Alternate Energy Systems, Inc.

A Corporation devoted to Your Energy Needs

LPG / Air Mixers: What You Need To Know

A Comparison of Blending Technologies

LPG/Air Mixers have been used for decades to produce Synthetic Natural Gas (SNG). SNG is a blend of LPG and air that has the same Wobbe Index as Natural Gas (Methane). By matching the Wobbe Index, SNG has the same combustion characteristics as, and can therefore be freely interchanged with, Natural Gas. This has lead to the use of LPG/Air Mixers as both primary fuel sources and stand-by systems. Additionally, LPG/Air Mixers have seen extensive use in Peakshaving and CityGas applications.

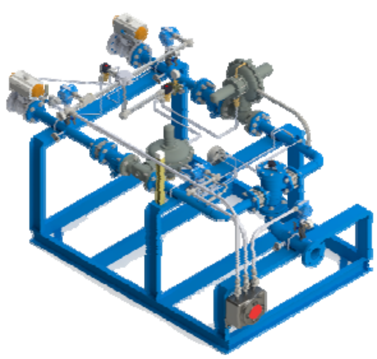
There are several types of LPG/Air mixing technologies available in the market. The largest group of these Mixers are often referred to as "Proportional" Mixers. These are Mixing systems that can easily change the blending ratio of LPG and air. The three dominant technologies are:

1. Piston Operated Mixers (AES POM)
2. Floating Variable Orifice or Consta-Mix Mixers (FVO or CM)
3. "Flow-Meter" type Mixers (sometimes called AFC)

While all of the above designs are capable of producing acceptable SNG under ideal operating conditions, not all Mixers deliver reliable results under ALL operating conditions.

The **Piston Operated Mixer (POM)** manufactured by Alternate Energy Systems, Inc. (AES) is a time-tested and proven design that has been used world-wide for more than 40 years. In fact, the design is so simple and well-tested that some even refer to it as "Old Fashioned". At the heart of the POM Mixer is the POM valve itself. This patented valve uses a simple floating piston design to not only set the blending ratio of LPG and air but also exactly match SNG production to customer demand. The beauty of the POM design is that it does not rely on diaphragms, flow-meters, dynamic seals, or complicated differential pressure arrangements, but instead utilizes fundamental physical properties that almost anyone can understand.

POM Mixers have been manufactured for many years and have seen continual improvements of their control components, but without any changes to the main design concept. The mixers have been approved by Factory Mutual (FM Global) and the Canadian Standards Association (CSA). Mixers with European CE Mark comply with all applicable EU Directives (ATEX, PED, etc.).



How do Alternate Energy Systems' POM LPG-Vapor / Air Blenders work ?

Standard high capacity / high pressure LPG vapor / air blenders used to be very complicated pieces of machinery, difficult to set up, and requiring a very high level of maintenance. With the advent of the POM, "Piston Operated Mixer", these installer and operator "nightmares" are a thing of the past. The impressive simplicity of the POM guarantees the ultimate in accuracy, reliability and flexibility, and allows the POM to be manufactured in virtually any capacity and of any material compatible with the gasses that are being blended. By using a piston, there are no design pressure or temperature restrictions commonly found with diaphragms (FVOs), which have high-temperature restrictions or may stiffen and crack in cold temperatures or over time.

Compared to systems with complicated mixing valves, which typically use differential pressure feedback, POM systems impress with their simple installation, setup, operation and maintenance, their unsurpassed operational reliability, their quick response to load changes, and their turn-down ratio of 40:1 or better.

Compared to blending systems that rely on the presence and accuracy of Vortex (or other types of) flow meters to pre-set the blending ratio ("feed-forward" or "forward control"), and then have to wait for a signal from a gas analyzer (usually a Calorimeter) to make adjustments to the blending ratio until the actual gas properties match the desired values (feed-back), POM blenders are much faster to respond to load changes (flow changes).

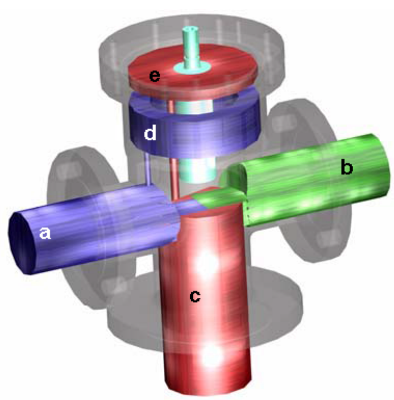
While the flow meter based blenders cannot operate accurately without the presence of a gas analyzer, POM blenders will maintain their blending ratio regardless of the flow demand. This has been proven time-and-time again in demanding applications. A typical example for this is the fuel supply to float glass plants, where the periodic "reversals" (100% flow for 20 minutes; 100% to 0% in 10 seconds; no-flow for several seconds; 0% to 100% in 5-10 seconds) usually upset flow meter based blenders to the point that some users have decided to use them for "Asset Protection" only, but not for "Profit Protection" (keep the furnace warm, but don't produce glass, because the gas properties are not good enough). POM blenders, on the other hand, have no problem maintaining the blending ratio even under these conditions, and have therefore become a quasi-standard for the glass industry.

Once set, the POM will blend two gasses at a constant ratio: the result is an LPG / air mixture which is compatible with natural gas, regardless of the downstream demand. The POM system is a "pushthru" system. This means that it is not necessary to reduce the compressed air or the LPG vapor to zero pressure during the mixing process, before compressing both air and gas to the desired pressure. The POM system utilizes the existing pressure in the LPG to satisfy most industrial and utility peak shaving applications.

HOW IT WORKS – The dominant gas (i.e. LPG) enters the mixer at Inlet Port "A". The blend gas (i.e. compressed air) enters at Inlet Port "B". Both gasses exit together at Exit Port "C". A small connecting bore connects Inlet Port "A" with Chamber "D" and, another bore connects Chamber "E" (through the piston) with Exit Port "C".

When turned off, or during no-flow periods, the piston rests in the closed position. Upon demand for gas, pressure at Exit Port "C" drops slightly. This change in pressure is passed through the piston to Chamber "E". The pressure at Inlet Port "A" (dominant gas) is greater and, since this area connects to Chamber "D", the piston will rise or descend with demand changes or pressure drops at Exit Port "C". When the flow rate is constant, the piston will "float", partially opening the inlet gates A and B. This results in a very accurate positioning of the piston, accurately metering the flow of gas, regardless of the downstream demand.

BLENDING RATIO ADJUSTMENT – A segment "G", cut out of the piston, matches the edge of the cutouts in Port "A-B". The piston is positioned between a sliding, pinned guide and the top of the piston. A knurled knob, attached to the stem of the guide, easily allows adjustment to be made externally by rotating the guide (and with it the piston), to restrict either Inlet Port, thereby controlling the ratio of gas and air. The piston is designed with a series of grooves, called a "labyrinth", which generates circular "O" rings or vortices which prevent the gasses from transferring between the top and bottom chambers. This design eliminates the need for a diaphragm or a mechanical seal such as a piston ring. It also allows the POM to be equipped with an actuator/positioner for automatic correction of the properties of the mixed gas, i.e. Calorific Value, Wobbe Index Number, O_2 content, Specific Gravity, etc.



Gas Flow through POM Valve

Legend:

A Dominant Gas Inlet (LPG)

B Compressed Air Inlet

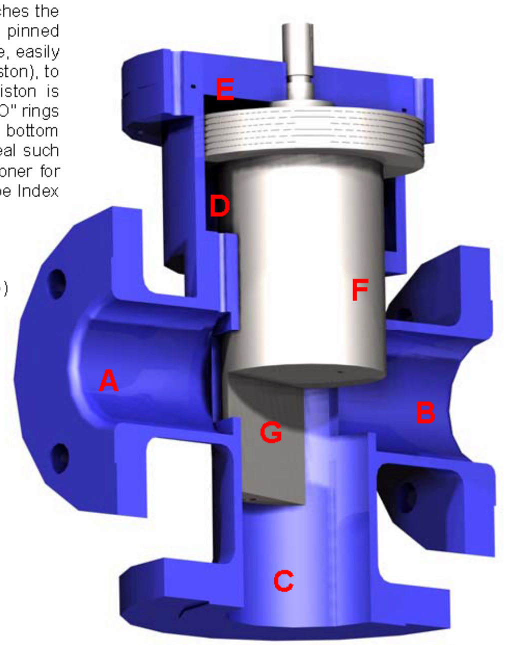
C Mixed Gas Outlet

D Dominant Gas Loading Chamber

E Mixed Gas Flow Sensing Chamber

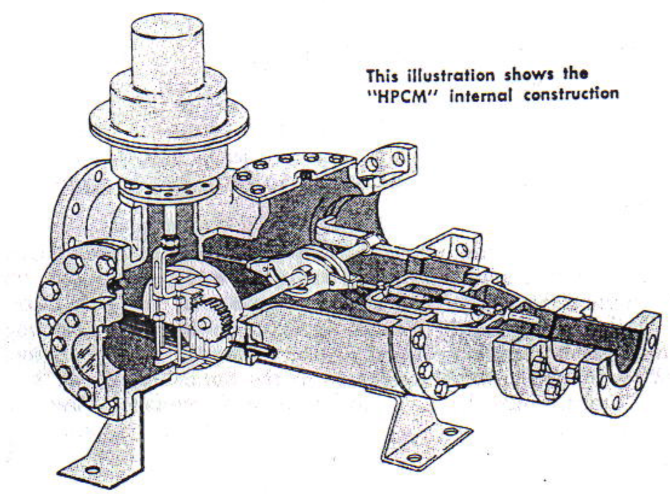
F Piston

G Piston Cutout for Ratio Adjustment



Floating Variable Orifice Mixers or Consta-Mix (FVO or CM) are manufactured by several companies throughout the world. While they appear similar in operation, FVO/CM should not be confused with the patented POM Mixer.

While the POM utilizes a simple floating piston design, in which all movement of the piston is created through simple physical principles as described above, FVOs and CMs typically rely on some combination of diaphragms, complex linkages, and mechanical seals and/or sleeves for proper operation. This is illustrated in the schematic of an Eclipse HPCM (High Pressure "Consta-Mix"). As can be seen below, there are far more moving parts and "points for failure" in these designs.



For these FVO and CM systems, improvements in control and peripheral components cannot make up for fundamental deficiencies in the reliability and simplicity of the mixing valve.

"Flow-Meter" type Mixers (AFC), or so-called Active Flow Control Systems, are a more recent development in the SNG industry. However, these designs are based in a misplaced enthusiasm for "high-technology", rather than fundamental improvements to time-tested methods.

At the core of any AFC system are Flow-Meters. These meters do provide interesting, real-time information on the mixing process, but they also naturally add additional "points for failure" to the mixer as a whole. In essence, AFC mixers utilize many of the same principles and components as other Mixing system, but incorporate the additionally complexity and maintenance requirements of flow-meters.

While manufacturers of AFC Mixers may claim that their flow-meters require no maintenance and have no drift, this is simply not the case. Regardless of the flow-meter technology used (thermal mass flow, positive displacement, vortex, differential-pressure, etc.) maintenance and calibration of the meters is required. This has been proven not only in the SNG market, but in every technical market in the world (waste water, power generation, chemical processing, etc).

Manufacturers of AFC Mixers often like to claim that other mixing technologies are prone to contamination by heavy ends (C5+) in LPG, while these have no effect on their product. This could not be further from the truth. While AES agrees completely that all LPG equipment will be exposed to heavy ends and are subject to poor performance or failures because of it, the AFC mixers are acutely prone to problems arising from heavy ends due to their reliance on delicate flow-meters.

Every flow-meter technology available on the market is affected by heavy ends. Vortex flow-meters rely on very precise flow channels inside of the meter and often require straightening vanes or very precisely controlled flow paths both upstream and downstream of the meters. When these flow path and vanes are contaminated (coated) with heavy ends, the accuracy of the meters is greatly impaired. Thermal mass flow meters rely on a heated and a reference element to be inserted directly into the flow stream. When these elements become contaminated (insulated) with heavy ends, their accuracy is also negatively affected. The same is true for all flow-metering technologies.

The impact that pressure and temperature compensation play on the flow reading must be considered as well. In order to accurately determine the flow, the meter must first take a flow reading and then correct it for pressure and temperature. The accuracy of the pressure and temperature transmitters have an effect on the overall accuracy of the reading. These transmitters must also be individually cleaned and maintained. When the variances in all three accuracies are taken into account, the claimed overall accuracy of the system becomes questionable.

Additionally, most modern digital flow-meters are calibrated for a particular target fluid. In the case of LPG this poses additional problems. Throughout much of the world LPG composition varies greatly and often. These variations can be seasonal, regional, or even occur from one delivery to another. It is not uncommon for LPG make-up (%Propane/%Butane) to vary from 80/20 to 20/80 at a given installation location over the course of only a few months. With these changes of make-up, the physical properties of the LPG change, meaning that flow-meter readings will be inaccurate. This may be due to a change in viscosity for Vortex meters or a change in specific heats for thermal mass flow meters.

If a Mixing system is controlled based on flow conditions alone, this mixing system can only be as accurate as its flow-meters. While the manufacturers of such systems will claim that this is very accurate indeed, this accuracy is achievable only in very tightly controlled and clean laboratory conditions. Real world conditions and heavy ends contamination will ensure that the observed “real” accuracy of these meters will never approach the advertised values.

Control philosophies referred to as Auto-Ratio-Control are in fact based on assumptions. In order to “pre-set” the blending ratio, one must know what the make-up of the LPG feedstock is. Without this information, it is impossible to accurately select the appropriate proportion of air to blend with the LPG to achieve the target Wobbe Index. Without real-time information, feed-forward control is an educated guess at best, particularly when LPG composition varies greatly over time. In order to achieve the advertised results, a gas analyzer (Gravitometer or Calorimeter) must be used to provide reliable feedback to the system. This is why feed-forward control (Auto-Ratio-Control) cannot be taken at face value. If LPG feedstock properties were to change and these values were not entered into the control system of the AFC, or if they were not

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known explicitly, than the AFC's Auto-Ratio-Control would be actively setting an improper blending ratio. In fact, if one reads the AFC mixer literature very closely, they will see that "Automatic Ratio **Adjustment**" is only available when an **optional** Wobbe Index Meter is installed. This means that without a Wobbe Index Meter installed, the AFC can only set blending ratios based on *assumptions* of LPG make-up, and that the flow values displayed are often "close enough" at best.

The AFC mixers certainly appear to be more modern and sophisticated than other types of Mixers. However, if one looks past all of the technology, the inherent problem outlined above become apparent. AFC mixers work well under very precise and static conditions. It has been the observation of several user and industries (particularly the glass industry) that the AFC mixers do not react very well to disturbances in the system, like sudden changes in LPG feedstock or sudden spikes in demand.

POM Mixer Standard Control System

While it is mentioned above that the POM "is so simple and well-tested that some even refer to it as 'Old Fashioned'", the control system and operator experience have never ceased to evolve and today represent some of the most advanced SNG systems in the world.

Every POM Mixer comes standard with:

- Industry Leading PLC Controls (Siemens, Allen-Bradley, GE, etc.)
- Full Color High-Resolution LCD Touchscreen
- Integrated VNC Server for Remote Monitoring and Operation
- LPG Inlet Pressure Transmitter (Rosemount 2088)
- Compressed Air Inlet Pressure Transmitter (Rosemount 2088)
- SNG Discharge Pressure Transmitter (Rosemount 2088)
- LPG/Air Differential Pressure Transmitter (Rosemount 3051)
- Real Time Display of All Process Values
- Trend recording of all process parameters – up to two years of stored data on onboard, removable flash storage
- Full alarm history - up to two years of stored data on onboard, removable flash storage
- Full event log - up to two years of stored data on onboard, removable flash storage
- Selectable language and engineering units
- Multi-tiered, password-protected login levels
- Alarm Strobe and Siren
- Full Integration with all SNG system components (Vaporizers, Pumps, Truck Unloading, ESD System, Controlled Vent Device, Tank Level) – Single Source Operation
- Optional Integration into Plant Control/SCADA system – Profibus, Profinet, Modbus, Ethernet I/P, etc.
- All Controls Designed and Programmed "In-House"

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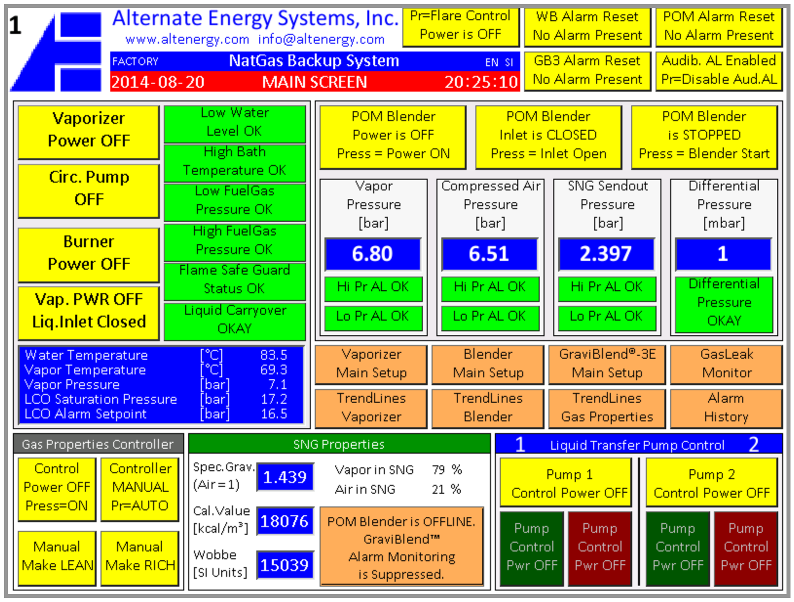
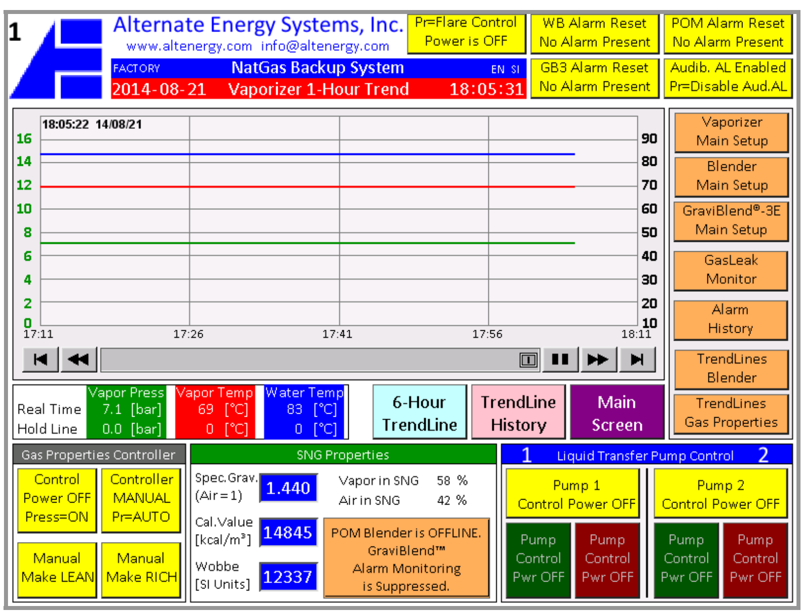


Typical AES Control System "Main Screen"
Integrated to Include: POM, Vaporizer, Liquid Transfer Pumps (Duplex), SNG Properties Analyzer (GB-3), Gas Properties Controller (AccuBlend), Controlled Vent Device (Flare)



Typical AES Control System Trend Line Data
1-hour Trend Shown, Real Time and Hold Line Data Available

Comparison of POM and AFC Mixers

	AES - POM	Aether DBS- AFC
Class 1 Division 1 Group D - Standard	X[1]	✓
Auto Ratio Controller	**Not Required**	✓
LPG Pressure Transmitters - Standard	✓	✓
Air Pressure Transmitters - Standard	✓	✓
SNG Pressure Transmitters - Standard	✓	X
Differential Pressure Transmitters - Standard	✓	X
Touchscreen - Standard	✓	✓
Integration of Mixer into Overall SNG System Controls - Single Point Operation - Standard	✓	X
Remote Monitoring and Control using Integrated VNC Server - Standard	✓	X
All Controls Produced "In-House"	✓	X
Unlimated Utility Power Supply Options to Match Site Conditions	✓	X
Standard Communications Protocols Available (Profibus, Profinet, Modbus, etc.)	✓	✓
All On-Skid Components Pre-Wired and Pre-Tested	✓	✓
Design Eliminates Dependency on Flow-Meters	✓	X
Design Relies on Vertical Movement of Control Device	✓	✓
Industry Leading Flow Capacities	✓	X
Industry Leading Operating Pressure Range	✓	X

[1] - Class 1 Division 1 Group D construction is available. However, AES does not require purchase of this option if it is not needed.

As can be seen above, when factual information is used to compare the POM and AFC Mixers, the conclusions that can be drawn are vastly different from findings published by other authors. For example, some publishers are so bold as to claim that POMs do not come standard with pressure transmitters or touchscreens. This leads one to ask what other non-factual information is being published by these parties.

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