Ely Energy Inc.
Global Leaders in PROPANE Energy Systems

Propane-air Standby Systems: An Overview

Why is Propane-air used?

Mixing PROPANE with air in an appropriate ratio creates **Synthetic Natural Gas** or so-called PROPANE-AIR. PROPANE-AIR provides nearly identical combustion characteristics to natural gas. Therefore, PROPANE-AIR and NG can be used interchangeably and burner, regulator and orifice adjustments are not necessary.

Questions often arise regarding the **air quality** associated with PROPANE-AIR. The air quality required is as follows:

- *Suppressed compressed air dew point* 15 – 20°F (8.3 – 11.2°C) *below inlet dew point*
- *Remove contaminants 10 microns or larger*
- *Allow minimal trace of lubricants and aerosols*
- *Provide air inlet pressure at minimum* >35 PSIG *(2.4 bar g) above the PROPANE-AIR Discharge Pressure*

PROPANE-AIR is desirable when there is an absence or a shortage of natural gas in a region. PROPANE-AIR can be used, for example, to precede the availability natural gas or to augment the gas supply where natural gas is already available. It's also more convenient than traditional PROPANE cylinder gas.

PROPANE-AIR systems provide a convenient, consistent, high quality fuel with combustion characteristics similar to natural gas. In emerging economies where natural gas is in its infancy, PROPANE-AIR plants allow local gas utility firms to "build up" a customer base during planning and construction of a natural gas transmission line. The availability of PROPANE-AIR also entices commercial and industrial growth since such customers can install natural gas equipment before the arrival of the natural gas.

PROPANE-AIR systems also allow significant opportunities for managing peak load gas demand situations. For example, daily or hourly demand for natural gas can vary between ten percent (10%) to three hundred and fifty percent (350%) of the yearly average. Consequently, even though natural gas processing plants and transmission lines are sized for a very large capacity, only a small percentage of that capacity is typically used. An PROPANE-AIR system can provide for peak loads, rather than require installation of an additional expensive natural gas storage facility.

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The advantages of PROPANE-AIR under specific situations are obvious. One side benefit is that PROPANE-AIR eliminates recondensation problems commonly associated with undiluted PROPANE vapor, as the "tempering" of the PROPANE with air suppressed the dew point. Below we examine the similarity of PROPANE-AIR burning characteristics to those of natural gas, and the hydrocarbon dew point consequences of PROPANE-AIR mixtures.

COMBUSTION PARAMETERS of PROPANE-AIR

Combustion parameters affecting fuel interchangeability include:

1. Specific Gravity
2. Calorific Value
3. Wobbe Index
4. Flame propagation and color
5. Hydrocarbon Dew point

1. SPECIFIC GRAVITY

The specific gravity of a gas is its density relative to air. The specific gravity of air equals 1.0; natural gas is typically 0.60. Undiluted propane and butane vapor have specific gravities of 1.52 and 2.0, respectively. Consequently PROPANE-AIR *always* has a specific gravity greater then 1.0.

Both natural gas and PROPANE-AIR mixtures use the same combustion equipment. Most natural gas has an average heat value of approximately 8500 - 9350 Kcal/Nm^3, and a specific gravity of around 0.6. Mathematical models validated by field experience prove that compatible PROPANE-AIR comprised of propane and air to replace natural gas has a heat value of around 12,500 Kcal/Nm^3 and a specific gravity of 1.31. PROPANE-AIR comprised of butane-propane and air to replace natural gas has a calorific value of around 13,800 Kcal/Nm^3 and a specific gravity of 1.461. A spreadsheet for calculating replacement gas values can be provided by **EEI** upon request.

The difference in heat values of an original fuel, versus a replacement fuel results primarily from differences in specific gravities and ultimately, chemistry. The higher the specific gravity, the heavier the gas. Consequently, fixed openings such as burner orifices, regulators, and certain types of flow meters allow less flow of a heavier gas than a lighter gas. Physics state that the flow of gas through any orifice is directly proportional to the square root of its specific gravity. Therefore, a heavier gas (*i.e. replacement PROPANE-AIR mixture*) must have a **higher calorific value** to provide the same energy input into a burner as a lighter gas. In a simple minded way, the heavier gas flows more slowly through the orifice hence each unit volume must have a higher calorific value in order to make up for the reduced flow. However, on the downstream side of the orifice, gases with **matching Wobbe values will provide equal net energy.**

2. CALORIFIC VALUE

Data tables typically state calorific values as either ***gross*** *calorific value* or ***net*** *calorific value*. The difference between the two calorific values is the latent heat of condensation of the water vapor produced during combustion.

Gross calorific value assumes all water produced during combustion is condensed. In other words, the *latent heat of condensation* is utilized. **Net calorific value** assumes water leaves with the combustion products without being condensed.

Gross calorific value is of no interest for most consumers since appliances are unable to utilize the heat content of the water vapor. **One should compare fuel prices based on net calorific value.** This is especially true for natural gas (methane) since the increased hydrogen content results in high water formation during combustion.

However, **to evaluate combustion characteristics,** use the **gross calorific value** since the volume of combustion air, and the volume of combustion products produced are equal for each hydrocarbon. If the net calorific value is used there will be slight deviations between the volumes of combustion air and the products.

3. WOBBE INDEX

Wobbe Index is a property of an individual gas that allows matching an *original gas* (*e.g. natural gas*) to a *replacement gas* (*e.g. PROPANE-AIR mixture*). **If two different gasses possess an identical Wobbe Index they will produce an equal amount of heat from any given burner.** The Wobbe Index is a critical factor when considering PROPANE-AIR plant data. We state the Wobbe Index (WI) as:

WI = Calorific Value (CV) of a gas divided the by the square root of the SG of the gas. This WI must be matched with the WI of the replacement gas - calculated the same way.

As the above formula indicated, the Wobbe Index is a function of gas quality. It varies relative to the PROPANE-AIR blending ratio, and hence the PROPANE end member composition. **Hydrocarbon gases with an identical Wobbe Index generate equal amounts of heat and combustion products. Also, they require the same amount of combustion air.** If a burner is adjusted to a specific calorific value, or Wobbe Index, and it is provided a replacement gas of a lower Wobbe Index, minor combustion characteristics will be noticed. Flame characteristics at the burner dictate the limits of the fuel composition acceptance. Substituting one gas for another of a higher Wobbe Index typically allows a narrow acceptance range. Excessive size of the flame and incomplete combustion determine the acceptance range.

4. FLAME PROPAGATION AND COLOR

Flame propagation velocities of PROPANE and butane nearly equal those for methane. Therefore, no significant flame lift differences occur between natural gas and PROPANE-AIR mixtures. In terms of color, PROPANE-AIR mixtures produce a more yellow flame due to the number of carbon atoms in the PROPANE or butane molecule relative to natural gas. For example, PROPANE has approximately twenty percent more carbon than methane, and butane has approximately twenty four percent more carbon. Yellow tips are of no concern and will not impair burner operation or efficiency.

5. HYDROCARBON DEW POINT

The *hydrocarbon dew point* is the temperature at which a specific PROPANE composition condenses from vapor to the liquid phase. Dew point calculation for PROPANE is beyond the scope of this document. Dew point data is important, however, because recondensation of PROPANE vapor in distribution lines can create hazardous situations. Dilution of PROPANE vapor with air **significantly depresses the dew point**, making PROPANE-AIR mixtures advantageous for many applications. Various graphs are available that illustrate the relationship between the percentage of PROPANE in an PROPANE-AIR mixture and the dew point at various pressures.

STANDBY SYSTEMS: A DISCUSSION

So called PROPANE-AIR Standby systems provide an PROPANE-AIR mixture to an industrial customer when natural gas is curtailed or, when the pricing of NG versus PROPANE-AIR is unfavorable.

The capacity of such a facility **must successfully operate at both the peak and minimum consumption periods**. Grossly oversized plants often function inefficiently during minimum demand hours do to poor turndown of the systems. Similarly, undersized plants will be unable to provide an adequate source of fuel during peak demand periods.

Decisions on plant capacity require accuracy regarding gas consumption. An analysis should examine hourly maximum consumption, as well as potential growth to the facility. In the analysis, a graph might be created to display projected minimum gas consumption during a twenty-four hour period. A second graph could illustrate a twenty-four hour period at maximum consumption.

Industrial PROPANE-AIR Systems typically distribute at between .4 bar g and – 6 bar g. EEI can provide distribution pressures to 12 bar g or higher if required but costs and recondensation issues must be carefully addressed.

PROPANE-AIR COMPATIBILITY WITH NATURAL GAS

PROPANE-AIR has a higher specific gravity than the natural gas it replaces. Consequently, less PROPANE-AIR flow through a pipe or orifice compared to natural gas given the same pressure drops. We compensate for reduced volumetric flow by increasing the calorific value of the mixed gas (PROPANE and Air).

In other words, since less gas (PROPANE-AIR) flows through the pipe - the gas must carry a higher heating value.

What we provide is an PROPANE-AIR with the same Wobbe Value (*i.e. energy value*) as the natural gas it is replacing.

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BASICS OF AN PROPANE-AIR PLANT
(Design / Mfg / Erect)

- **Manufactured Equipment**
- TTU (Truck Transfer Unloading) Station
- PROPANE Storage Tank and Associated Trim (Valves etc.)
- PROPANE Process Pumping System
- PROPANE Vaporization System
- PROPANE-AIR (Propane + air) Mixing Module
- Calorimeter (Optional depending on application)
- **Engineering**
- Civil work, Interconnecting piping, valves, regulators, filters, wiring, fencing, etc.
- Mechanical design (piping)
- Concrete
- Electrical Design
- Controls Design
- **Field Services**
- Field Supervision as required
- Commissioning - Training

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