Casing Gas Compression

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Casing Gas

- Oil in formations includes natural gas in solution
- For oil to flow into a well, the pressure at the bottom of the well must be less than that of the formation. As oil flows into the well, gas will come out of solution and collect in the casing
- This gas was traditionally dealt with in one of two ways
  - Venting the casing to atmosphere
  - Connecting the casing to the flow line

Casing Pressure

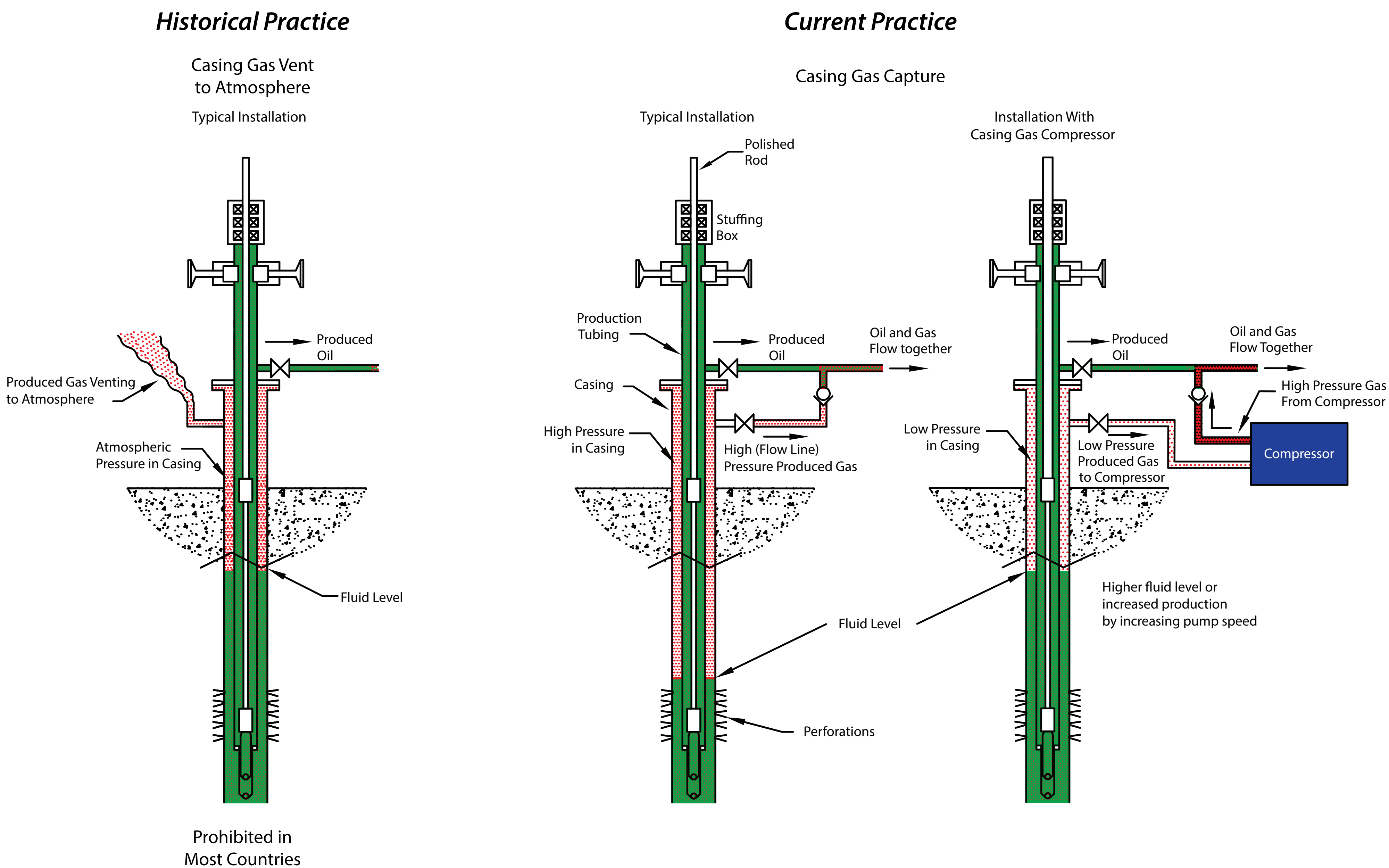
Vent to atmosphere

- Venting methane to atmosphere is bad for the environment, methane has 25x the greenhouse effect of CO_2 (based on 100 year global warming potential)
- Wasting a potentially valuable and finite resource
- This practice is now illegal in many countries for the above reasons

Connect to flow line

- Can reduce well performance due to high backpressure on formation
- Convenient, only 1 pipeline required, gas can be separated from stream and used at battery

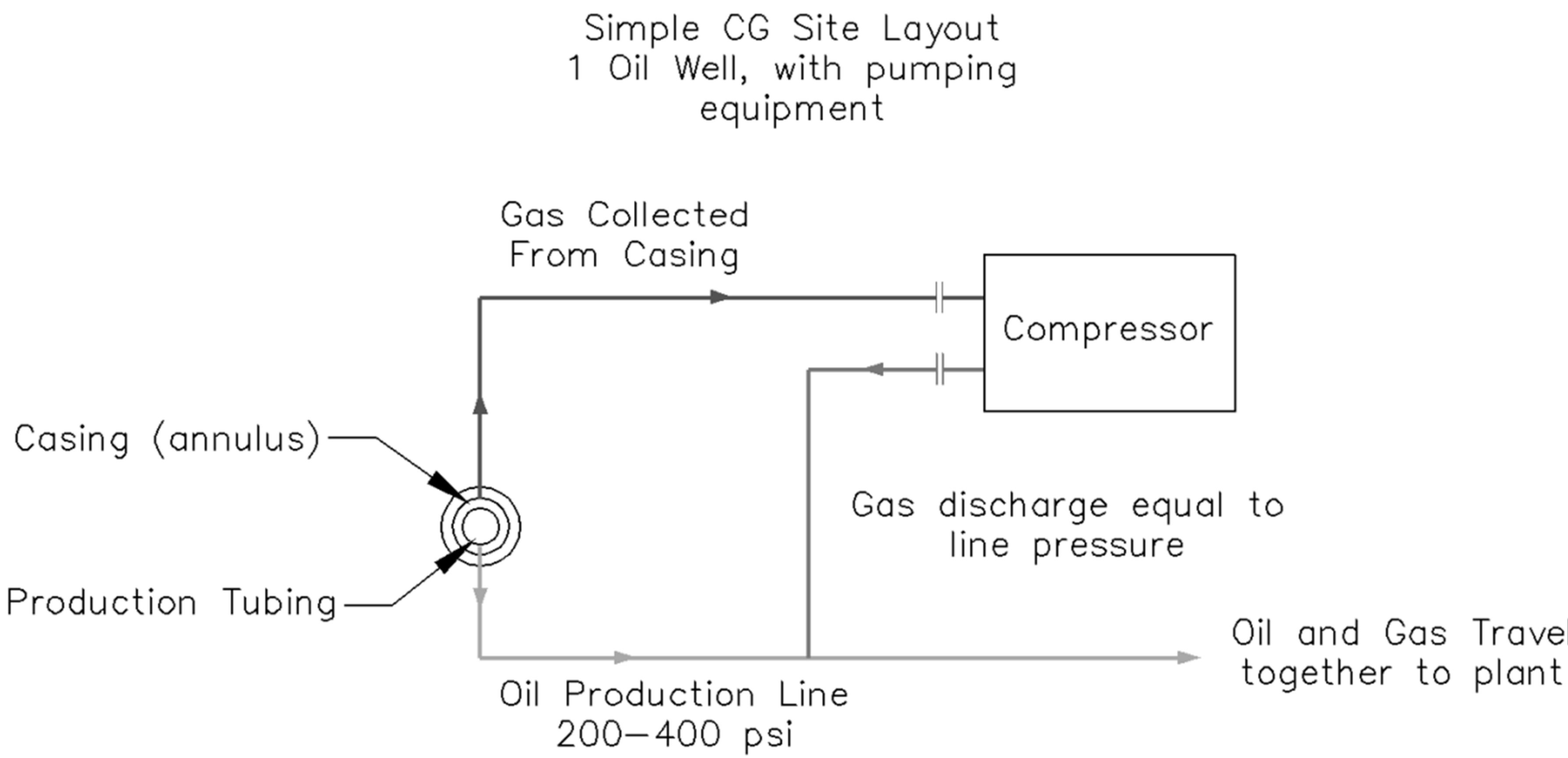
Well Connection Diagram



Why Casing Gas Compression?

- No venting –deliver gas to flow line
- Can use gas as fuel or sell it
- Reduce casing pressure, lowering the backpressure on the formation. This will:
  - Increase rate of oil production
  - Increase overall oil recovery

Typical Site Layout



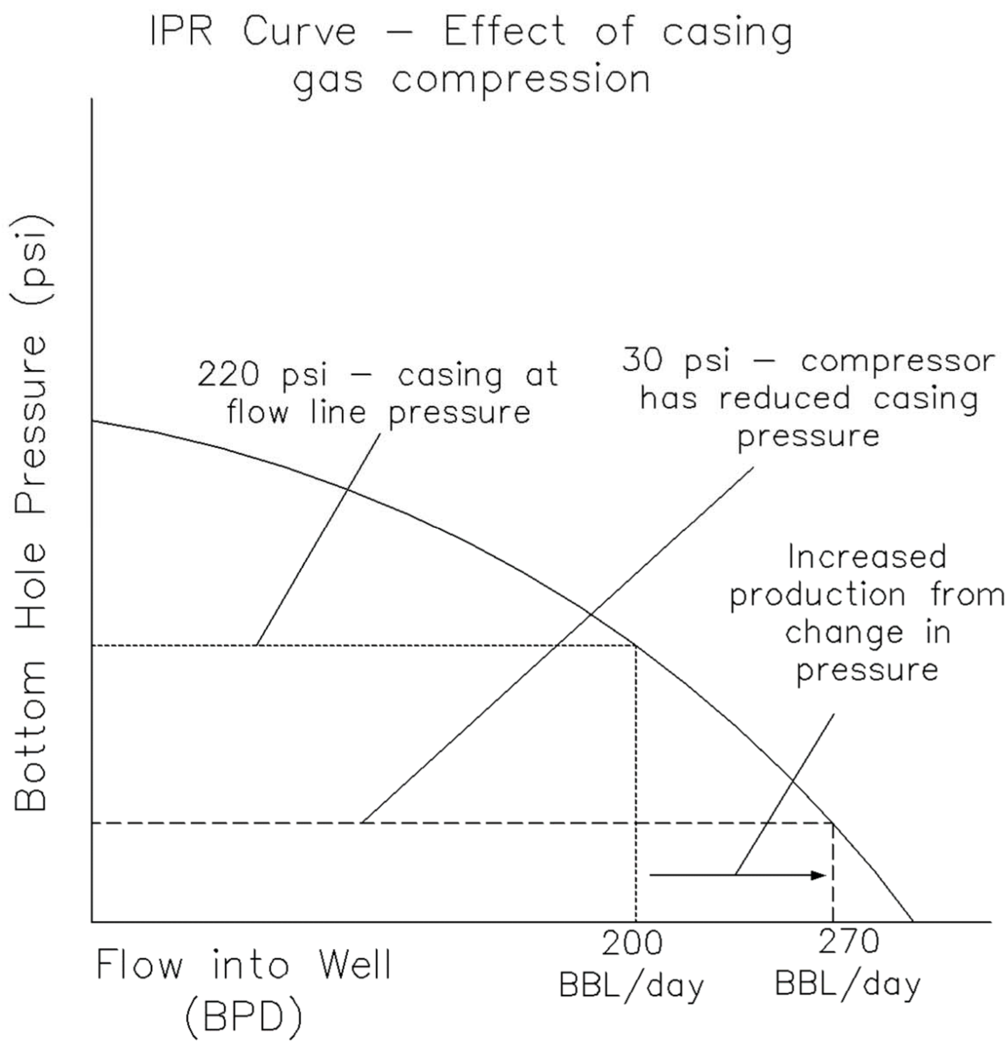
What does it do

- Reduce pressure in casing, lowering bottom hole pressure
- Differential pressure between the formation and bottom hole is what drives the inflow of oil to the well
- Maximum flow line pressures can reach between 1380-2070 kPa / 200-300 psi
- A compressor can typically reduce casing pressure to 35-207 kPa / 5-30 psi, depending on size and gas flow
- Reduction of backpressure against the formation results in higher oil recovery rate
- This effect will be more significant on low pressure formations
  - Formation pressure of 20700 kPa (3000 psi), well is 1380 kPa (200 psi), drops to 207 kPa (30 psi), change is 6%
  - Formation pressure is 6894 kPa (1000 psi), well is 1380 kPa (200 psi), drops to 207 kPa (30 psi), change is 18%

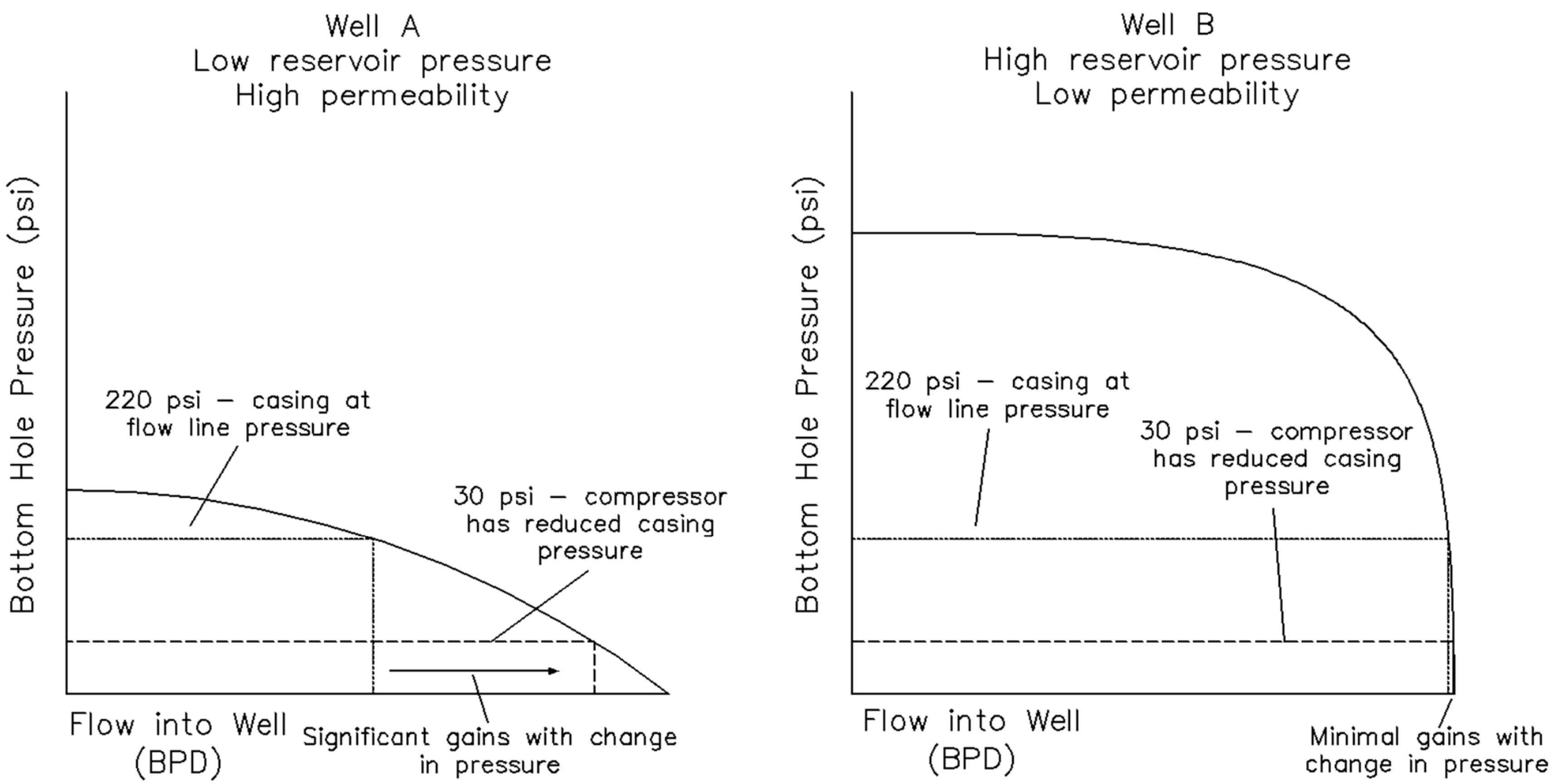
IPR Curves

- Inflow Performance Relationship
- Indicate change in inflow rates with change of bottom hole pressure
- Essentially, the reservoir's ability to flow to the well at a range of bottom hole pressures
- Depends on reservoir structure, permeability, pressure, and other factors
- Can be used as a first indicator of a well potentially suited for casing gas compression

Example IPR curve



Suitability of a well for casing gas compression



Wells Prone to Gas Lock

- Gas lock may occur due to a variety of conditions, such as high GOR, pump spacing, and pump landing location
- A gas locked pump can cause severe equipment damage
- On wells where this is a known issue, a casing gas compressor may aggravate the problem, as lowering downhole pressure will increase the rate of gas breakout
- Potential solutions would be:
  - Resetting pump spacing to maximize pump compression ratio
  - Adding a gas anchor or other gas separation device to the pump
  - Change to a pump designed to handle gas
  - Re-landing the pump further below the perforations
- If these do not solve the problem, this well may not be suitable for casing gas compression
- The solution may be to increase head pressure on the pump. This would involve maintaining greater fluid height in the well. Essentially, giving up some amount of production rate in order to avoid gas lock issues.
- Testing is critical, the only way to ensure that a well is suitable for casing gas compression is to test in advance

Testing for suitability

- Trailer mounted compressors are simple to move around, saving labor and time over testing with a skid mounted unit
- Screw compressors are quite flexible in performance can be adapted to a wide range of operating conditions
- Gas driven, will run off compressed gas, no need for an electrician to hook up power
- A test compressor will determine exactly how a well will respond to casing gas compression, making the economics of the application a certainty rather than speculation
- Can be equipped with a flow meter to precisely determine required size of compressor

How do we do it

- Small Hydraulic Compressor – CHC0615
  - Low flow (0.1-3 e3m3/day or 0.3-105 mcfd)
  - Shut in pressure up to 10000 kPa / 1500 psi
- Large Hydraulic Compressor – CHC1050
  - Medium flow (1-10 e3m3/day or 35-350 mscfd)
  - Shut in pressure up to 10000 kPa / 1500 psi
- Oil Flooded Screw
  - High flow (6-37 e3m3/day or 200-1300 mscfd)
  - Shut in pressure up to 2070 kPa / 300 psi

Hydraulic Casing Gas Compressor

- Purpose design for low volume casing gas applications
- Ideal for single well application
- Compressor is designed for sweet or sour service
- No operator setup or adjustment is required
- Eliminates issues common with conventional casing gas compressors
  - No process valves or coolers to become contaminated
    - No inlet valve
    - No recycle valve
    - No intercooler
  - No liquid handling system (compressor can pump liquid or gas)
    - No separator
    - No level shutoff
    - No level switch
    - No liquid pump
- Ultra reliable gear pump and electric motor power supply
- Minimum moving parts
- Satellite call out system notifies operators if unit shuts down
- No external leak points for oil or gas seals
- Automatic restart if grid power is lost
- Capacity control
  - Compressor will adjust cycle rate to match flow
  - Up to 100% turn down

HCG Performance 15hp (US units)

CHC0615 with HC613 Compressor
Maximum ΔP: 225 psi

SUCTION PRESSURE	DISCHARGE PRESSURE								
	75	100	125	150	175	200	225	250	275
5	38	37	35	34	33	32	31		
10	49	48	47	45	44	43	42		
15	61	59	58	56	55	54	53		
20	72	70	69	68	66	65	64		
30	95	93	91	90	88	87	86	84	
40	118	116	114	112	111	109	108	106	
50	140	139	137	135	133	132	130	129	127

CHC0615 with HC616 Compressor
Maximum ΔP: 350 psi

SUCTION PRESSURE	DISCHARGE PRESSURE								
	200	225	250	275	300	325	350	375	400
5	20	19	19	18	17	16	16		
10	27	26	26	25	24	23	23		
15	34	33	32	32	31	30	29		
20	41	40	39	39	38	37	36		
30	55	54	54	53	52	51	50	49	
40	70	69	68	67	66	65	64	63	
50	84	83	82	81	80	79	78	77	76

*Projected Performance based on 2500 ft, gas density .665, temp 68 ºF Pressures in PSI Flow Rates in MSCFD

HCG Performance 50hp (US units)

CHC1050 with HC1022 Compressor
Maximum ΔP: 225 psi

	DISCHARGE PRESSURE								
SUCTION PRESSURE	75	100	125	150	175	200	225	250	275
5	100	95	91	87	83	79	75		
10	130	125	121	117	112	108	104		
15	160	156	151	147	147	138	134		
20	191	186	181	177	1722	168	164		
30	252	247	242	237	233	228	223	219	
40	314	308	303	298	293	288	284	279	
50	376	370	364	359	354	349	344	339	334

CHC1050 with HC1028 Compressor
Maximum ΔP: 380 psi

	DISCHARGE PRESSURE								
SUCTION PRESSURE	200	225	250	275	300	325	350	375	400
5	45	43	41	39	36	34	32	30	
10	61	59	58	56	53	52	49	47	
15	77	76	75	73	71	68	66	64	
20	97	95	93	90	88	86	83	81	78
30	131	129	127	125	123	120	118	115	113
40	165	164	163	161	158	155	157	150	148
50	200	197	195	193	190	188	186	183	181

*Projected Performance based on 2500 ft, gas density .665, temp 68 ºF Pressures in PSI Flow Rates in MSCFD

HCG Performance 15hp (metric)

CHC0615 with HC613 Compressor Maximum ΔP: 1550 kPa										
		DISCHARGE PRESSURE								
SUCTION PRESSURE		510	690	860	1035	1200	1380	1550	1720	1900
	35	1.1	1.1	1.0	1.0	0.9	0.9	0.9		
	70	1.4	1.4	1.3	1.3	1.3	1.2	1.2		
	100	1.7	1.7	1.7	1.6	1.6	1.5	1.5		
	140	2.1	2.0	2.0	1.9	1.9	1.9	1.8		
	200	2.7	2.7	2.6	2.6	2.5	2.5	2.5	2.4	
	275	3.4	3.3	3.3	3.2	3.2	3.1	3.1	3.0	
	345	4.0	4.0	3.9	3.9	3.8	3.8	3.7	3.7	3.6

CHC0615 with HC616 Compressor Maximum ΔP: 2400 kPa										
		DISCHARGE PRESSURE								
SUCTION PRESSURE		1380	1550	1720	1900	2070	2240	2400	2585	2760
	35	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5
	70	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7
	100	1.0	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.8
	140	1.2	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.0
	200	1.6	1.6	1.6	1.5	1.5	1.5	1.5	1.5	1.4
	275	2.0	2.0	2.0	2.0	1.9	1.9	1.9	1.9	1.8
	345	2.5	2.4	2.4	2.4	2.3	2.3	2.3	2.3	2.2

*Projected Performance based on 760m, gas density .665, temp 20 ºC Pressures in kPa Flow Rates in 1000 m3/day

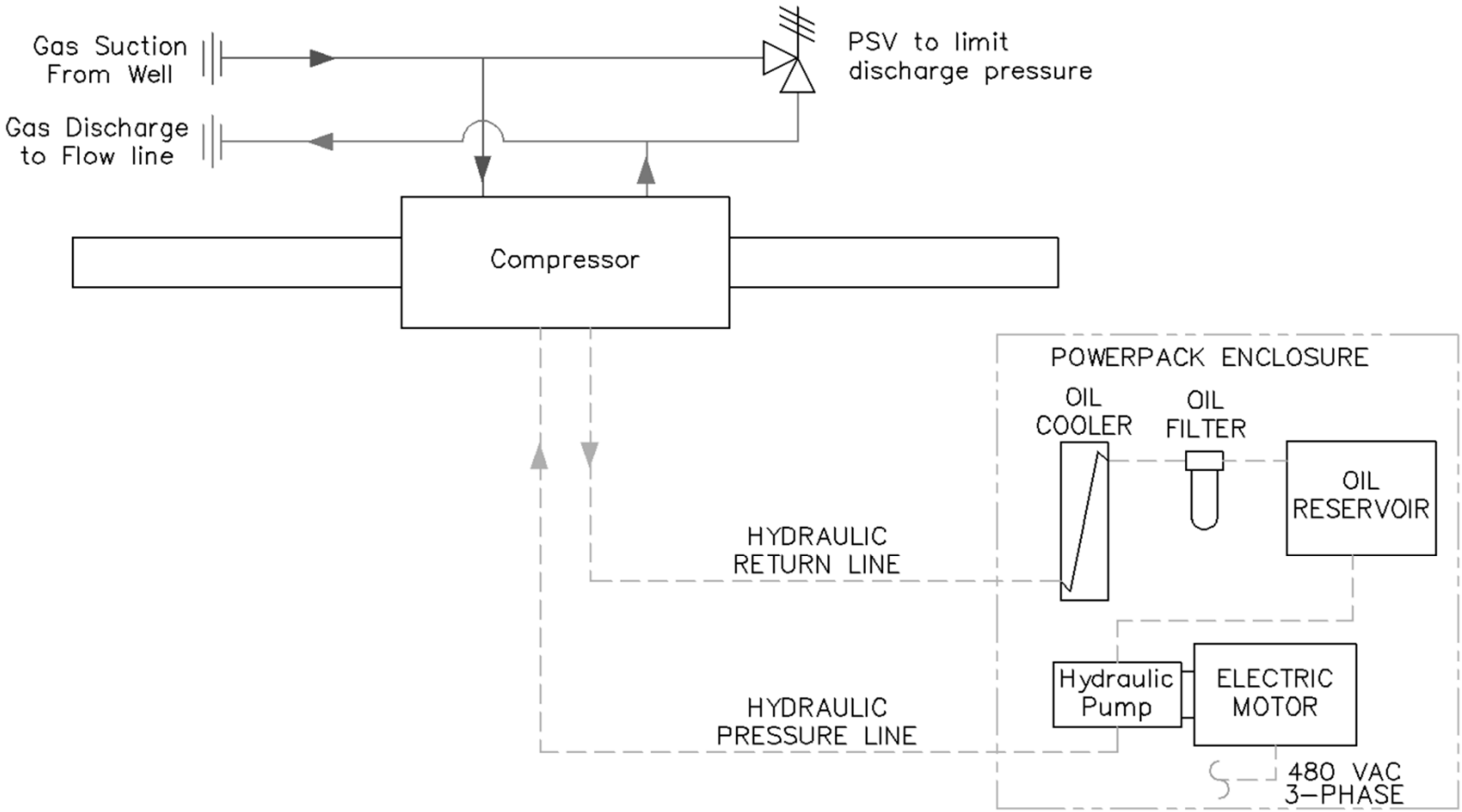
HCG Performance 50hp (metric)

CHC1050 with HC1022 Compressor Maximum ΔP: 1550 kPa										
		DISCHARGE PRESSURE								
		510	690	860	1035	1200	1380	1550	1720	1900
SUCTION PRESSURE	35	2.84	2.72	2.59	2.48	2.36	2.25	2.14		
	70	3.71	3.58	3.45	3.33	3.21	3.09	2.98		
	100	4.58	4.45	4.31	4.19	4.21	3.94	3.82		
	140	5.45	5.31	5.18	5.05	49.20	4.80	4.67		
	200	7.21	7.06	6.92	6.77	6.64	6.51	6.38	6.26	
	275	8.97	8.81	8.66	8.52	8.37	8.24	8.10	7.97	
	345	10.74	10.57	10.41	10.26	10.11	9.97	9.83	9.69	9.54

CHC1050 with HC1028 Compressor Maximum ΔP: 2600 kPa										
		DISCHARGE PRESSURE								
		1380	1550	1720	1900	2070	2240	2400	2585	2760
SUCTION PRESSURE	35	1.29	1.23	1.17	1.10	1.04	0.98	0.91	0.85	
	70	1.74	1.69	1.66	1.59	1.53	1.47	1.39	1.33	
	100	2.20	2.17	2.15	2.09	2.02	1.95	1.88	1.82	
	140	2.77	2.71	2.65	2.58	2.51	2.44	2.37	2.31	2.24
	200	3.74	3.69	3.66	3.58	3.51	3.44	3.37	3.29	3.22
	275	4.71	4.69	4.67	4.59	4.51	4.44	4.49	4.29	4.22
	345	5.71	5.63	5.57	5.51	5.43	5.37	5.31	5.23	5.17

*Projected Performance based on 760m, gas density .665, temp 20 ºC Pressures in kPa Flow Rates in 1000 m3/day

Typical process diagram



Shutdowns and warnings

- The PLC manages all aspects of compressor operation. It will provide the following alarms:
  - Low suction pressure
  - High discharge pressure
  - High discharge temperature
  - High oil temperature
  - Low oil level
- As well as shutdowns for these conditions:
  - Oil level low
  - Oil leak detected
  - Motor overload
  - Failure to cycle
- Compressor will send a message via satellite to indicate an alarm or shutdown condition

Shutdown Interlock

- When compressor shuts down casing pressure will rise
- This leads to a drop off in inflow to the well
- It is possible that while the compressor is shut off the pumpjack could pump itself off, damaging equipment
- Using an interlock so that both compressor and pumpjack shut off together will prevent this
- On certain wells this may not be needed, a simple auto bypass may be sufficient to maintain production until the compressor can be restarted