
UNVEILING THE MAGIC OF MIDSTREAM INNOVATION
2025
GPA MIDSTREAM CONVENTION
Welcome!

Lubricant Carry Over Implications

The Operational and Gas Quality Implications of Entrained Lubricants from Gas Compressor Lubricant "Carry Over"

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2025 UNVEILING THE MAGIC OF MIDSTREAM INNOVATION
GPA MIDSTREAM CONVENTION

GPA MIDSTREAM ASSOCIATION

Lubricants AREN'T Magic or Dark Art
Lubricants ARE Good Engineering/Chemistry

Basics come from high school chemistry

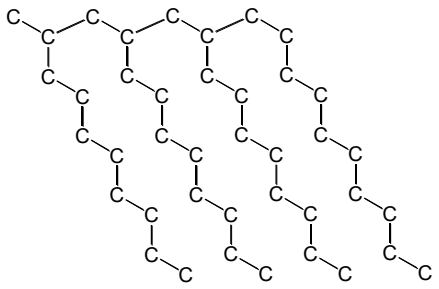
Like dissolves Like

- **Hydrocarbon Gases are <u>excellent solvents</u> for hydrocarbon oils**
  - Motor oil, Mineral Oil, and PAOs
  - Solvents cut viscosity!

Even methane and ethane are solvents at higher pressure
If it goes in a can, it is an excellent solvent

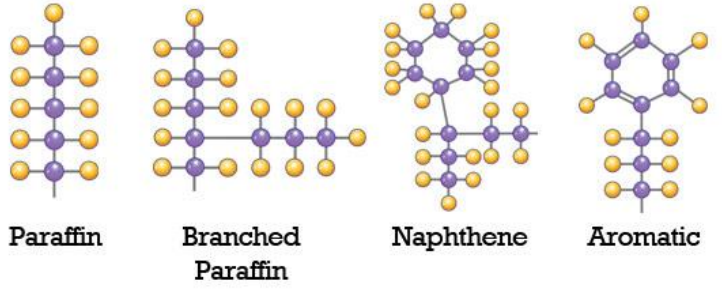
Molecular Structures - Simplified

- PAO



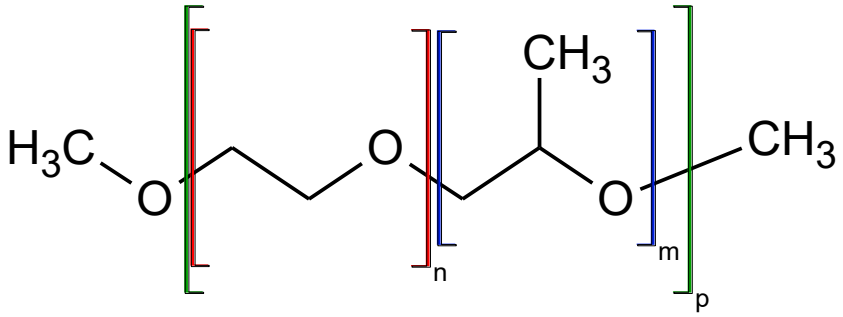
Poly-α-Olefins

- MO



Mineral oils, engine oils

- PAG



Polyalkylene Glycol

High School Chemistry – Part 2 - Simplified

Dalton's Law of Partial Pressures

$$P_{total} = P_{gas1} + P_{gas2} + P_{gas3} + \cdots$$

or

$$P_{gas,i} = y_{gas,i} P_{total}$$

Example - Well Composition Analysis

GAS ANALYSIS SERVICE

2030 Afton Place
Farmington, NM 87401
(505) 325-6622

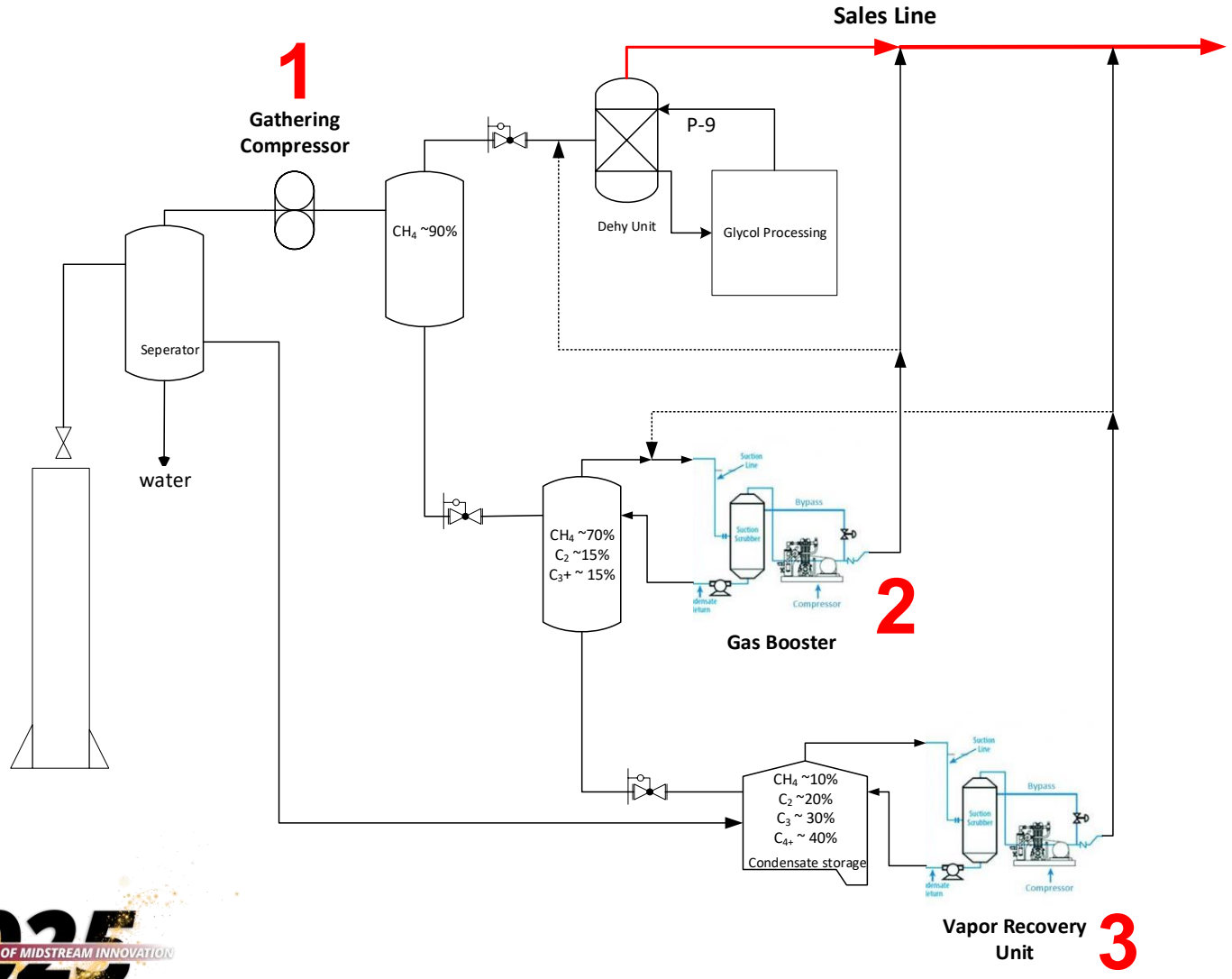
Analysis No: FX130006
Cust No: 29800-10135

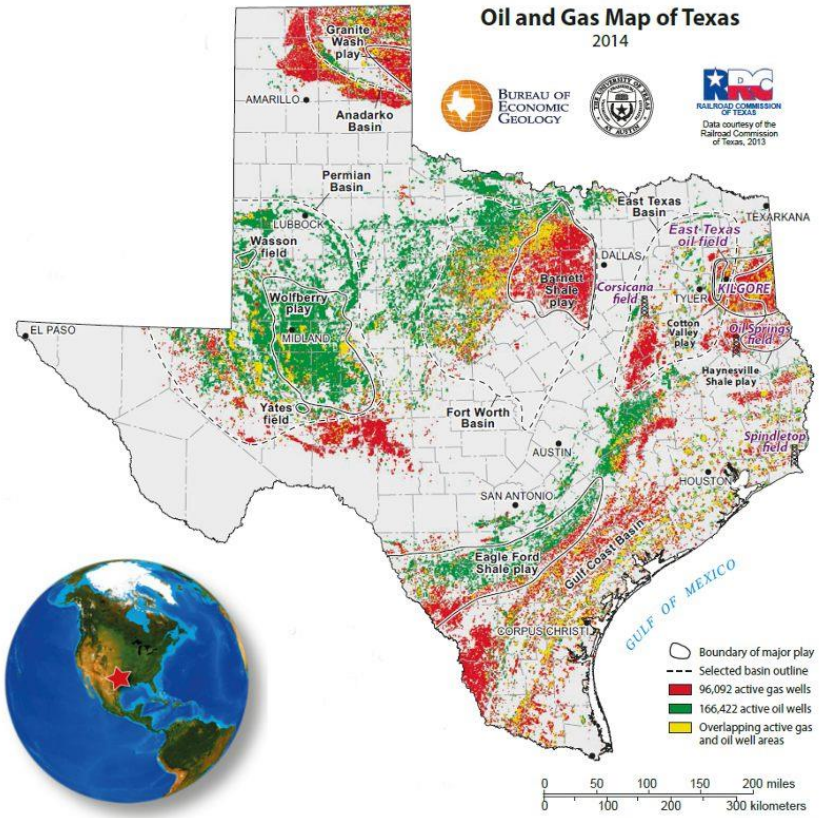
Remarks: PRESSURE: 13.79 OZ; PRESSURED WITH HELIUM TO 30 LBS.
WELD COMP SUCTION INLET GAS

Analysis

Component::	Mole%:	**GPM:	*BTU:	*SP Gravity:
Nitrogen	1.064	0.1180	0.00	0.0103
CO2	1.868	0.3220	0.00	0.0284
Methane	26.745	4.5840	270.12	0.1481
Ethane	26.562	7.1810	470.07	0.2758
Propane	27.387	7.6280	689.08	0.4170
Iso-Butane	4.737	1.5670	154.04	0.0951
N-Butane	8.835	2.8160	288.22	0.1773
I-Pentane	1.270	0.4700	50.81	0.0316
N-Pentane	1.033	0.3790	41.41	0.0257
Hexane Plus	0.499	0.2250	26.30	0.0165
Total	100.000	25.2900	1990.07	1.2258

Different locations, different situations Pipeline, Field, and Processing





Gas Mix Oil

Case 1 – Gas Gathering (clean gas)

	Mol % Mild Pipeline	Partial Pressure, bara
Methane	95	65
Ethane	2.5	1.75
Propane	0.2	0.14
Butanes	~0	small
Pentanes	~0	small
C6+	~0	small
N_2 & CO_2	2.3	small
Example Operating Conditions		
Discharge Temperature, °C (°F)	105 (221)	
Discharge Pressure, bara (psig)	70 (1000)	
Oil Cooling Temp Drop, K (°R)	-	
Oil Injection Temp, °C (°F)	-	
Compressor Type	Large Frame Piston	
Compressor Viscosity Requirements, cSt	>16	
Approx. Gas Dew Point, °C (°F)	-	

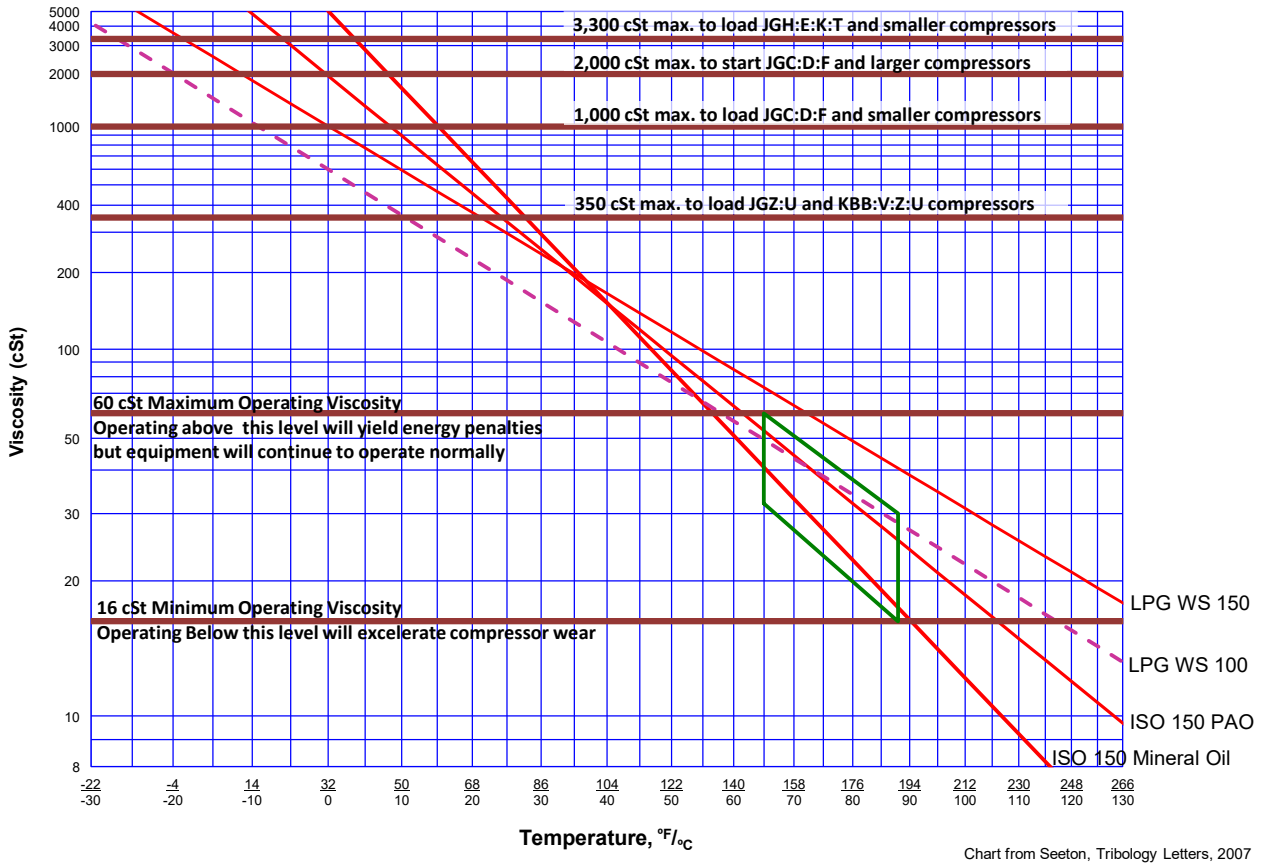


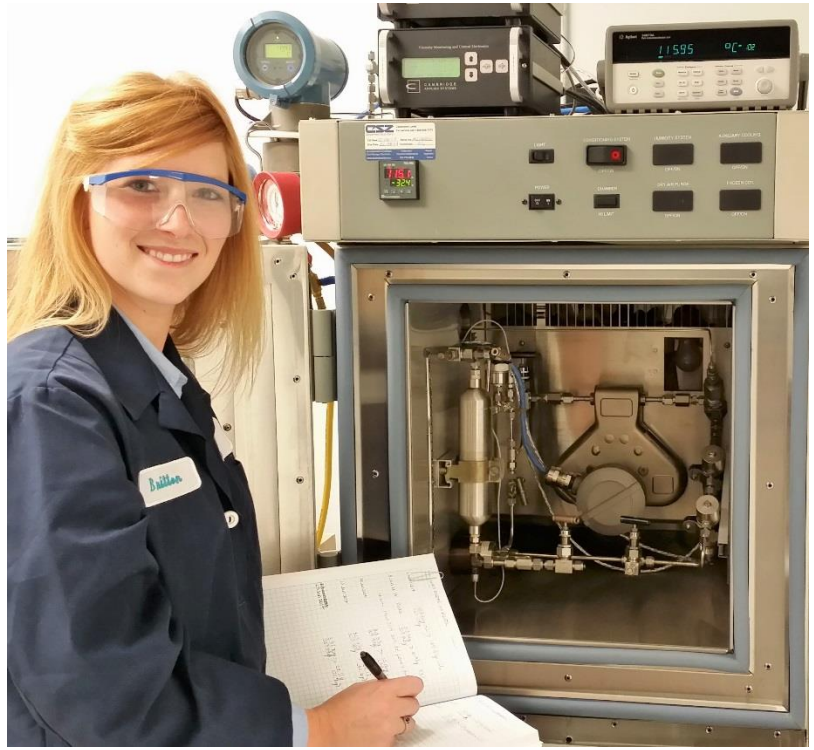
Chart from Seeton, Tribology Letters, 2007

Hypothesis: Use the Neat Oil data for lub selection
Eng Method: 1st Need to understand gas dilution
Remember: 16 cSt Min. Op. Viscosity

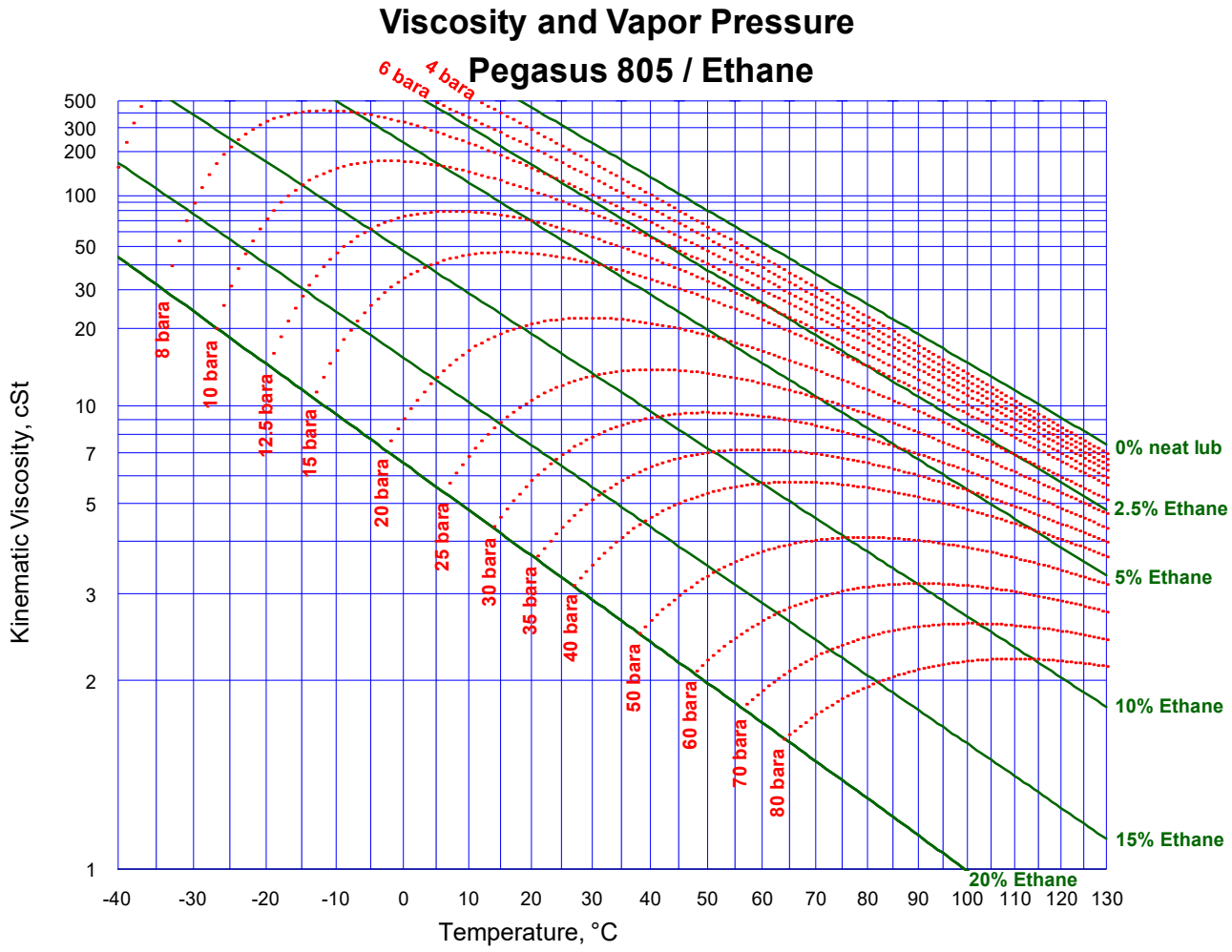
GMRC Project (2018)

- Measure the solubility and viscosity
  - Temperature: -30 to 130°C (-22 to 266°F)
  - Pressure: up to 150 bara (2250 psig)
  - Composition up to 30% dissolved gas

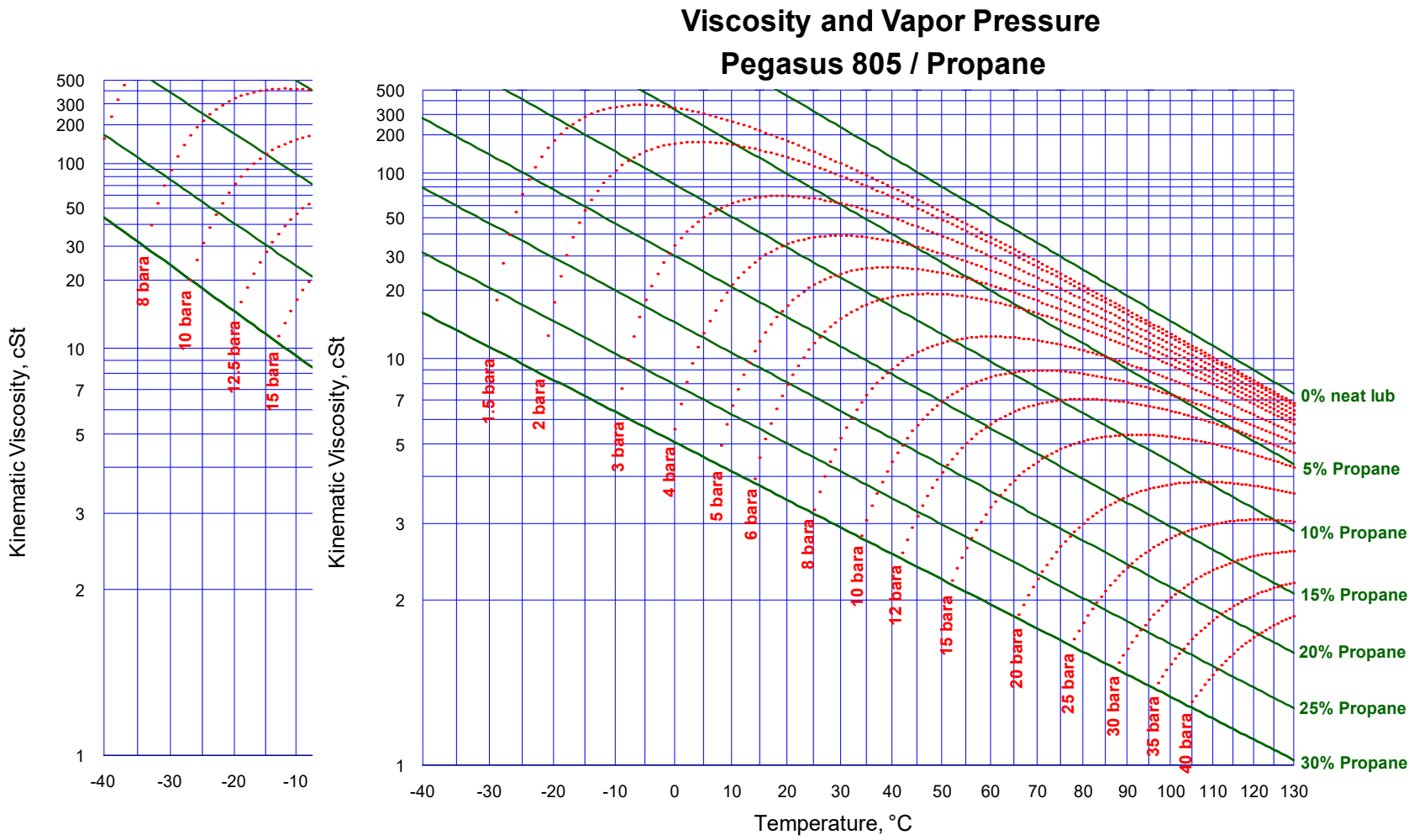
Gases	Lubricants
Methane	MO 150 (Pegasus 805)
Ethane	R&O 150 (Lubsoil Synthetic 2150)
Propane	WS PAG (Progiline LPG WS 150)
Butane & iButane	
Pentane & iPentane	
Hexanes	
CO_2	



GMRC Project - Results



GMRC Project – Results
Mineral Oil (engine oil similar)



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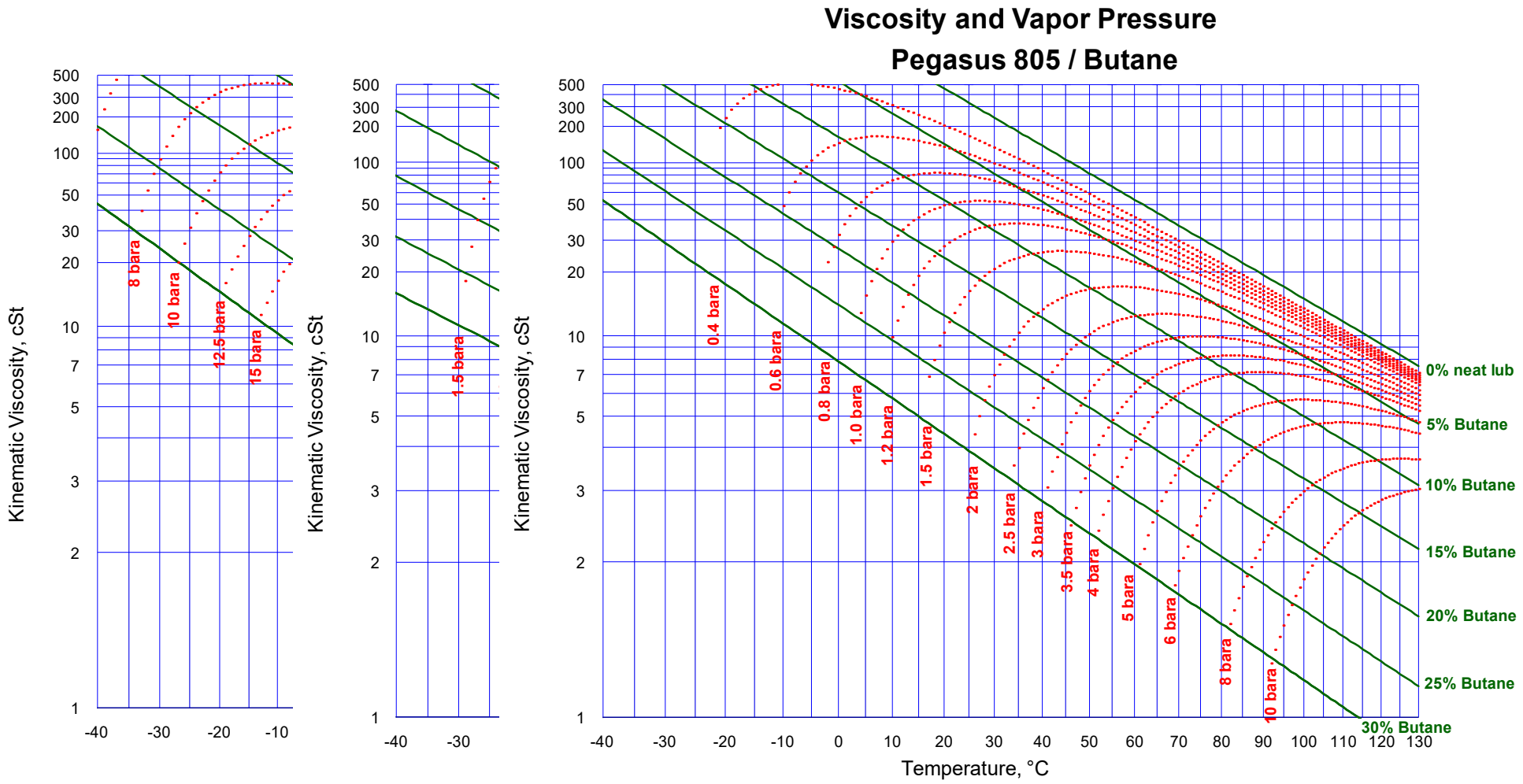

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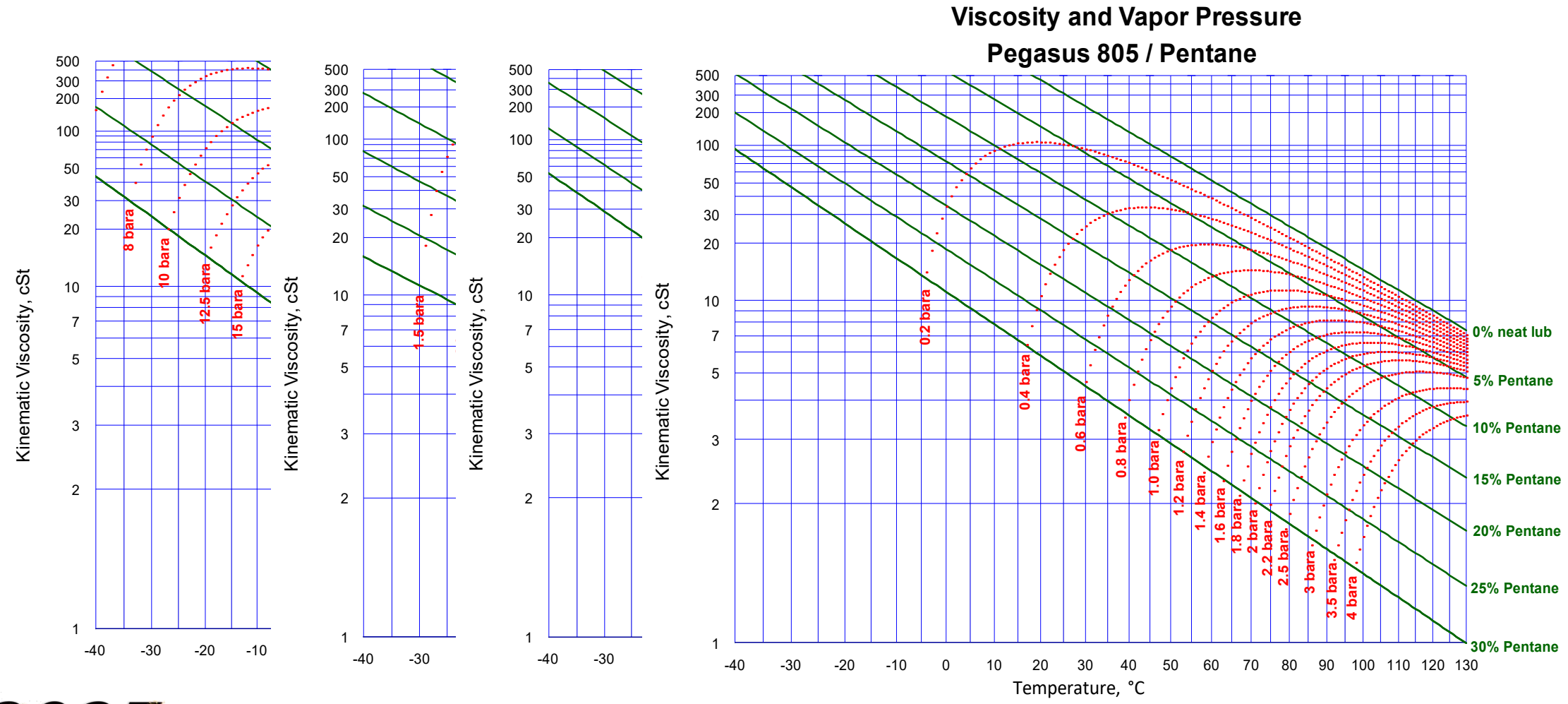
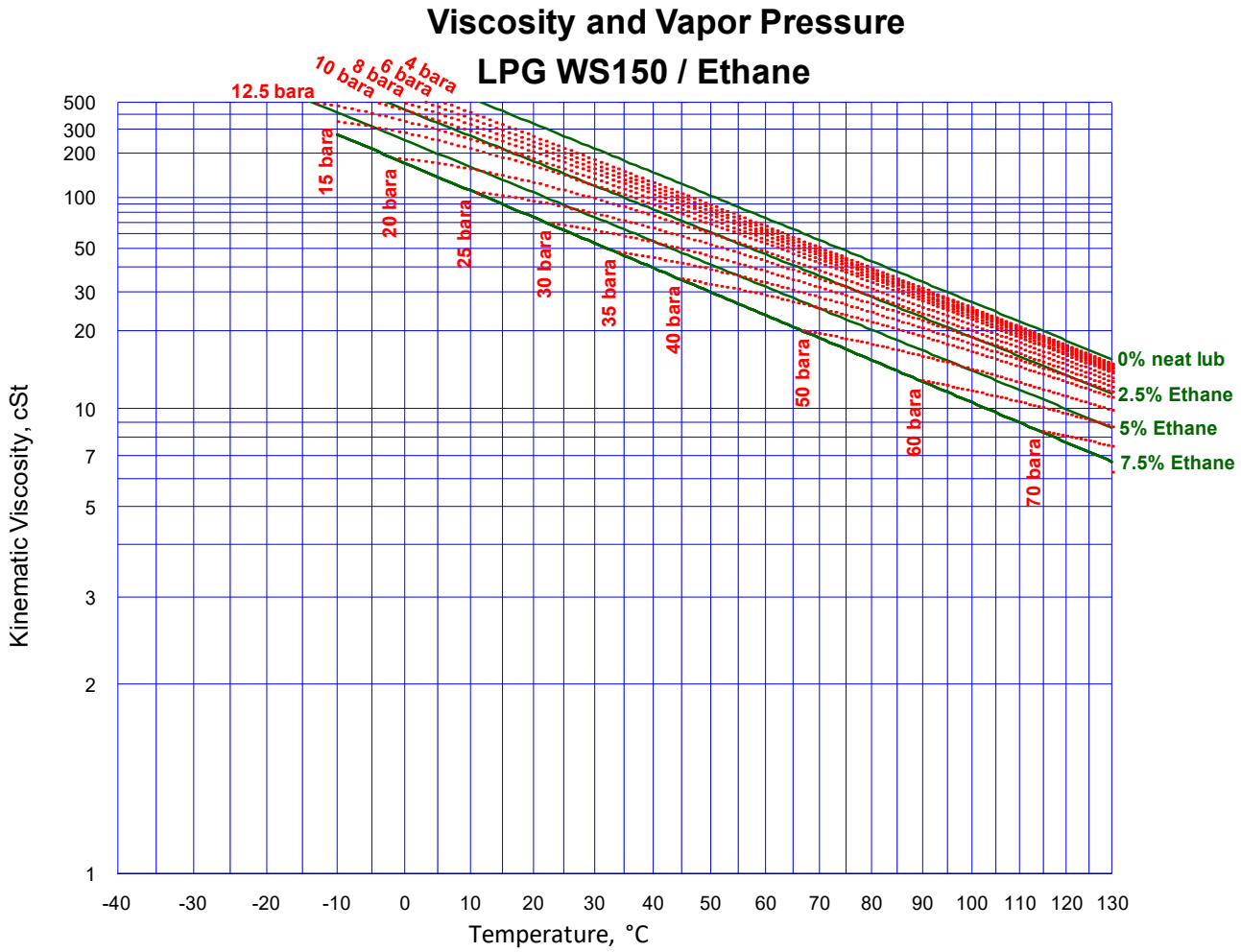
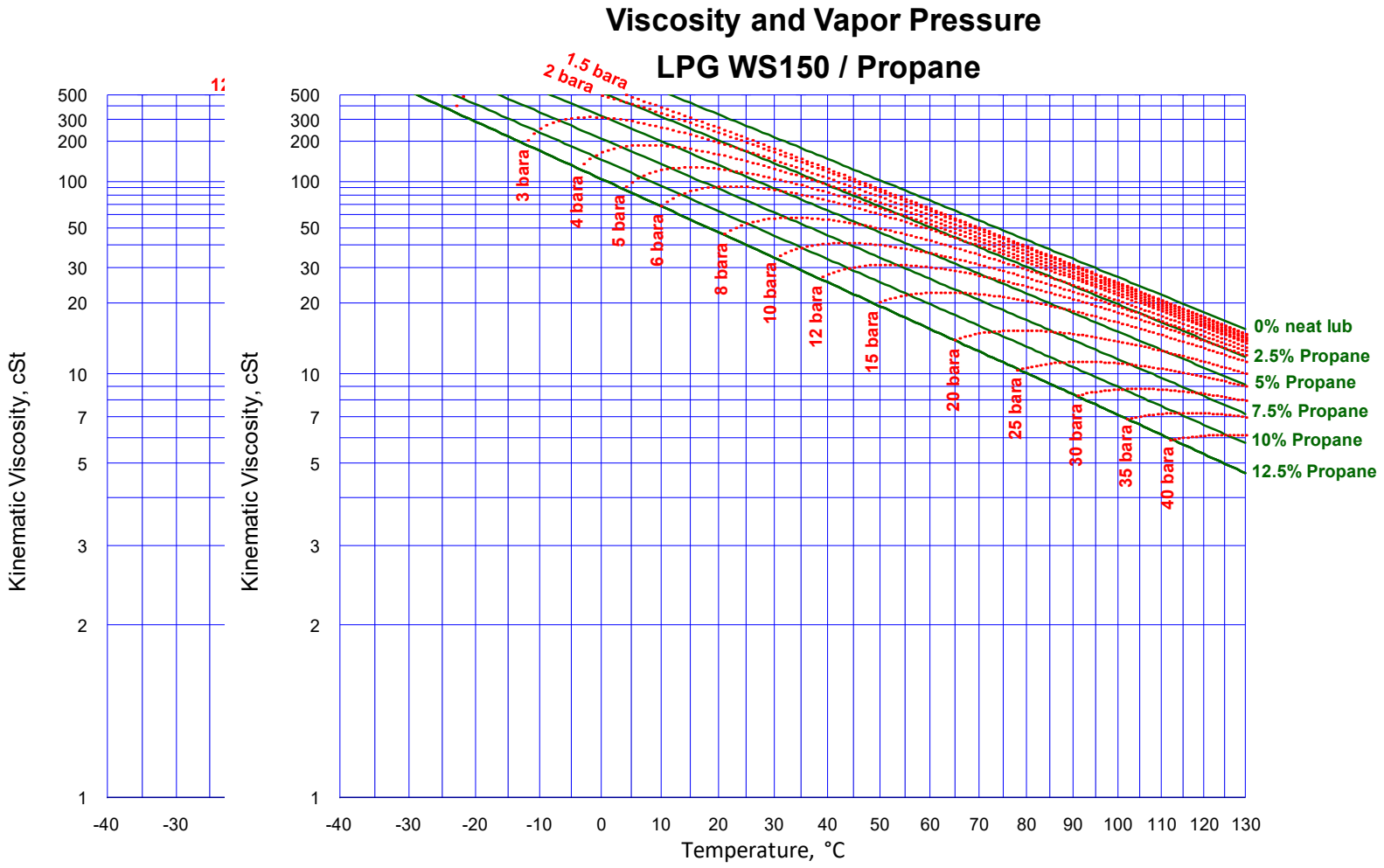


GMRC Project – Results Water Soluble PAG



GMRC Project – Results
Water Soluble PAG



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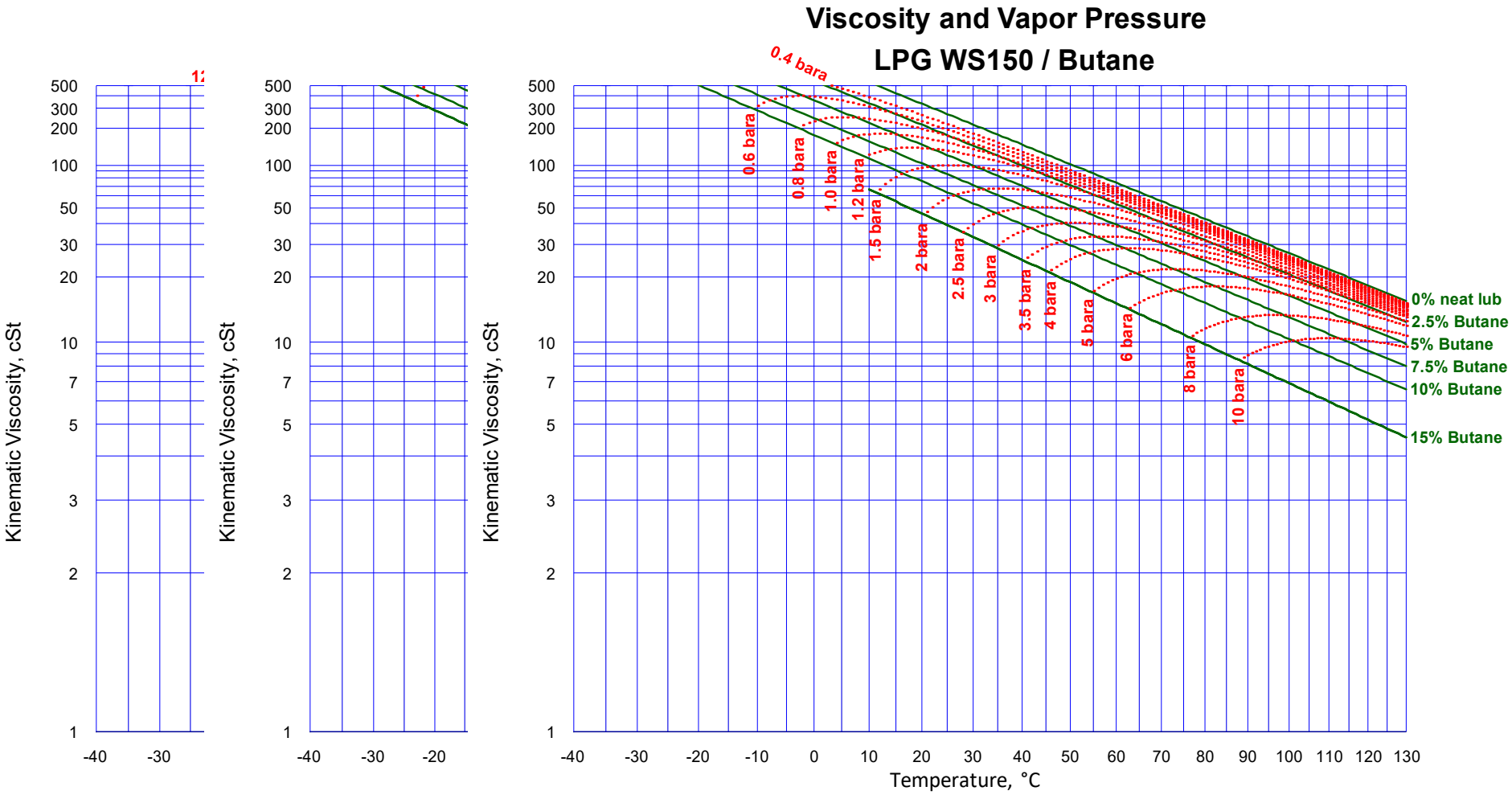

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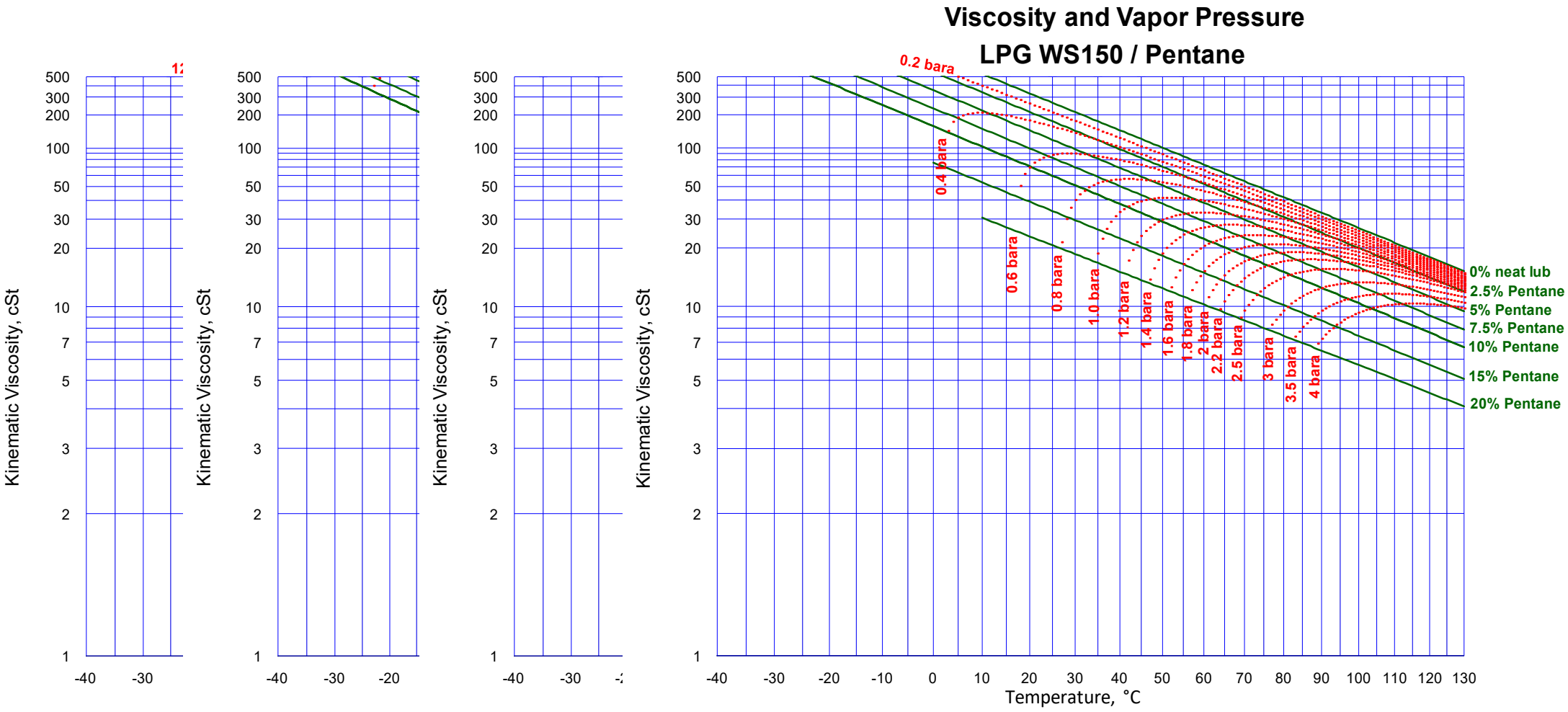
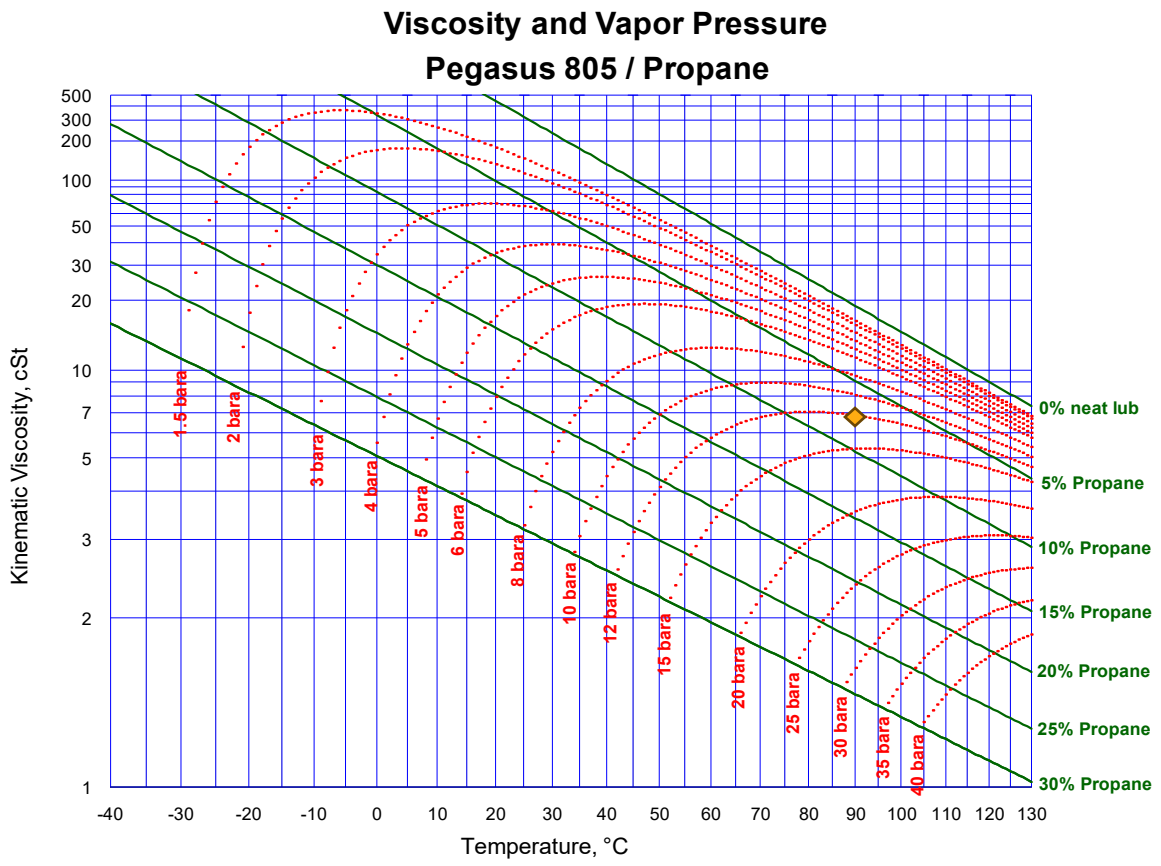
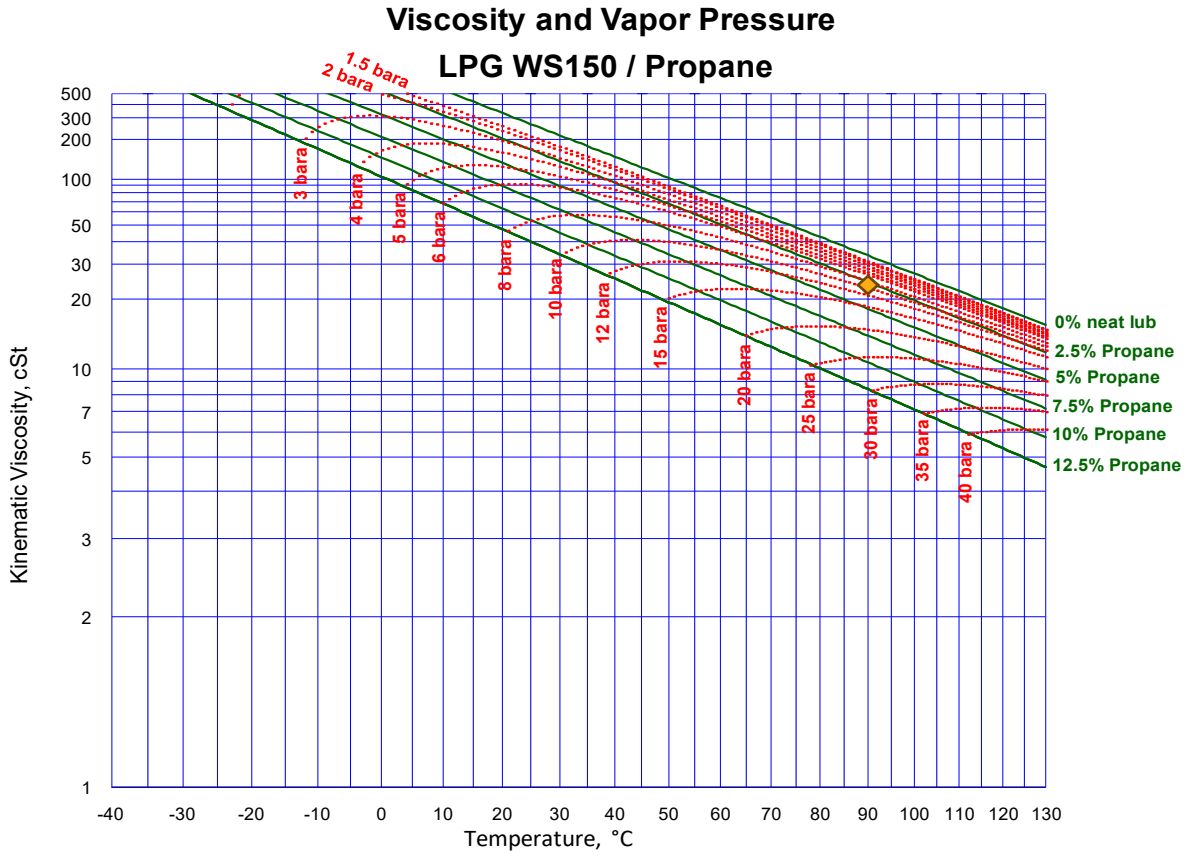


GMRC Comparison - Propane





At 195°F (90°C) and 160psig (10 bara)

MO / Engine Oil → 7 cSt

PAG → 25 cSt

Case 1 – Gas Gathering

	Mol % Mild Pipeline	Partial Pressure, bara
Methane	95	65
Ethane	2.5	1.75
Propane	0.2	0.14
Butanes	~0	~0
Pentanes	~0	~0
C6+	~0	~0
N_2 & CO_2	2.3	Disregard for simplicity
Example Operating Conditions		
Discharge Temperature, °C (°F)	105 (221)	
Discharge Pressure, bara (psig)	70 (1000)	
Oil Cooling Temp Drop, K (°R)	-	
Oil Injection Temp, °C (°F)	-	
Compressor Type	Large Frame Piston	
Compressor Viscosity Requirements, cSt	>16	
Approx. Gas Dew Point, °C (°F)	-	

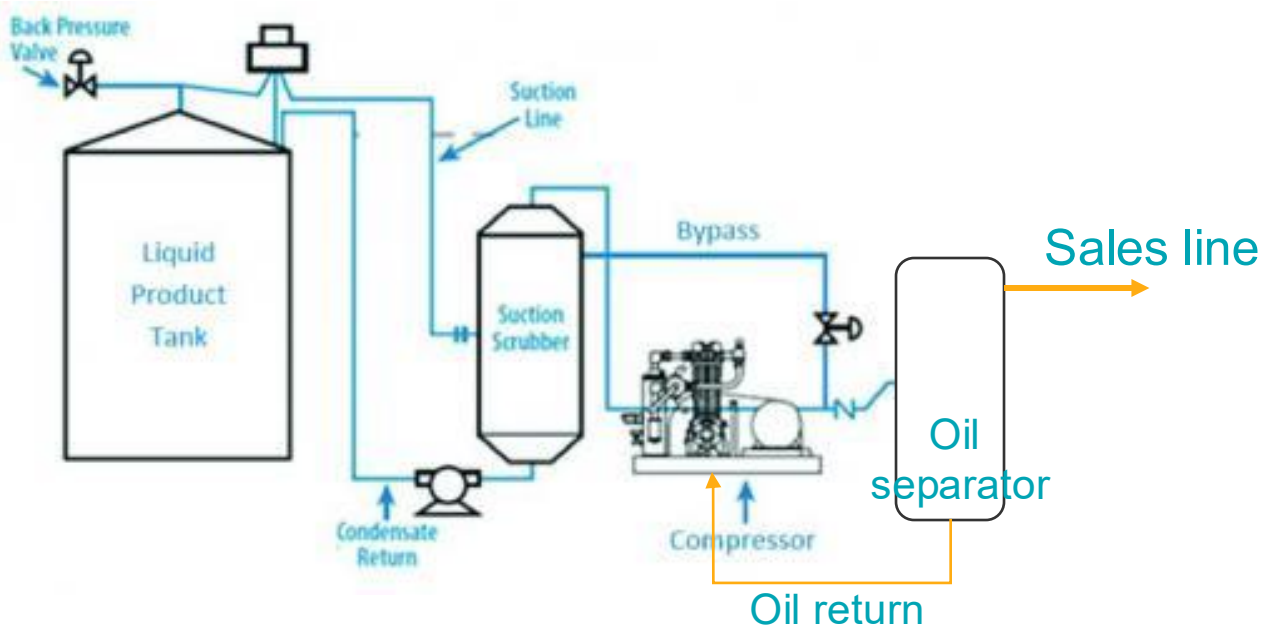
	Pegasus 805 MO 150	Progiline/Lubsoil LPG WS 150
Neat Lubricant Viscosity, cSt	12.6	24
Liquid composition (% g/g)		
Methane	1.3	1.2
Ethane	0.16	0.27
Propane	0.17	0.13
Butanes	0	0
Pentanes	0	0
C6+	0	0
Working Viscosity, cSt	8.5*	18*

Recommendation: 16 cSt Min. Op. Viscosity

- Use PAG for pressure > 750 psi
- MO and PAO tend to use high oil feed rates to maintain 16 cSt – high Carry Over

Case 2 – Gas Boosters

	Mol % VRU	Partial Pressure, bara
Methane	27	5.9
Ethane	27	5.9
Propane	27	5.9
Butanes	14	3.04
Pentanes	2.2	0.48
C6+	0.5	0.11
N_2 & CO_2	2.3	Disregard for simplicity
Example Operating Conditions		
Discharge Temperature, °C (°F)	125 (257)	
Discharge Pressure, bara (psig)	21.7 (300)	
Oil Cooling Temp Drop, K (°R)	40 (72)	
Oil Injection Temp, °C (°F)	85 (185)	
Compressor Type	Screw	
Compressor Viscosity Requirements, cSt	**13-40**	
Approx. Gas Dew Point, °C (°F)	**56 (133)**	



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Pentanes	2.2	0.48
C6+	0.5	0.11
N_2 & CO_2	2.3	Disregard for simplicity
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	Pegasus 805 MO 150	Progiline/Lubsoil LPG WS 150
Neat Lubricant Viscosity, cSt	12.6	24
Liquid composition (% g/g)		
Methane	0.11	0.12
Ethane	0.6	0.5
Propane	2.2	1.3
Butanes	3.3	1.6
Pentanes	1.2	0.6
C6+	0.8	0.5
Working Viscosity, cSt	**7.7**	**23**

Recommendation: 13-40 cSt Op. Viscosity

- **Use PAGs**
- **MO and PAO have wash out issues**

Case 2 – Gas Boosters (2)

Tulco Lubsoil LPG WS 150	Discharge Temperature, °F											
	190	200	210	220	230	240	250	260	270	280	290	300
	Viscosity, cSt											
Injection Temperature, °F 160	23.3	24.8	26.3	27.7	29.0	30.3	31.5	32.6	33.6	34.6	35.6	36.5
170	20.7	22.1	23.3	24.5	25.6	26.7	27.7	28.7	29.6	30.5	31.3	32.1
180	18.5	19.7	20.8	21.8	22.8	23.7	24.6	25.4	26.2	27.0	27.7	28.3
190	16.7	17.7	18.6	19.5	20.4	21.2	22.0	22.7	23.4	24.0	24.6	25.2
200		16.0	16.8	17.6	18.3	19.0	19.7	20.3	20.9	21.5	22.0	22.5
210			15.2	15.9	16.5	17.2	17.7	18.3	18.8	19.3	19.8	20.2
220				14.4	15.0	15.6	16.1	16.5	17.0	17.4	17.8	18.2
230					13.7	14.2	14.6	15.0	15.4	15.8	16.2	16.5
240						12.9	13.3	13.7	14.1	14.4	14.7	15.0
250							12.2	12.6	12.9	13.2	13.5	13.7
260								11.5	11.8	12.1	12.3	12.6
270									10.9	11.1	11.4	11.6
	Sum of Dissolved Gas, g/g											
	0.075	0.069	0.064	0.060	0.056	0.052	0.049	0.046	0.043	0.041	0.039	0.037

Screw Compressor: 13-40 cSt Op. Viscosity

Reduce Carry Over - use solubility and viscosity Data to set:

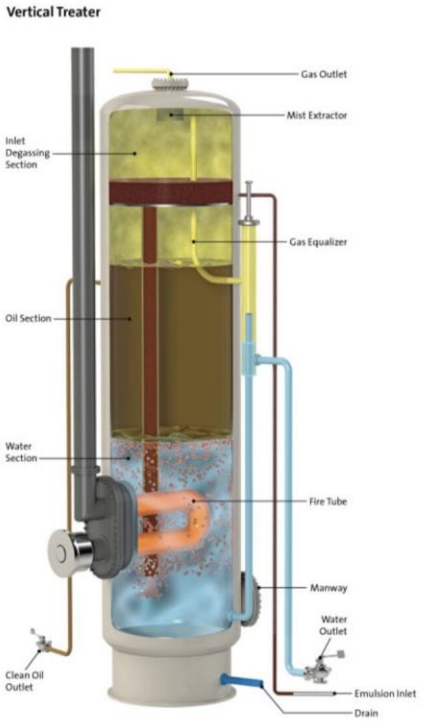
- **Discharge Temps – avoid the Dewpoint**
- **Injection Temps – HXer and Flow rate (orifice size) dependent**
- **Dewpoint is 133°F (56°C) – Insulate the Oil Seperator!!**

Case 3 – VRU

after too hot Heater/Treater

aka "Damned Heater/Treater" or BTEX removal

	Mol % VRU	Partial Pressure, bara
Methane	27 → 21	3.2
Ethane	27 → 17	2.6
Propane	27 → 24	3.6
Butanes	14 → 21	3.1
Pentanes	2.2 → 10	1.5
C6+	0.5 → 6.5	1.0
N_2 & CO_2	2.3 → 0.5	Disregard for simplicity
Example Operating Conditions		
Discharge Temperature, °C (°F)	110 (230)	
Discharge Pressure, bara (psig)	15 (200)	
Oil Cooling Temp Drop, K (°R)	40 (72)	
Oil Injection Temp, °C (°F)	70 (158)	
Compressor Type	Screw	
Compressor Viscosity Requirements, cSt	**13-40**	
Approx. Gas Dew Point, °C (°F)	**90 (195)**	



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Oil Injection Temp, °C (°F)	70 (158)	
Compressor Type	Screw	
Compressor Viscosity Requirements, cSt	**13-40**	
Approx. Gas Dew Point, °C (°F)	**90 (195)**	

	Pegasus 805 MO 150	Progiline/Lubsoil LPG WS 150
Neat Lubricant Viscosity, cSt	36	56
Liquid composition (% g/g)		
Methane	0	0
Ethane	0.25	0.32
Propane	1.7	1.0
Butanes	4.4	2.1
Pentanes	4.7	2.3
C6+	8.8	5.3
Working Viscosity, cSt	**4.6**	**17**

Recommendation: 13-40 cSt Op. Viscosity

- **Use PAGs**
- **MO and PAO have disappeared downstream**

Case 2 – VRU with BTEX HeaterTreater

Tulco Lubsoil LPG WS 150		Discharge Temperature, °F											
		190	200	210	220	230	240	250	260	270	280	290	300
		Viscosity, cSt											
Injection Temperature, °F	160	8.5	10.6	12.7	14.9	17.0	19.0	21.0	23.0	24.8	26.6	28.3	29.9
	170	7.8	9.7	11.5	13.4	15.2	17.0	18.8	20.4	22.0	23.6	25.0	26.4
	180	7.2	8.8	10.5	12.1	13.7	15.3	16.8	18.3	19.7	21.0	22.3	23.4
	190	6.6	8.1	9.6	11.0	12.5	13.8	15.2	16.4	17.6	18.8	19.9	20.9
	200		7.5	8.8	10.1	11.3	12.6	13.7	14.8	15.9	16.9	17.9	18.8
	210			8.1	9.2	10.4	11.4	12.5	13.5	14.4	15.3	16.1	16.9
	220				8.5	9.5	10.5	11.4	12.3	13.1	13.9	14.6	15.3
	230					8.8	9.6	10.4	11.2	12.0	12.7	13.3	14.0
	240						8.9	9.6	10.3	11.0	11.6	12.2	12.7
	250							8.9	9.5	10.1	10.7	11.2	11.7
	260								8.8	9.3	9.8	10.3	10.8
	270									8.6	9.1	9.5	9.9
		Sum of Dissolved Gas, g/g											
		0.193	0.164	0.141	0.124	0.109	0.098	0.088	0.079	0.072	0.066	0.060	0.055

Screw Compressor: 13-40 cSt Op. Viscosity

Reduce Carry Over - use solubility and viscosity Data to set:

- **Discharge Temps – Run HOT! PAGs can take it**
- **Injection Temps – HXer and Flow rate (orifice size) dependent**
  - **Higher flow rate is <u>not</u> better**
- **Dewpoint is 190°F (89°C) – Insulate the Oil Seperator!!**

Other Observations from the Field

- **Insulate the Oil Seperator**
  - Airflow over the separator causes dew formation on the inner surface
    - MO and PAO cause washout, PAG causes a 2nd liquid phase

- Use an electrical pump on the Suction Accumulator
  - Should always have power!
  - Eductor pumps can be problematic unless the unit runs continuously

- Electrical Heaters
  - The recommended watt density is between 15 and 20 W/in^2
  - Using water heater elements will burn the oil!

Other Observations from the Field

- Engine Oil is not Compressor Oil
  - Detergent packages in many engine oils cause a stable foam in filter units

  - Removal requires good shovel-trowel technique

Fall is Approaching!!!

- The Weather
  - *"I don't want your oil; I don't want it even if it is free!!"*
  - Early Cold Fronts
    - Oil storage tanks are still warm, producing vapors
    - Condensation in pipes acting as HXers
    - Pressure switches won't trigger because the condensation keeps pressure low
    - Later in the day as the lines are full, the units switch on and the compressor oil gets washed down stream
  - Solution
    - Run suction accumulator pumps
      - Return condensate to tanks
    - Run compressors in bypass
    - Turn on heaters in separators and accumulators

Carry Over is a Design Parameter

- **For large recips** - Compressor lubricant feed rate (carryover) is set by the oiling system
  - Oil separators can be used to return lubricant to compressor low stages
    - Can be 1st cost-prohibitive – but pays back over time
    - ASTM coded vessels vs. oil cost
      - If using engine oil – send downstream and use fresh "sweetened" oil in the engine
        - Can lead to foam clogging and plugging issues – detergent packages
      - If using PAG – use an oil separator

Carry Over is a Design Parameter

- **For Screw Compressors** - Carryover is a function of separator efficiency
  - For lean gas – Mineral Oils and PAO (premium synthetic) can be used
  - For NGL rich gas – PAGs must be used

  - For sour gas streams, carryover can reduce/eliminate oil changes
    - Also help with pipeline corrosion and hydrates reduction with proper WS PAG selection

Questions?

Thank you!