



Natural Gas Filtration Applications

Natural gas is an abundant clean-burning fuel that provides an important part of the overall energy usage in the United States. Gas (CH_4), also known as methane, undergoes a number of processes as it is transported from wellhead to end-user, and many of these steps require filtration of the product. Impurities such as pipe scale, iron sulfide, hydrates, water, liquid hydrocarbons, sulfur products and carbon dioxide must be removed before it is deemed “pipeline quality”.



Natural Gas Well and “Christmas Tree”

Gas-fired engine-compressor sets “gather” the natural gas from the wellheads, and pump it to a gas processing plant to make it marketable.



Engines are often in Remote Sites



Horizontal Compressor

The following map shows the network of pipelines that transport natural gas throughout the United States, as monitored by our Federal Energy Regulatory Commission.



Interstate Gas Pipelines

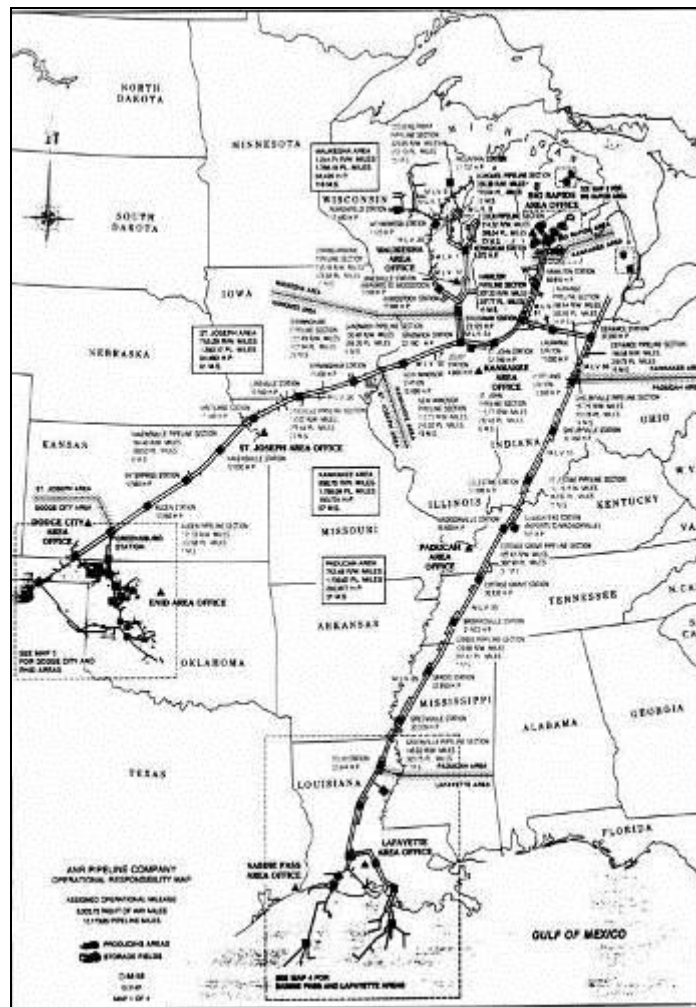
Notice the spider-webs of pipelines in the Gulf area, in western Texas, in the panhandle of Oklahoma and in western Pennsylvania. Several pipelines come in from Canada. Most of the gas is pumped to the upper Midwest and industrial sectors of the Northeast.

The natural gas is pumped in large underground pipelines, often 24" to 36" in diameter, at pressures of up to 3000 psig, traveling about 60 feet per second (approximately 40 miles per hour).



Natural Gas Pipeline & Compressor Station

These “compressor stations”, as they are called, are positioned about every 100 miles up the pipeline, to boost pressures and maintain flow.



Compressor Stations every 100 Miles

Most of the motive power comes from large stationary reciprocating engines that were built and installed in the latter half of the 20th Century. The engines are driven by the same natural gas that they are pumping. Many of these engine manufacturers are no longer in business, but their engines continue to run. In fact, with over 95% of the installed fleet still in operation, it is impossible to measure the half-life of these engines!

Clarke
Dresser Rand
Waukesha

Cooper Bessemer
Enterprise
White Superior

Delaval
Ingersoll Rand
Worthington



“Integral” Reciprocating Engine-Compressor

These old engine-compressor units are called “integrals” as they have both the power pistons and compressor pistons running off of the same crankshaft.



Integral Engine-Compressor

In the picture above, the horizontal cylinders are the compressors and the vertical cylinders drive the engine. These engines use spark plugs and require shining a timing light on the flywheel to set the spark, much like the automobile engines of their day. Note the large oil filter in the foreground of this photograph.

Many of the more recently-installed compressor stations are using turbine engines for their power. Turbines have better fuel efficiency, but lack the turndown capacity of a bank of recip's.

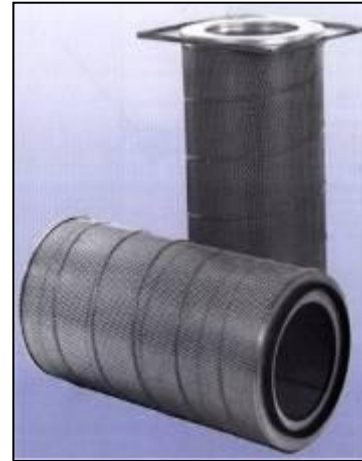
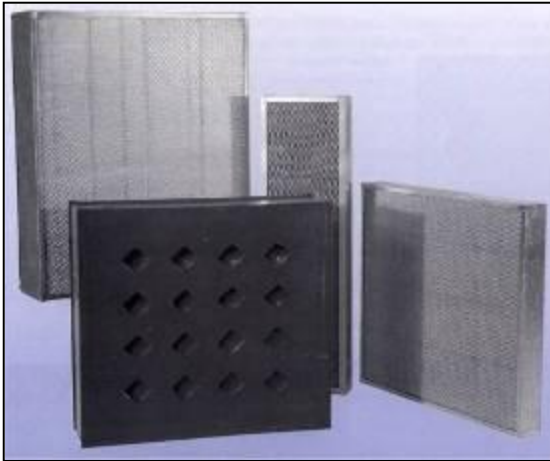


Turbine Engine-Compressor



Turbine & Recip Engine Air Filters

The air filters on turbines are typically much larger than on reciprocating engines. These filters are either flat panels or cylindrical in shape. Filtration Systems, Inc. makes both varieties.



Panel and Cylindrical Air Filters

The oil filters on these engines are primarily either sock-type (depth filters) or pleated-paper-in-a-can (paper filters). Again, Filtration Systems, Inc. manufactures both types. Sock-type oil filters are the preferred technology for these old recip's, because they hold an incredible amount of semi-solid contaminants (such as sludge and varnish), which would quickly blind-off a surface-type filter. Usually, these engines will run for thousands of hours before the oil filters need changing. Filtration Systems, Inc. also uses a special wood fiber in its sock filters that actually absorbs water and acids out of the oil that would otherwise attack the additive package in the lube oil.

Because gas-fired stationary engines run continuously, even trace amounts of sulfur in the fuel gas can quickly acidify the oil, caused by combustion byproducts that "blow-by" the rings and build up in the oil sump. Filtration Systems' filters actually extend oil-drain intervals, often allowing these engines to run a whole heating season (4,000 hours) between shut-down and change-out.



Sock-Type and Pleated Paper Oil Filters

The natural gas coming into these compressor stations also needs to be filtered. Even though it left the gas plant “clean and dry”, it can pick up particulates, such as pipe scale (rust), iron sulfide or hydrates (ice) along its journey north. The gas can also contain liquids – water from condensation, liquid hydrocarbons (drip gasoline or “C6+”) from isotherm changes, lube oil from the compressors, or process chemicals such as amine and glycol, from the gas plants. These are all removed ahead of the compressors by “filter-separators”. Liquids are non-compressible, you don’t want to slug a compressor!



Natural Gas Filter-Separator

These Filter Separators generally have two stages, a particulate filter-coalescer (with replaceable elements), followed by a separator (a vane, wave-plate, cyclone or knitted mesh pad) to knock out the coalesced liquids. The separated liquids (“drip gasoline” and water) are collected in sumps below the pressure vessel.



Natural Gas Filters (Note Vertical or Horizontal Liquid Sumps below Vessels)

The replaceable filter-coalescer elements usually use molded fiberglass media, as the fine fiber diameter and charged fiber-surfaces make it ideal for separating liquids from gas. Filtration Systems, Inc. has replacement elements for all types of filter-separators. All of its filter-coalescers are made with micro-fiberglass media.



Filters with Micro-glass Media Separate Liquids and Particulates from Natural Gas

Gas filter-separators hold dozens of replaceable filter elements, which are accessed by a closure at one end of the pressure vessel.



This Full-Opening Hinged Closure Facilitates Access to the Filter Elements

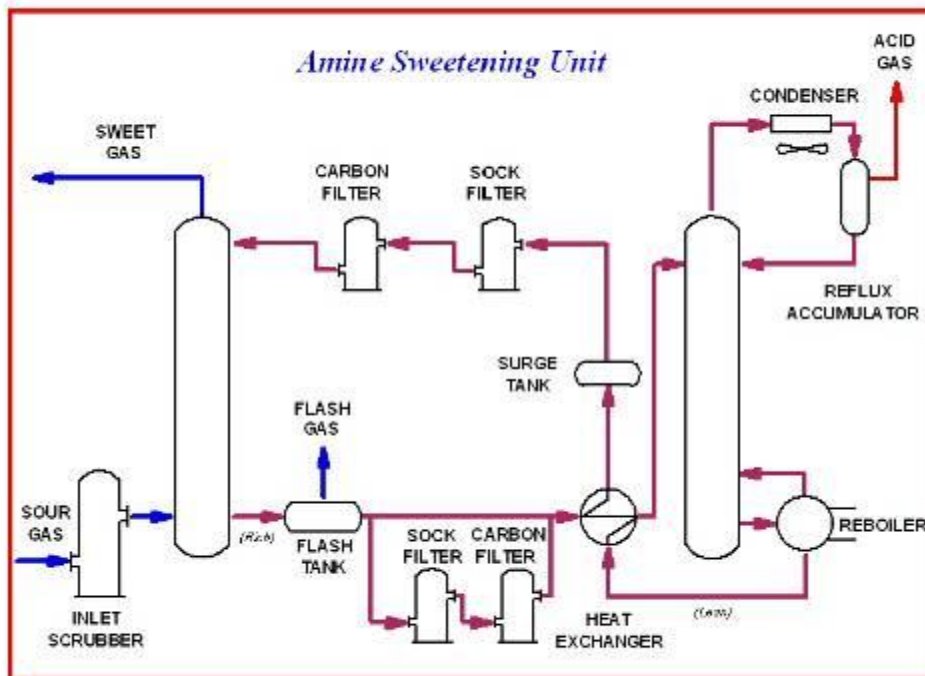
Wellhead gas requires purification to make it “pipeline quality” for market. These criteria include:

- 1,010 BTU \pm 5%
- <7 lbs. water vapor (H₂O) per 1000 Mcf
- <1% Oxygen (O₂)
- <4% Carbon Dioxide (CO₂)
- <3% Nitrogen (N₂)
- <20 grains total Sulfur (S) (mg/m³)
- <1 grain Hydrogen Sulfide (H₂S)

Carbon dioxide and hydrogen sulfide are particularly corrosive to pipes and equipment. Sour gas is “sweetened” in gas plants, which use amine as a solvent to strip these acidic chemicals out of the gas.

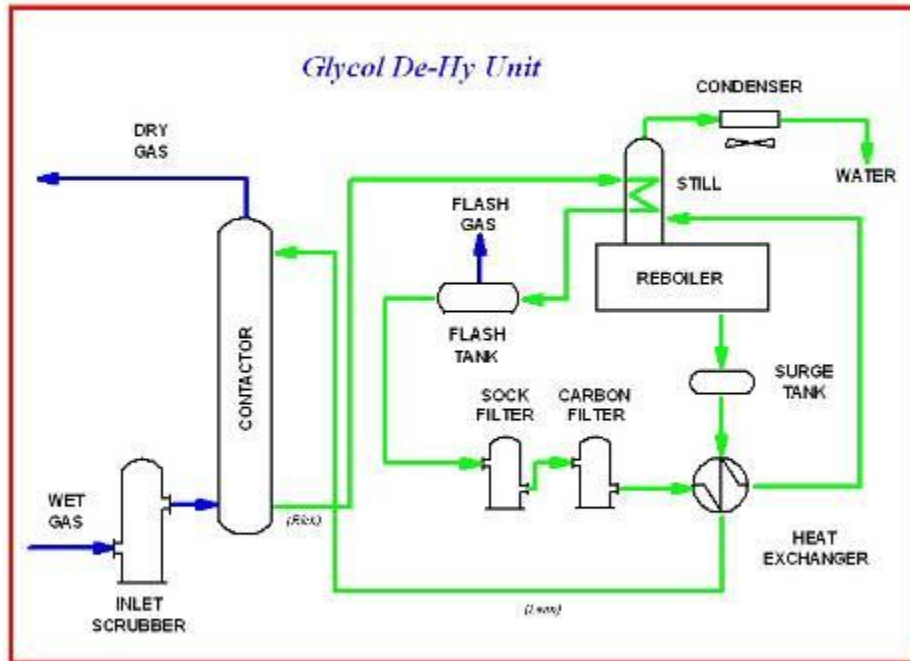
These amine units employ a reboiler in a closed-loop, once known as the “Claus Process”. Sour gas enters the bottom of the contactor and “lean” amine cascades down from the top of the tower through trays or packing. The amine strips the CO₂ &/or H₂S out of the gas, and sweet gas exits the top of the tower.

The amine exiting the bottom of the contactor is “rich” in acids, which are flared off as acid gas after separation in the reboiler tower.



Amine Unit Flow Schematic

A similar process is used to dehydrate natural gas, using glycol. These “de-hy” units dry the gas, as measured by its dew-point.



Glycol Unit Flow Schematic

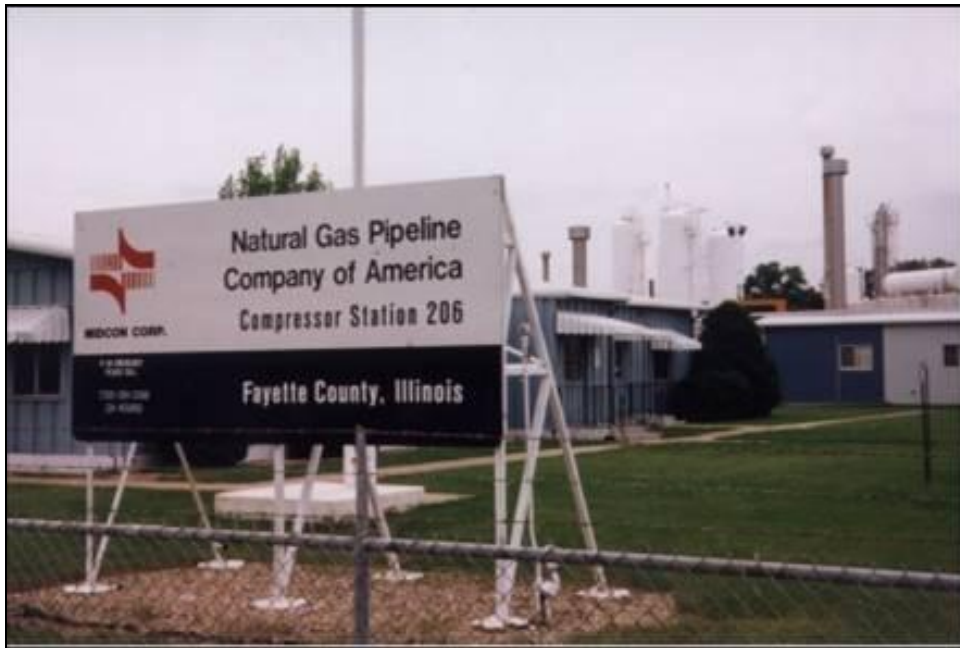
Filtration Systems, Inc. manufactures a number of filters for gas plant applications, primarily sock and carbon filters. Sock filters are affordable, have exceptional dirt-holding capacity, withstand the high temperatures and have excellent fluid compatibility. Its virgin, coal-based activated carbon has high abrasion-resistance and micro-porosity, to adsorb liquid hydrocarbons and heat-stable salt precursors.



Sock-Type and Activated Carbon Filters

Natural gas is often put into underground storage during the spring and summer months. Storage fields can be salt caverns, aquifers or depleted oil fields. Perfectly good pipeline-quality gas is pumped down-hole, and when it is withdrawn, it requires processing and filtration all over again!

These photographs were taken at an amine plant in southern Illinois.



Gas Sweetening Plant



Inlet Filter-Separator



Contact Tower



Inlet Gas Coalescers, note towers in background



Activated Carbon Filter

Gas Plant Buzzwords

Antifoam	Chemical additive used at amine plants.
Amine	A solvent used to remove acids from natural gas
Blanketing	Flowing gas & liquid in the same vessel
Break Time	Time required for a foam to turn back into a liquid
Burping	See carryover
Carry-Over	Process liquids exiting the top of the contactor
Contactor	A tower with trays or packing for counter-current flow
DEA	Diethanolamine, a type of amine
DEG	Diethyleneglycol, a type of glycol
De-Hy	A unit to remove H ₂ O from natural gas
Downcomer	A pipe going down
Fat	See Rich
FERC-636	Laws deregulating the gas transmission industry
Flash Tank	A drum to separate gas from liquids
Foaming	Bubble-formation in amine & glycol units (see Carry-Over)
Glycol	A chemical used to take water out of natural gas
Header	A pipe-distribution system
Huff-n-Puff	A back-pulse air filtration system
Injection	Pumping gas into an underground storage field
L & R's	Pig traps, for launching & receiving pipe pigs (cleaners)
Laterals	Pipes running at right angles to the main pipe
Lean	Amine that has been stripped of H ₂ S or CO ₂
MEA	Monoethanolamine, a type of amine
Off-Spec Gas	Natural gas that is not of pipeline quality
Overhead	Light-end gases, separated at refinery units

Pentane Insolubles	A measure of particulate contamination in lube oil
Pigging	Running a rubber barrel through pipe to clean it
Puking	See upset
Reboiler	Steam heater
Reflux	A return loop
Rich	Amine or glycol saturated with H ₂ S/CO ₂ or H ₂ O respectively
Riser	A pipe going up
Scrubber	A slug-catcher, to remove liquids from natural gas
Separator	A mist-eliminator, similar to a scrubber
Sour Gas	Natural gas with more than 3% H ₂ S or CO ₂
Shut-In	To block and purge a section of pipe
Slip-Stream	A bypass filtration diverter loop
Sphere	A rubber ball used to clean pipe and separate product
Still	A device used to separate water from glycol
Stripper	A liquid-liquid contactor
Sulfides	A black semi-solid contaminant in hydrocarbon processing
Sump	A collection tank below a separator; oil in a crankcase
Tail Gas	Waste gas from refining processes
TAN	Total acid number, a measure of lube oil degradation
TEG	Triethyleneglycol, a type of glycol
Two-Phase Flow	Running gas and liquid simultaneously through a vessel
Trays	A form of tower packing
Upset	Severe foaming, causing unit shut-down
Withdrawal	Taking gas out of storage during the heating season