20-47-55-108-65	17.67	10.05	17.67	3.99
III.	9	40	15	35 000	185	2	38,380	1000	-	38,380	-	2,360	2,360	135.0	0/6	3/3	15-63.5-55-135-65	10.66	8.28	10.66	1.83
	10	40	15	50 000	185	2	38,380	1000	-	38,380	-	1,524	2,360	136.0	0/6	3/3	15-63.5-55-136-65	10.66	8.28	10.66	1.83
	11	55	15	80 000	185	2	62,019	1000	-	62,019	-	2,937	2,937	124.0	0/6	3/3	15-49.5-55-124-65	17.23	9.80	17.23	2.95
IV.	12	50	15	180 000	63	1	119574	1000	-	119,574	-	783	783	54.0	0/6	6/0	15-29-55-65	16.32	10.19	33.22	16.53

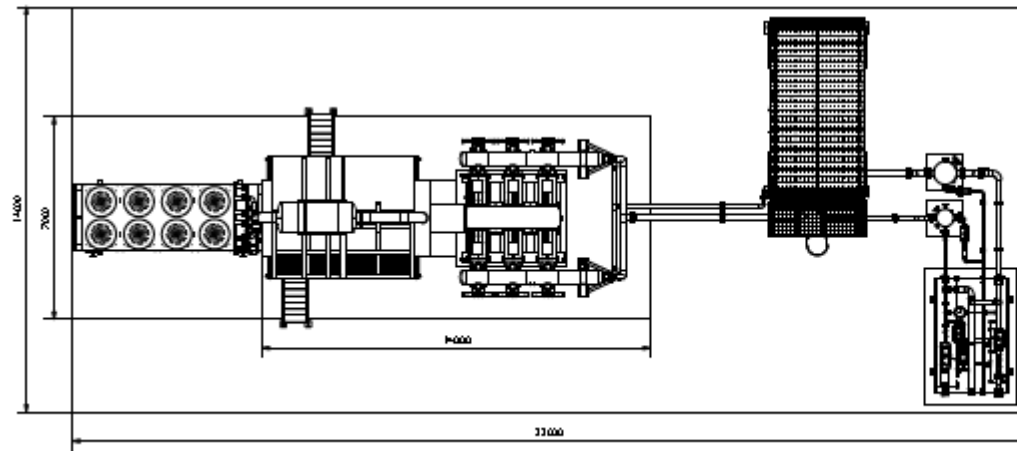
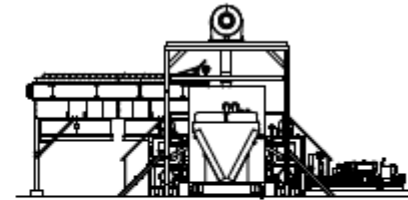
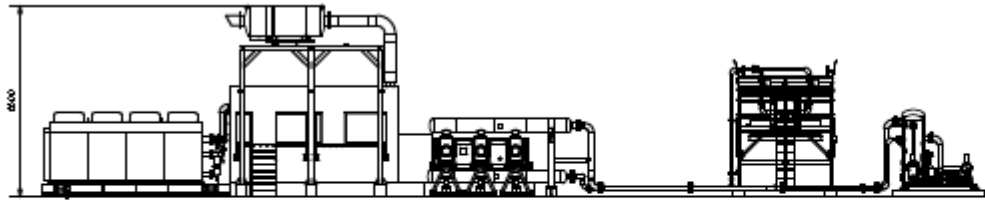
Picture of the Nr2 installation

Two compressor driven by middle voltage electric motor

Five compressor driven Warsila gas engine



Typical general arrangement of gas engine driven underground storage copressor unit





SELECTED REFERENCES OF GAS COMPRESSOR INSTALLATIONS BY GANZAIR

Customer	Type of compressor	Main driver	Qty	Power (kW)	Capacity (m3/h)	Suction pressure (bar)	Discharge pressure (bar)	Year
Slovakia	CAMERON C-Force34 (trailer mounted mobile unit)	CATERPILAR G3412LE gas engine	1	437	37500	5 – 74	75	2008
Czech Republic	CAMERON C-Force34 (trailer mounted mobile unit)	CATERPILAR G3412LE gas engine	1	437	37500	6 – 74	75	2009
Italy	CAMERON C-Force32	Electric motor	2	55	630	20	55	2008
Hungary	CAMERON MH62	Electric motor	1	560	166	20 – 40	75	2009
Hungary	Cameron Superior WG76	WARTSILA gas engine	5	4000	80000-108000	47 – 55	60 – 185	2009
Hungary	Cameron Superior WG76	Electric motor	2	5000	80000-108000	47 – 55	61 – 185	2009
Hungary	CAMERON AJAX integrated engine-compressor	integrated engine-compressor	1	220	12650	25-60	75	2011
Hungary	3SA 200 type containerized flare gas compressor	Electric motor	1	37	400	4-6	43-64	2011
Hungary	CAMERON C-Force32 (containerized portable unit)	Electric motor	1	110	500-11000	10-60	40-95	2012
Hungary	ST 30 type containerized flare gas compressor	Electric motor	1	30	300	3-6	43-64	2012
Hungary	Containerized high pressure CNG trailer filling compressor	Electric motor	1	110	1500	40-100	200	2012
Hungary	CAMERON C-Force32 (containerized portable unit)	Electric motor	1	110	500-11000	10-60	40-95	2012
Hungary	CAMERON AJAX integrated engine-compressor	integrated engine-compressor	1	220	12650	25-60	75	2012
Hungary	Waste gas compressor	Electric motor	1	110	1000	6	65	2012
Russia	CAMERON C-Force34 (containerized portable unit)	CATERPILAR G3412LE gas engine	4	437	37500	6 – 74	75	2013





Customer	Type of compressor	Main driver	Qty	Power (kW)	Capacity (m3/h)	Suction pressure (bar)	Discharge pressure (bar)	Year
Hungary	Well starter mobile compressor	diesel	1	30	500	20-50	150	2013
Hungary	Portable wellhead compressor	TEDOM gas engine	6	100	5000	3-40	20-40	2013
Hungary	VRC 2 type wellhead compressor	Electric motor	1	75	500-1800	10-60	40-65	2013
Hungary	VRC 2 type wellhead compressor	Electric motor	1	75	500-1800	7-13	20-50	2014
Hungary	Gas booster unit – natural gas gathering station	Electric motor	1	110	200-1000	7-12	55-65	2014
Hungary	CNG filling station compressor unit	Electric motor	1	110	260-710	2,5-8	220	2014
Hungary	Oil associated gas, flare gas and vapour recovery compressor	Electric motor	1	55	0-440	0-0,6	13	2014
Russia	CNG compressor station for LNG	CATERPILLAR G3412TA gas engine	4	373	1560-3005	6-12	250	2014
Slovakia	Pressure tester for mobile unit	Electric motor	2	11	24	1-3	250	2015
Hungary	CNG filling station compressor unit with adsorption dryer, cylinder storage and dispenser	Electric motor	1	55	200-260	2,5-5	250	2015
Serbia	Containerized compressor unit for oil associated gas	Electric motor	1	250	625-1460	1,7-2,5	35-45	2015
Hungary	Fuel gas booster for gas turbine	Electric motor	1	5,5	40	0-0,6	6	2015
Serbia	Containerized compressor unit for oil associated gas	Waukesha gas engines	4	230-440	1420-3580	2-3 12-17	12-17 45-51	2016
Hungary	CNG filling station compressor unit	Electric motor	5	110	260-710	2,5-8	220	2016
Czech Republic	CNG filling station compressor unit	Electric motor	1	45	110	1-2	250	2016
Serbia	Containerized compressor unit for oil associated gas	Waukesha gas engines	1	451-760	2080-5420	1,1-1,8	42-50	2017
Serbia	Containerized compressor unit for oil associated gas	Waukesha gas engines	1	230-440	1420-3580	2-3	12-17	2017





Customer	Type of compressor	Main driver	Qty	Power (kW)	Capacity (m3/h)	Suction pressure (bar)	Discharge pressure (bar)	Year
Lithuania	Mobile evacuation unit	Waukesha gas engine	1	437	35000	10	75	2017
Serbia	Containerised unit for oil associated gas	Waukesha gas engine	1	451-760	2080-5420	1,1 -1,8	42-50	2017
Croatia	Wellhead compressor	Electric motor	1	24	250	0,5	11	2017
Croatia	Gas booster unit – natural gas gathering station	Electric motor	1	160	625	2-5	50	2017
Hungary	Gas booster unit	Electric motor	1	25	670	0,5	70	2017
Russia	Mobil evacuation unit	Caterpillar gas engine	2	470	2000-35000	8-75	75	2017
Austria	Wellhead compressor	Electric motor	5	160 & 315	1500 & 3000	15	66	2017
Hungary	Gas booster unit for turbine	Electric motor	1	500	11000	25	62	2017
Poland	Gas booster unit	Arrow engine	1	150	80	2,0	45	2018
Hungary	Gas booster unit	Electric motor	1	75	1000	12	63	2018
Hungary	Gas booster unit	Electric motor	1	160	2500	20-25	50	2018
Hungary	Gas booster unit	Electric motor	1	160	2600	20-60	60-100	2018
Serbia	Containerized compressor unit for oil associated gas	Waukesha gas engines	1	451-760	2080-5420	1,1-1,8	42-50	2018
Hungary	Containerized compressor unit for oil associated	Electric motor	1	250	3500	5	20	2018
Hungary	Flare gas compressor	Electric motor	1	250	3500	5	20	2018
Hungary	Gas booster unit	Electric motor	1	200	2300	20	60	2018
Hungary	Gas booster unit	Electric motor	1	250	6000	50	75	2019
Slovenia	Gas booster unit	Electric motor	1	132	1250	8-20	60	2019
Hungary	Gas lifter unit	Waukesha gas engine	1	800	1000	10	160	2019





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Serbia	Gas booster unit	Waukesha gas engine	1	451-760	2080-5420	1,1-1,8	42-50	2020
Hungary	Gas booster unit	Electric motor	1	2990	40000	50	150	2021
Romania	Wellhead compressor	Tedom gas engine	2	100	3000	5-13	20-24	2021
Hungary	Gas booster unit	Electric motor	2	315	1000-3500	2-5	25	2021
Hungary	Gas lifter unit	Electric motor	1	1015	10000	10	160	2021
Hungary	Gas storage compressor	Electric motor	1	2796	20000-40000	36-50	125-140	2021
Hungary	Containerized compressor unit for oil associated gas	Electric motor	1	315	1667	0,5-1,0	4-11	2021
Hungary	Gas lifter unit	Electric motor	2	560	9000	35-40	140-160	2022

