Gas Properties

The gas method refers to the equations of state used to calculate the gas properties such as the ratio of specific heats, or N-value, and the compressibility values, or Z-values.

The Ariel performance software allows the use of either the Hall equation of state (developed by the Chemical Engineering department at Texas A&M University), or the VMG thermal software (developed by Virtual Materials Group). The VMG software uses an APR, Advanced Peng Robinson, equation of state. The VMG software includes a larger number of available gas components and the ability to perform liquid drop-out flash calculations.

The Hall method can be used when running "natural gas" based applications. The advantage of Hall equation of state is its speed when running larger multi-run calculations with natural gas where the speed of the multi-run may be hampered by the VMG calculation method. The HALL method includes water condensate calculations. The Hall equation of state supports 30 gas components.

The VMG method can be used for all applications. The advantage of VMG is its accuracy and condensate flash calculations when running performance on heavy gasses or non-hydrocarbon based gasses. The VMG method performs hydrocarbon liquid drop-out flash calculations as well as water condensate calculations. The VMG equation of state supports thousands of gas components.

Ariel performance software will flag the user if the Hall option is used when the VMG option should be used due to the potential of non-water liquid dropout.

For assistance or questions regarding either gas property calculation method please contact The Ariel Application Engineering Department.

Gas Properties - Air

Gas Name	Chemical Formula	Chemical Family
Air	Air	Non-Flammable Gases
Synonym(s)	Breathing Air, Compressed Air and Medical Air	

Molecular Weight	Critical Pressure (psia)	Critical Temperature (R)	Ratio of Specific Heats
28.975	547	239	1.406

Physical Characteristics	Solubility
Colorless, Odorless	Slightly soluble, but main components are higher soluble.

Applications or Uses

Many uses - Combustion, Life Support and Source of Power. Underbalanced Drilling, De-watering.

Hazards

Supports Combustion. Exposure at higher pressure can cause physical problems.

Material Requirements

Slightly oxidizing characteristics. Can be contaminated by corrosive components (CO_2, NH_3, H_2S etc.). Many applications require non-lube construction. Materials will be designed for continuous duty at 400 F (204 C), however, applications are to be limited to 350 F (177 C) discharge shutdown temperature.

Lubrication

Standard guidelines for lube or non-lube service. Special lubricants for greater than 500 psi. Typically use mineral oils when less than 500 psi and a diester when greater than 500 psi. Special precautions should be taken to prevent oil accumulation in piping and heat exchangers, minimize drops or low points. Prevent excessive lubrication. When synthetic oils are to be used, they must also be used during the mechanical run test.

Comments (see also Air Service topic)

Proper temperatures must be maintained to prevent carbon build-up (leads to explosive situations) and proper materials for applicable operating pressure must be used. Materials will be designed for 400 F (204 C) continuous duty, however discharge temperatures will be limited to 350 F (177 C) max. Standard performance runs are used, however humidity must be accounted for and when applicable, the inlet filter pressure drops must be accounted for. Sizing must be based on an entire range of operating conditions. Always request all operating conditions.

Gas Properties - Carbon Monoxide

Gas Name	Chemical Formula	Chemical Family
Carbon Monoxide	CO	Non-Metal Oxide Gas
Synonym(s)	Carbonic Oxide, Carbon Oxide	

Molecular Weight	Critical Pressure (psia)	Critical Temperature (R)	Ratio of Specific Heats
28.010	515	242	1.404
Physical Characteristics		**Solubility**	
Colorless gas with metallic taste and odor		Practically insoluble in water. Soluble in organic solvents containing Benzene	
Applications or Uses			
Fuel. Metallurgy. Chemical Processes. Synthesis Processes.			
Hazards			
Extremely Toxic. Asphyxiant. Extremely Flammable.			
Material Requirements			
Incompatible with strong oxidizers (Chlorine, Bromine...). At temperatures above 900 F, cast iron is attacked by CO. Nickel and Cobalt should be avoided due to corrosion. Natural rubber and neoprene are chemically attacked by CO.			
Lubrication			
Standard lubricating practice recommended for pressures up to 2000 psig. Non-lube applications should be avoided (see notes below).			
Comments			
Due to toxicity of gas, purged packing is always required. Two compartment distance pieces are highly recommended, or long single compartment with a nitrogen buffered packing and purged distance piece. Limit discharge temperature to 255 F(121 C) if possible. Non-lubricated applications should be avoided. Cylinders tend to develop "hot spots" which result in Carbon Monoxide Dissociation. Hard carbon deposits my be formed and CO2 produced. Limit discharge temperatures to 225 F (107 C). Ariel does not quote carbon monoxide applications non-lubricated.			

Gas Properties - Carbon Dioxide

Gas Name	Chemical Formula	Chemical Family
Carbon Dioxide	CO_2	Acid Anhydride
Synonym(s)	Carbon Anhydride, Carbonic Acid, Dry Ice	

Molecular Weight	Critical Pressure (psia)	Critical Temperature (R)	Ratio of Specific Heats
44.010	1073	548	1.300
Physical Characteristics		**Solubility**	
Colorless, Odorless		Soluble in water, alcohol and alkalis	
Applications or Uses			
Urea Plants, Carbonation, Chilling and Freezing, Fire Protection, Chemical and Synthesis Processes, Re-Injection.			
Hazards			
Asphyxiant. When mixed with water, produces Carbonic Acid.			
Material Requirements			
Dependent on operating conditions is be corrosive. Please review the guidelines of the Ariel Applications Manual.			
Lubrication			
Standard guidelines for lube or non-lube service. CO_2 may combine with water to produce Carbonic Acid. This acts as a solvent and tends to dilute cylinder lubricating oil. CO_2 is soluble in mineral oils, which reduces oil/gas mix viscosity. In addition, mineral oils are completely miscible into CO_2, thereby reducing the quantity of lubricant at the lube site. Compounding or PAG synthetics are commonly used. Follow guidelines of Ariel Packager Standards.			
Comments (see also Carbon Dioxide Service topic)			
When used in Re-injection or Urea plants, the gas is compressed to higher pressures and may reach critical point or dense phase region at interstage pressures. Due to the critical temperature (88 degrees F) and pressure of 1073 psia, it is imperative to monitor interstage pressures and temperatures. If interstage pressures are near critical or above, it may be necessary to control temperatures out of the intercooler to ensure there is a margin above critical temperature or dense regions.			

Gas Properties - Ethylene

Gas Name	Chemical Formula	Chemical Family
Ethylene	C_2H_4	Alkenes, Aliphatic Hydrocarbons
Synonym(s)	Bicarburated Hydrogen, Acetene, Elayl, Etherin	

Molecular Weight	Critical Pressure (psia)	Critical Temperature (R)	Ratio of Specific Heats
28.050	748	509.5	1.255
Physical Characteristics		**Solubility**	
Flammable, Colorless, Slightly sweet odor		Soluble in water and alcohol. Dilutes lube oil.	
Applications or Uses			
Manufacture of Ethylene Glycol. Plastics at higher pressures. Food Processing. Also used as an illuminant with other gasses for lighting. Generally used at relatively higher pressures. .			
Hazards			
Asphyxiant. Dispersible over a large area and does not dissipate into atmosphere. Long range ignition possible. Handle in well ventilated area.			
Material Requirements			
Non-corrosive. Standard materials apply.			
Lubrication			
Standard guidelines for lube or non-lube service. Has a tendency to dissolve into lube oil, thereby reducing oil viscosity.			
Comments			
No special problems with compression. However, in the event ethylene oxide can be formed, extreme care is required. In certain cases, Ethylene Oxide and copper can combine to form Acetylene. If Ethylene Oxide is present, do not use yellow metals.			

Gas Properties - Helium

Gas Name	Chemical Formula	Chemical Family
Helium	He	Inert Gas
Synonym(s)	Helium USP	

Molecular Weight	Critical Pressure (psia)	Critical Temperature (R)	Ratio of Specific Heats
4.003	33.2	9.47	1.666
Physical Characteristics		**Solubility**	
Colorless, Odorless, Tasteless		Slightly soluble in water. Readily absorbed by oil.	
Applications or Uses			
Leak Testing, Zeppelins, Mixed with oxygen for diver breathing tanks. Typically higher pressure applications, greater than 1000 psi.			
Hazards			
Asphyxiant. Handle in well ventilated area. Lighter than air, collects in overhead pockets. Difficult to detect leakage.			
Material Requirements			
Non-corrosive. Standard materials. Piston rings, riders and packing ring materials need to be reviewed.			
Lubrication			
Standard guidelines for lube or non-lube service.			
Comments			
Requires Helium leak test. Follow guidelines for Low Molecular Weight as detailed in Ariel Applications Manual. Due to the extremely high Ratio of Specific Heats, closely monitor discharge temperatures. Even though Helium has twice the molecular weight of Hydrogen, it tends to be more difficult to seal. Elastomer seals are prone to leakage. Special seals may be required and a double seal arrangement is quite common, if not required.			

Gas Properties - Hydrogen

Gas Name	Chemical Formula	Chemical Family
Hydrogen	H_2	Flammable Gasses
Synonym(s)	Molecular Hydrogen	

Molecular Weight	Critical Pressure (psia)	Critical Temperature (R)	Ratio of Specific Heats
2.016	188	61	1.410
Physical Characteristics		**Solubility**	
Colorless, Odorless, Lighter than air		Slightly soluble in water. Higher solubility in oil.	
Applications or Uses			
Hydro-cracking, Hydro-treating and various other industrial uses. General operating ranges: 800 to 1000 PSI for pipelines and approx. 2500 PSI for Hydrocracking.			
Hazards			
Explosive, Flammable. Difficult to detect. Lighter than air therefore accumulates in overhead pockets. Asphyxiant. Should be handled in well ventilated areas. Difficult to detect, flame is invisible in daylight. Leak test by soap bubble.			
Material Requirements			
Non-corrosive. Standard materials are commonly used. Cast iron cylinders are acceptable. At higher pressures >1000 PSI generally use ductile iron or steel. Piston rings, riders and packing ring materials need to be reviewed.			
Lubrication			
Standard guidelines for lube or non-lube service.			
Comments			
Requires Helium Leak Test. Follow guidelines for low molecular weight as detailed in Ariel Applications Manual. Limit discharge temperature to 275 degrees F or less.			

Gas Properties - Methane

Gas Name	Chemical Formula	Chemical Family
Methane	CH_4	Alkane
Synonym(s)	Marsh Gas, Natural Gas, Methyl Hydride	

Molecular Weight	Critical Pressure (psia)	Critical Temperature (R)	Ratio of Specific Heats
16.040	673	343.7	1.310
Physical Characteristics		**Solubility**	
Colorless, Odorless, Tasteless		Slightly soluble in water. Soluble in alcohol and most petroleum products.	
Applications or Uses			
Fuel or Chemical use			
Hazards			
Flammable. Explosive. Asphyxiant. Lighter than air so collects in overhead pockets. Handle in well-ventilated areas.			
Material Requirements			
Standard materials of construction			
Lubrication			
Standard guidelines for lube or non-lube service.			
Comments			
No special considerations for compression.			

Gas Properties - Natural Gas

Gas Name	Chemical Formula	Chemical Family
Natural Gas	CH_4 + HC's	Alkane
Synonym(s)	Sweet Gas, Marsh Gas, Natural Gas, Methyl Hydride	

Molecular Weight	Critical Pressure (psia)	Critical Temperature (R)	Ratio of Specific Heats
18.910	670	382	1.288
Physical Characteristics		**Solubility**	
Colorless, Odorless, Tasteless (See Comments)		Slightly soluble in water. Soluble in alcohol and most petroleum products.	
Applications or Uses			
Fuel or Chemical use			
Hazards			
Flammable. Explosive. Asphyxiant. Lighter than air so collects in overhead pockets. Handle in well-ventilated areas.			
Material Requirements			
Standard materials of construction			
Lubrication			
Standard guidelines for lube or non-lube service.			
Comments			
Natural Gas mixtures vary dependent on the where and how it is produced. The mixture used for Physical Properties shown is a clean, dry, "sweet natural gas" with the following composition: 85% Methane, 10% Ethane, 3% Propane, 1% Butane, 0.5% Nitrogen and 0.5% CO_2. The information is to be used as a guideline. Special care must be taken to determine the presence of water, H_2S and debris. Residential (and some commercially applied) Natural Gas has an odorant added to aid in leak detection.			

Gas Properties - Nitrogen

Gas Name	Chemical Formula	Chemical Family
Nitrogen	N_2	Inert Gas
Synonym(s)	Nitrogen NF	

Molecular Weight	Critical Pressure (psia)	Critical Temperature (R)	Ratio of Specific Heats
28.010	493	227	1.404
Physical Characteristics		**Solubility**	
Colorless, Odorless		Slightly soluble in water and alcohol.	
Applications or Uses			
Fertilizer Production, Purge Gas, Injection			
Hazards			
Asphyxiant. Titanium will burn in the presence of pure nitrogen.			
Material Requirements			
Non-corrosive. Standard materials of construction. Piston rings, riders and packing rings need to be reviewed.			
Lubrication			
Standard guidelines for air apply.			
Comments			
Closely monitor discharge temperature. Bone dry nitrogen can cause problems with packing, rings, and wear bands. Ensure that materials are selected for the specific moisture content.			

Gas Properties - Propane

Gas Name	Chemical Formula	Chemical Family
Propane	C_3H_8	Alkane - Hydrocarbon
Synonym(s)	Dimethylmethane, LP-Gas, LPG	

Molecular Weight	Critical Pressure (psia)	Critical Temperature (R)	Ratio of Specific Heats
44.090	661	666	1.14

Physical Characteristics	Solubility
Colorless. Liquefied, flammable gas with a Natural Gas odor. Turns gaseous at atmospheric pressure and temperature.	Almost insoluble in water, but highly soluble in alcohol and petroleum products.

Applications or Uses
Fuels. Used as a solvent. Refrigerant Applications. Food additive. Aerosol propellant.
Hazards
Asphyxiant. Very heavy gas, collects in low level areas. Dispersible over a large area and does not dissipate into atmosphere. Long range ignition possible. Handle in well ventilated areas.
Material Requirements
Standard materials of construction. Due to typical low temperatures in many applications, must ensure all materials are acceptable for temperature.
Lubrication
Has a tendency to dissolve into lube oil, thereby reducing oil viscosity.
Comments (see also Propane Service topic)
In propane applications, it is very important to analyze gas mixture to verify properties at actual operating conditions. In lower suction temperature applications, like refrigeration service, the first interstage may not require cooling.