2.2.11 Storage and Transportation

Although not shown in Figure 2.1, one other "process" tied in with gas plants is storage and transportation. Chapter 12 discusses the storage and transportation of natural gas and NGL products.

2.2.12 Liquefaction

As noted earlier, liquefaction is not common in the United States, but is becoming more important worldwide as more gas is imported to industrial nations from remote locations. Also, liquefaction plays an increasingly important role as a means for gas storage. Chapter 13 discusses liquefaction processes. Because of the unique properties of liquefied natural gas (LNG), the chapter includes storage, transportation, and vaporization processes as well. These aspects are important to countries, such as the United States, that import LNG.

2.3 IMPORTANT SUPPORT COMPONENTS

Some important components of all gas plants are omitted from detailed discussion in this book. These components include utilities, process control, and safety systems. The Engineering Data Book (2004a) provides more details on these topics.

2.3.1 Utilities

Utilities include power, heating fluids (steam and oil), cooling water, instrument air, nitrogen-purge gas, and fuel gas. Most gas plants purchase electrical power, but some generate at least part of their power on site. Cogeneration plants are becoming more attractive options for reduction of operating costs, especially when gas turbines are used for driving compressors. Compared with refineries and most chemical complexes, steam and hot oil are not extensively used in gas plants. Their primary uses are for regeneration of solvents and some reboilers. Cooling water is used primarily in heat exchangers on compressors. The Engineering Data Book (2004c) has an excellent discussion on water treating chemistry.

An uninterrupted source of clean, dry instrument air is critical to plant operations because the air drives most automated valves. Typical pressures are around 100 psig (7 barg). Plants use one or more backup compressors to ensure that air is always available. Many operations have molecular sieve driers (see Chapter 6) to avoid potential line freezes in cold weather. In areas of high instrument flow rates, air receivers permit large flow rates without pressure drops (Engineering Data Book, 2004c).

Nitrogen is used as a purge gas around rotating seals, as well as to purge and blanket vessels. The required purity depends upon the application but usually is not high. In many cases, the enriched nitrogen is obtained from membrane or pressure swing adsorption (PSA) separation (see Chapter 9 for details). If large volumes are required, cryogenic fractionation of air is the most economical process (Engineering Data Book, 2004c).

Gas plants use the gas they process to fuel the facilities. Boilers, hot-oil furnaces, and reciprocating compressors can use low pressure gas. The primary concern is having a particulate-free gas and a roughly constant heating value. The Engineering Data Book (2004c) states that for gas turbines, which are discussed in Chapter 4, the required fuel-gas pressure may be as high as 600 psia (41 bar).

2.3.2 Process Control

Process control has always played a role in gas plants but has become more important over the years as companies try to reduce labor costs. Most plants use good digital control systems (DCS) for individual units to provide both process control and operations history. Since the 1990s, advanced process control (APC) systems, which "sit" on top of existing DCS systems, provide sophisticated plant control. APC uses multivariable algorithms that are trained in the plant to optimize operations. Another aspect of process control commonly used is SCADA (supervisory control and data acquisition). One important use of SCADA is the monitoring of field operations, with the capability of controlling dehydration equipment, flow valves, and compressor stations from the gas plant.

Automation requires accurate input data to make the proper control decisions. Plants usually have a full-time instrument technician to maintain and calibrate the many temperature, pressure, and flow sensors, as well as instruments required for compositional and trace-component analysis.

2.3.3 Safety Systems

Safety systems are critical to all gas plants. These systems include the emergency shutdown of inlet gas, as well as relief valves and vent systems leading to the flare. The Engineering Data Book (2004b) provides criteria for sizing relief systems and flares. Proper sizing of relief valves, rupture disks, and piping is important to ensure that operating systems can be vented quickly. The design often is complicated by the need for two phase flows through valves and lines.

Pipe flares are probably the most common flare in gas plants. In normal operations, the flare flame is barely detectable. If the plant is venting mostly methane, the flare flame is bright but smokeless. If methane plus heavier hydrocarbons are flared, the flame will smoke. To make the flare smokeless, steam or high-flow-rate air or fuel gas is added. If the fuel has a low Btu content (e.g., tail gas from a sulfur recovery unit), fuel gas is added to ensure complete combustion.

2.4 CONTRACTUAL AGREEMENTS AND ECONOMICS

When operational changes are under consideration, the customary analysis for optimization of the balance between capital expenditures and operating costs applies. However, contractual agreements complicate a gas plant economics study whenever the producer and processor are not the same company. Five basic kinds of contracts are commonly used between producers and processors (Kuchinski, 2005):

1. Fee based
2. Percentage of proceeds
3. Wellhead purchase
4. Fixed efficiency
5. Keep whole

2.4.1 Fee-Based Contracts

In fee based contracts, the producer pays the gas processor a set fee on the basis of gas volumes produced. The processor may obtain additional income by charging fees for additional services, such as gathering, field compression, pipeline transmission, and marketing. In these contracts, the processors income is independent of gas and NGL prices.

2.4.2 Percentage of Proceeds Contracts

In percentage of proceeds (POP) contracts, the two parties agree to what percentage of the proceeds from the sale of the gas and liquids is to be retained by the producer. Typically, the producer retains more than 70% of the proceeds from the sale of all products. In the case of multiple producers, each has a percentage share of the proceeds, allocated on the basis of each producer's contribution to the proceeds. Allocations are computed on the basis of the Btu content of the gas delivered at the wellhead for a producer divided by the sum of the Btu content of the gas from all producers. Producers and processors share the effect of gas and NGL price fluctuations.

2.4.3 Wellhead Purchase Contracts

In wellhead purchase contracts, the processor executes a contract to purchase total Btus from the producer at a negotiated price usually based against an index. This purchase is a straight-forward purchase, and the processor's profits depend upon the cost of gathering and production and the selling price of the gas and liquids.

2.4.4 Fixed Efficiency Contracts

In fixed efficiency contracts, the processor agrees to provide a certain percentage recovery (efficiency) of the heavier than methane components from the gas and to pay the producer on the basis of the market value of the theoretical liquid production and resultant residue gas. The processor makes money by processing at a higher efficiency (higher fraction of the liquids removed from the feed stream). Processor profits hinge on actually having higher recoveries and a favorable price margin.

2.4.5 Keep Whole Contracts

In keep whole contracts, the processor agrees to process or condition the producer's gas for sale in the natural gas market and to return to the producer 100% of the Btu content of the raw gas (keep the producer whole on Btus) in exchange for retaining ownership of all liquids extracted from the gas. The processor usually retains all liability for fuel, processing costs, and the purchase of replacement of Btus extracted as a liquid product.

These contracts are more complex, more favorable to the producer, and more risky to the processor. The producer, in essence, sells the whole hydrocarbon stream, at the price of natural gas on a Btu basis, to the processor. The processor makes or loses money, depending on the price difference (price margin) between natural gas and the NGL, which the processor sells.

Most contracts contain penalties for variations from contracted liquid content, impurities, and delivery pressure. Contracts may be set to allow for incremental variations from base composition. Contracts are commonly a combination of two or more of the five basic types.

How costs are shared between producer and processor for capital projects depends upon the nature of the project and the contract. New capital items that benefit both parties may be cost shared. However, maintenance, replacements, and costs of environmentally driven projects are borne by the processor as a cost of staying in business. Situations arise in which costs are too high for the processor to absorb alone, and producers must decide to either share the costs or cease production.

The combination of the varied and complex contractual agreements, the proprietary nature of economic data, and the sometimes biased data in the literature limits the discussion of economics in this book. Chapter 14 provides some capital cost data, but otherwise, only qualitative economic comparisons are provided in the other chapters.

To show how the various processing components tie together, Chapter 15 briefly describes three gas plants. The plants differ in both feed and product slate.

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