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Report on the Elements of a Gas Processing Plant, Including Capacity Building, Best Practices, International Norms, and Risk Mitigation Strategies
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Acronyms and Abbreviations

AGE	Afghan Gas Enterprise
API	American Petroleum Institute
BTU	British Thermal Units
CO_2	Carbon Dioxide
DEG	Diethylene Glycol
H_2S	Hydrogen Sulfide
ISO	International Standards Organization
MCF	Million Cubic Feet
MEG	Monoethylene Glycol
MoMP	Ministry of Mines and Petroleum
NFPP	Northern Fertilizer and Power Plant
NGPP	Natural Gas Processing Plant
PO	Purchase Order
ppm	Parts per Million
QA/QC	Quality Assurance / Quality Control
RFI	Request for Information
RFQ	Request for Quotation
TEG	Triethylene Glycol
TREG	Tetraethylene Glycol
WSA	Wet Gas Sulfuric Acid

1 Executive Summary

This report is the third in a series of three reports detailing natural gas processing and gas gathering best practices and training. This report is focused on Afghanistan's Ministry of Mines and Petroleum (MoMP) with the assumption that this entity will continue to have an oversight role for the Afghan Gas Enterprise (AGE). Alternative developments, such as the conversion of AGE into a free-standing commercial corporation or some type of joint operations between the Afghan Government and an outside company from the gas processing industry is not specifically examined. The inclusion of these possibile arrangements would unnecessarily expand the scope of the reports while not materially changing the examination of the technical and operational requirements necessary for gas processing operations. Each report was designed to stand alone with material tailored for the intended audience. While this report remains fairly technical in nature, the intent is to provide background for MoMP personnel on some of the basics of natural gas processing and to highlight best practices. The requirement to establish a culture of safety and an understanding of optimal gas processing operations and maintenance capacity must be embraced by everyone involved with maturation of the natural gas sector as well as AGE.

MoMP personnel should have a basic understanding of the various gas processing functions and associated best practices. While this report does not expect that it would actually be involved in day-to-day operations, MoMP personnel will undoubetly be required to understand AGE's requirements and will need to be able to clearly explain functionality, shortfalls and attendant risks associated with AGE change and maturation. Since design, related analysis, and material procurement will continue to be a component of AGE's budget, this report provides a basic primer on design and also presents a fairly detailed explantion of procurement best practices. Transparent and expedient procurement policies and procedures will remain a prerequisite for reliable, safe and complaint natural gas delivery.

The final sections of this report suggest a recommended process for risk analysis and presents a risk analysis of AGE's midstream processing. As a proposed method to inform and tailor future, capacity building efforts, a functional this report presents a functional "gap analysis" of AGE with key deficiencies related to the risk analysis. The analysis demonstrates that a "broad brus" approach to funding and contracting for AGE capacity building is too simple. The advances and growth experienced by AGE over the past three years during the construction and subsequent operation of the compressor/dehydration plant at the Khoja Gogerdak Gas Plant in Sheberghan, Afghanistan are indicative of the potential for a different approach to capacity building. Experience has demonstrated that through the utilization of detailed risk and gap analyses in conjunction with a capacity building program that allows AGE staff to work alongside industry experts offers the most expedient method to build a new AGE corporate culture.

2 Scope of this Report

This report intends to assist MoMP in determining and deciding best practices for the processing of natural gas, particularly natural gas that contains high levels of hydrogen sulfide (H_2S) and carbon dioxide (CO_2). Included are descriptions of the processes for removing these harmful components from the gas stream to produce "pipeline quality" gas. Emphasis is placed on risk and capability gap analyses in order to best define capacity building efforts with an emphasis on safe practices.

3 Current Afghan Gas Enterprise Natural Gas Processing

AGE is currently processing natural gas at several locations to prepare the gas for distribution to end users. Current processing is primarily limited to separation of water and other liquids from the gas stream, monitoring for H_2S content and manually routing sour versus sweet gas between headers dedicated to each product. Dehydration capabilities have been recently installed at Khoja Gogerdak and are now functional. An amine gas processing or "sweetening" unit has been constructed at Yatimtaq station, but still requires some final assembly installations, commissioning and training of AGE personnel before it will be operational.

Natural gas, as it is produced from the wellhead is composed primarily of methane, together with smaller percentages of other hydrocarbons, which may include, ethane, propane, normal butane, isobutane, normal pentane, isopentane, hexane and other heavier hydrocarbons. It may also contain water, water vapor, other gases; such as CO_2, nitrogen, oxygen, and other impurities such as H_2S. Although some natural gas is produced from the wellhead in a form that is immediately usable, most natural gas produced from wellheads contains some of these additional elements, which can be detrimental to the transportation, safety, or ultimate use of the gas. In order to safely and/or economically transport and utilize the gas, processing or treating the natural gas is necessary. The gas remaining after treating is commonly referred to as "pipeline quality gas."

Pipeline quality gas is generally considered to have the following properties:

- A specific British thermal unit (BTU) content ranging between 985 and 1085 BTU per cubic foot of gas.
- Be delivered at a specified hydrocarbon dew point temperature level below which any vaporized gas liquid in the mix will tend to condense at pipeline pressure
- Contain no more than trace amounts of H_2S, CO_2, nitrogen, water vapor, and oxygen
- Be free of particulate solids and liquid water that could be detrimental to the pipeline and pipeline equipment.

In order to produce pipeline quality natural gas, the gas must be treated or processed to remove undesired elements. The primary types of natural gas processing include the following:

- Separation
- Dehydration
- Natural Gas Treating

3.1 Separation

Most natural gas wells produce some quantities of liquid hydrocarbons and water. Separators are designed to separate the natural gas from the liquids including water and liquid hydrocarbons. Separators may be either two-phase or three-phase. A two-phase separator is designed to separate liquids from the gas stream or in the case of an oil well, to separate the gas from the oil being produced.

A three-phase separator separates gas from the liquids as well as water from the liquid hydrocarbons. Where the production is primarily liquid hydrocarbons/oil, separation normally occurs at or very near to the wellhead. Two-phase separation of liquids from flow streams that are primarily gas may be located at the wellhead, but may also be located at compressor stations, meter stations and gas treating facilities.

Where gas from the wellhead has significant components of H_2S and/or CO_2, it is often advisable to locate separation equipment near the wellhead, since both H_2S and CO_2 are very corrosive when combined with water. Although separators are designed in many configurations, all separators work on the same basic principle and include the following:

3.1.1 A cylindrical inlet device:

The flow is injected into a cylindrical or spherical vessel so that the linear motion of the gas liquid flow is stopped and a centrifugal acceleration is established inside the vessel. This acceleration results in a force of up to 500 times the force of gravity. This centrifugal force draws the liquid to the outside walls of the vessel where the liquid droplets are forced together and eventually fall to the bottom of the vessel. The gaseous part of the flow continues out the top of the vessel. The vast majority of the separation process occurs during the acceleration of the fluid in the upper portion of the vessel.

3.1.2 A large settling section:

This section must be of sufficient length or height to allow the liquid droplets to settle out of the gas stream and with adequate surge room for slugs of liquids. The settling section allows the turbulence in the fluid stream to subside and gives more time for entrained gas to bubble through the liquid. The design of the additional space in the lower part of the separator vessel for liquid slugs or surges is dependent on the size of liquid slugs likely to occur. Obviously, separators at the wellhead are more likely to experience slugs, but each application should be analyzed to determine what size liquid slug could be experienced and the downstream effect of allowing a slug of liquid to get past the separator. This could be particularly important where the gas stream is flowing into a natural gas compressor or sensitive customer process.

3.1.3 Mist extractor:

Wire mesh or vanes located near the gas outlet of the vessel allow small liquid particles that did not settle out by gravity or the centrifugal acceleration to coalesce and fall to the bottom of the separator.

3.1.4 Liquid level controls:

Level control devices are required to allow for evacuation of the liquids from the bottom of the separator. These will include a dump valve, liquid level control instrumentation that monitors the liquid level and signals the dump valve to open until a sufficient amount of the liquid has been drained, a site or gauge glass and a storage or disposal facility to handle the liquid hydrocarbons and water removed by the separator.

3.1.5 Separator Types

There are four major types of basic separator configurations that are generally available from a number of manufacturers worldwide:

- Vertical Separators
- Horizontal Single Tube Separators
- Horizontal Dual Tube Separators
- Spherical separators

The figure below depicts AGE's vertical separators in use at the Khoja Gogerdak Station to remove liquids, primarily water from the gas stream prior to compression for delivery to the Northern Fertilizer and Power Plant (NFPP) located at Mazar-e-Sherif. The horizontal separator in the foreground further separates any free water that may be in the pipeline after compression.

Figure 3-1: Existing Vertical Separators at Khoja Gogerdak and New Horizontal Separator during Installation

3.2 Dehydration

Reliable dehydration of natural gas is a best practice for operation of a midstream natural gas system. Dehydration is defined as the removal of water that is associated with the natural gas in the form of vapor entrained with the natural gas. Dehydration of the gas stream is necessary for the efficient operation of gas transmission pipelines. The removal of water vapor prevents the formation of natural gas hydrates, which can block the pipeline. Water within the pipeline can also encourage corrosion, especially where CO_2 or H_2S are in present. Water vapor also tends to become free water as the temperature decreases. It collects in low spots on the pipeline causing significant reductions in the pipeline flow efficiency.

There are four main methods of natural gas dehydration:

- Refrigeration
- Membrane processes
- Adsorption

3.2.1 Refrigeration

Refrigeration involves rapidly lowering the gas pressure to cool the gas. Water vapor then tends to liquefy and can be removed by a separator. In general, this process will not remove enough of the water from the gas stream to obtain pipeline quality gas. Therefore, when used it is generally used in combination with one of the other methods.

3.2.2 Membrane Processes

Membrane processes are only economical for small gas flows, such as for instrument gas or fuel gas for other process equipment. It is not feasible to use with more significant gas flow volumes.

3.2.3 Adsorption

Adsorption generally yields the lowest water content. This process is done with a two-bed system, where the beds are filled with adsorbents such as silica gel. The gas flow is passed through one of the beds, where the adsorbent removes the water from the gas. When the adsorbent nears saturation, the gas stream is then switched to the other bed. Hot dry gas is then blown through the first adsorber. The gas is then cooled so that the water vapor condenses and drops out in a separator.

The efficiency of the process depends on the absorbent used, but is generally not economical at higher flows. Adsorbents are generally more expensive than absorbents (typically, glycol) and require more energy to regenerate. An absorption process dehydration unit is installed on the fuel gas system at the Yatimtaq gas sweetening plant. It is efficient when processing with smaller volumes such as those required for fuel gas.

3.2.4 Glycol Dehydration (Absorption)

Glycol dehydration is the most commonly used method of natural gas dehydration. Glycol has the advantages of having a high affinity for water vapor, is non-corrosive and is fairly easy to regenerate with low chemical losses. Several different forms of glycol are used in absorption dehydration including:

- Monoethylene Glycol (MEG)
- Diethylene Glycol (DEG)
- Triethylene Glycol (TEG)
- Tetraethylene Glycol (TREG)

TEG and TREG have the best absorption properties and can be regenerated at higher operating temperatures, with TREG having the best overall properties for removal of water from the gas stream. However, due to the cost differential, TEG is most commonly used as providing the best overall efficiency based on operating costs.

Wet or saturated gas is injected into the bottom of an absorber column, also known as a contactor tower, while lean or dry glycol is injected near the top. The glycol then cascades over a number of trays within the contactor, comingling the glycol with the gas stream; the lean glycol has an affinity for water vapor, which bonds with the glycol. The now dry gas passes out the top of the contactor, generally through a heat exchanger to lower the temperature of the lean glycol before it is injected into the absorber column. Glycol has more affinity for water at lower temperatures.

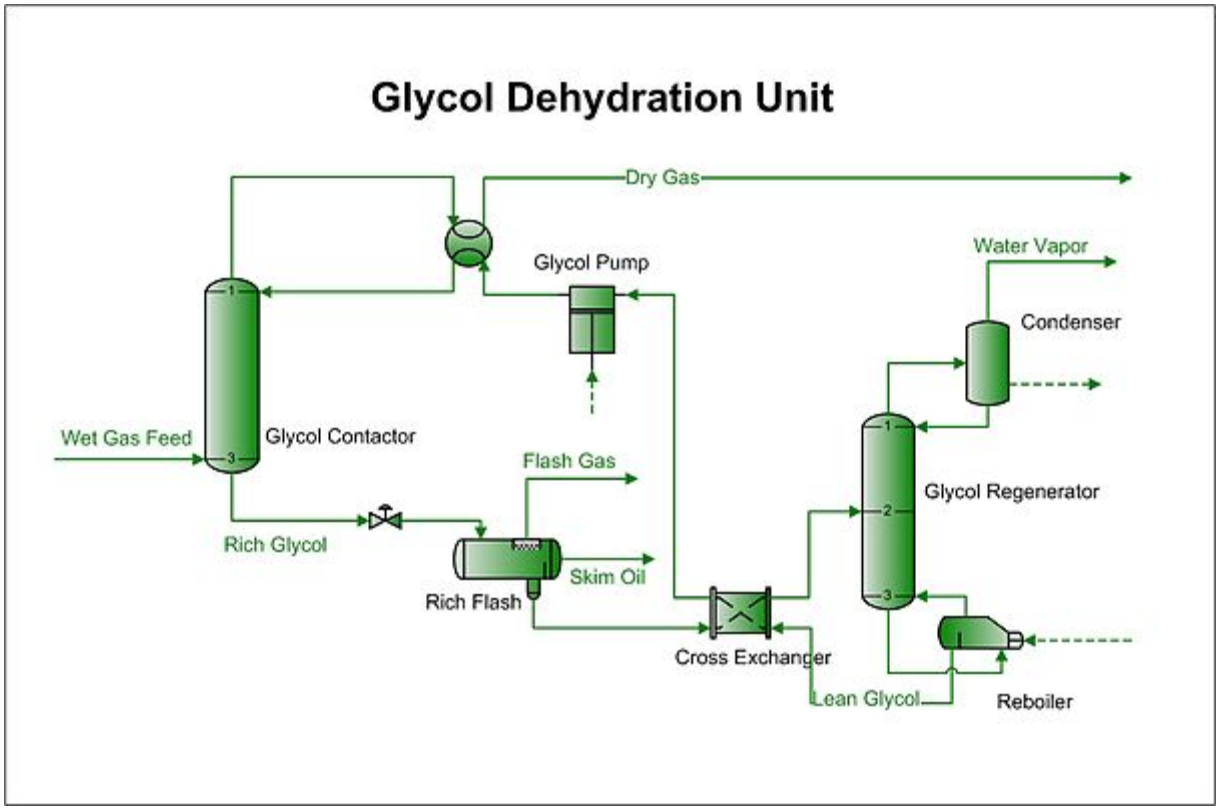


Figure 3-2: Glycol Dehydration Process

The wet or rich glycol, which now includes the water vapor removed from the gas stream, passes out of the bottom of the contactor through a flash tank where gas entrained with the glycol is collected. It then passes through a heat exchanger to further cool the incoming lean glycol.

The rich glycol then flows into a regenerator or stripper column, which is mounted on top of the reboiler. The stripper column is packed with a ceramic packing. The rich glycol flows down the stripper column into the reboiler, where it comes into contact with rising hot glycol which has been heated in the reboiler to a temperature where the entrained water will vaporize and travel up the still column through an atmospheric reflux condenser before being released to the atmosphere.

For TEG glycol systems, the glycol can be heated to a maximum of 400° F (204° C), which ensures that virtually all of the water contained within the rich glycol is vaporized (98.6% purity). The now lean glycol can be stored or re-circulated through the system.

The regeneration system operates at just above atmospheric pressure to keep air out of the system. Glycol is circulated by means of pumps that may be powered by the pressure of the rich glycol or electricity.

Figure 3-3: TEG Glycol Dehydration (Absorption Type) at Khoja Gogerdak

3.3 Natural Gas Treating

Natural gas containing high levels of H_2S can cause illness and death in relatively small concentrations. H_2S is colorless and in small quantities has an odor similar to rotten eggs. Upon inhalation, H_2S very rapidly paralyzes the olfactory nerve which effectively kills the sense of smell as a warning indicator. It is heavier than air, having a specific gravity of 1.1, which causes it to concentrate in low areas, rather than dissipating into the air.

Best practices generally agree that natural gas containing four parts per million (4 ppm) or less is generally considered to be "pipeline quality sweet natural gas." Some jurisdictions, such as the Texas Railroad Commission, allow concentrations as high as 100 ppm to be considered as sweet gas. Natural Gas with higher concentrations of H_2S is referred to as "sour natural gas." When H_2S is combined with CO_2, as is often found in natural gas well streams, the combination creates what is termed "acid gas." Acid gas, in addition to being deadly as described above is very corrosive to steel.
In order to safely transport and utilize natural gas with high H_2S or H_2S combined with CO_2, it is necessary to remove the harmful components. The process of removing H_2S and CO_2 from natural gas flow streams, as discussed prior is referred to as either treating, processing, or sweetening.

There are a number of processes that can be used for sweetening natural gas. Depending on the relative quantities of H_2S and CO_2 in the gas stream, one or more methods of removal of these components may be preferable to another. The most common methods of H_2S and CO_2 removal from natural gas are as follows:

- Amine Treatment Plant Processes
- Iron Sponge Processes
- Proprietary Processes
- Claus Process for Sulfur Recovery
- Wet Gas Sulfuric Acid Process

3.3.1 Amine Treatment Plant Process

The alkanolamine treatment process is the most commonly used process to sweeten natural gas. These are commonly referred to as amine treatment processes or plants. The most common alkanolamines used are:

- Monethanolamine
- Diethanolamine
- Methyldiethanolamine

Other amines that are less often used include:

- Diisopropanolamine
- Aminoethoxyethanol Diglycolamine

Amines are used in an aqueous solution. The selection criteria and concentration level of the amine type is based on the ratio of H_2S to CO_2 in the gas stream and the concentrations of each. Regardless of which amine is chosen for the gas stream conditions, the sweetening process is essentially the same. It is detailed on the proceeding page.

The sour natural gas normally runs through an inlet scrubber to remove any slugs of liquid, liquid hydrocarbon, grit or sand from the gas stream. After the scrubber, the gas is introduced into the bottom of an absorber or contactor tower. Lean amine (amine that has been stripped of H_2S and CO_2) is injected into the top of the tower. The tower includes a series of trays to increase the time for comingling the amine with the sour gas. Each tray has a liquid amine level of 2-3 inches (5-8 centimeters) maintained by a weir. The gas passes up from underneath the tray though openings in the trays causing it to bubble through the liquid forming froth. The H_2S and CO_2 are absorbed by the lean amine in the trays. The gas flows out of the top of the contactor tower as sweet gas.

The now rich amine (amine that has absorbed H_2S and CO_2) is run through a flash tank separator to remove any natural gas that may have carried over in the rich amine. Any liquid hydrocarbons are removed via conventional oil/water separation in this separator and the rich amine is drained from the bottom of the flash tank separator. Separation of the hydrocarbons also helps to prevent foaming due to hydrocarbons in the amine.

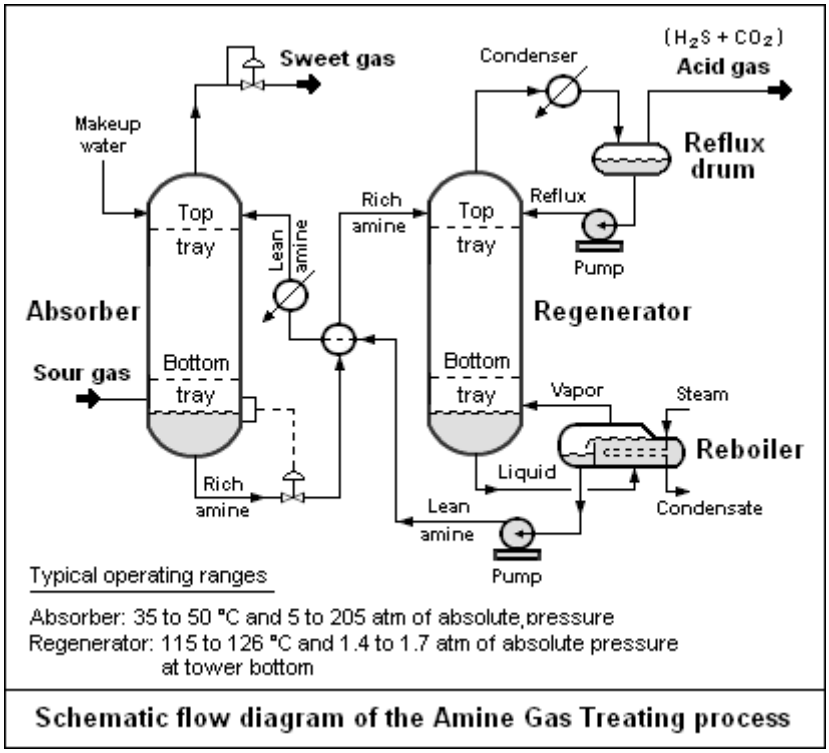


Figure 3-4: Typical Amine Plant Process Flow Diagram

The rich amine is then preheated by a heat exchanger utilizing heat from the lean amine, which must be cooled before being reinjected to the contactor. The rich amine is injected into the top of a stripper column (regenerator) which is packed with trays. As the rich amine flows down through the regenerator column, it is met by gas vapor, H_2S and CO_2 that is generated in the reboiler. This lowers the partial pressure of the H_2S and CO_2, causing the molecules to separate from the amine. Overhead gas is passed through a condenser to recover water and the small amount of amine that is vaporized by the regenerator. The condensed liquid and acid gas flow through a reflux drum from which it is pumped back into the regenerator column. The acid gas containing the concentrated H_2S and CO_2 is sent to a flare, incinerator, reinjected to a depleted well, used for sulfur recovery, or disposed of using a safe method. If further separated, CO_2 may also be reinjected for oil reservoir repressuring or pressure maintenance operations

The lean amine is then sent through a filter followed by an activated charcoal filter to remove any particulate matter that may have been picked up during the process. Depending on which amine is used, the amine may also be sent though a reclaimer to further purify the amine. The lean amine is then cooled before being pumped back to the top of the contactor tower to begin the sweetening process again.

Figure 3-5: Yatimtaq Amine Plant during Final Construction

3.3.2 Claus Process for Conversion of Hydrogen Sulfide into Elemental Sulfur

Where large quantities of H_2S are being removed from the gas stream, and where depleted well disposal of the acid gas is not feasible or in locations where local environmental regulations will not allow flaring or incineration of the residual H_2S, the preferred method of disposal of the residual H_2S resulting from the sweetening process is through recovery of elemental sulfur. The Claus Process has for many years been the best practice industry preferred method. First patented in 1883 by scientist Carl Friedrich Claus, the Claus process has become the industry standard for sulfur recovery.

The Claus process is a multi-step process that converts H_2S and oxygen to sulfur and water. The process is detailed below in the Claus Sulfur Recovery Process Flow Diagram.

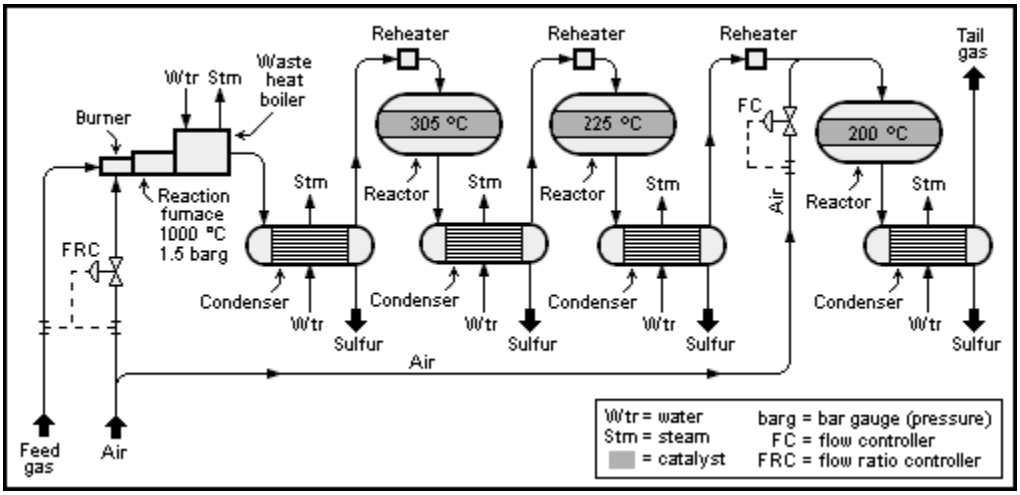


Figure 3-6: Claus Sulfur Recovery Process Flow Diagram

The world market for elemental sulfur has been depressed for a number of years. This is partially true due to the number of Claus plants in operation. Much of the sulfur produced is not sold due to market and transportation issues resulting in storage and disposal problems. Before a Claus plant is considered by AGE, the feasibility of developing an industry that can utilize the byproduct as feedstock and/or disposal/storage solutions for the sulfur should be investigated.

3.3.3 Disposal in a Depleted Formation

Another method of disposal of residual acid gas from the sweetening process is to pump the acid gas into a depleted gas or oil formation. Use of this disposal method is dependent on having a suitable formation in the near vicinity of the sweetening plant. Acid gas injection is becoming more prevalent around the world due to growing environmental concerns and applicable regulations and requirements. Disposal of both small quantities and large quantities of acid gas alike is problematic. In the past, oil and gas producers could flare the acid gas. New and stricter environmental regulations are curbing the disposal of sulfur compounds, sulfur dioxide-SO2, to the atmosphere. Acid gas Injection can be a viable alternative to installation of a Claus plant to recover the elemental sulfur. The basic process is shown in the process flow diagram for a typical acid gas depleted field injection on the following page.

3.3.3.1 Acid Gas Injection

Acid gas injection is quickly becoming the method of choice for disposal of the sour gas stream. Acid gas injection involves taking the acid gas from the amine regeneration system, compressing it to a sufficient pressure, and injecting the gas into a suitable underground reservoir rock formation. Acid gas injection becomes a near zero-emission process. During normal operation, all of the H_2S from the produced gas is reinjected. Only during interruptions or malfunctions will emissions occur, such as acid gas being sent to the flare. There are three basic components to the acid gas injection scheme:

- Compression
- Pipeline
- Injection well

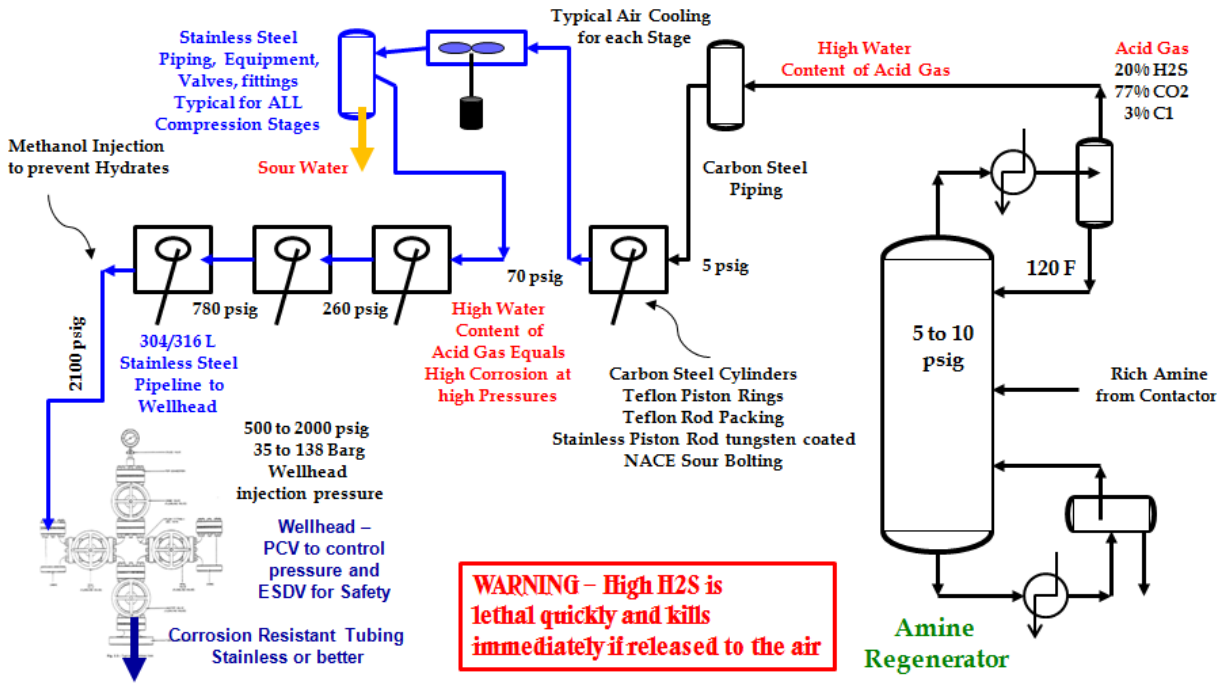


Figure 3-7: Typical Acid Gas Depleted Field Injection Process Flow Diagram

3.3.3.2 Compression Design for Acid Gas Injection Considerations

- High water content of the acid gas.
- Corrosion of piping and equipment at high temperatures and high pressure. Stainless steel materials are recommended downstream of the first stage of compression.
- Sour water from inter-stage compression scrubbers as water is condensed out of the acid gas stream as the pressure increases. Sour water should then also be injected into a reservoir rock similar to the gas stream.
- Hydrate formation in the injection line requiring methanol injection.

3.3.3.3 Compressor Design Considerations

- There are typically four stages of compression.
- Compression of hydrocarbons and temperature rise should be considered with the CO_2 and H_2S.
- Appropriate materials are required for cylinders and rods.
- An air cooler metallurgy and sizing needs to be planned due to water and CO_2 condensation.
- Compressor must have speed control to respond to acid gas volume changes.
- Compressed gas should be recycled.
- Fuel gas should not be used in the compression system for volume control as the light hydrocarbons and nitrogen affect the required injection pressure. Actual injection can stop as the gas head in the well tubing becomes lighter and then the bottomhole pressure cannot be overcome. The only way to overcome this is to increase the wellhead injection pressure. Gas injection temperature also can also make the gas head lighter, thus causing the same problem.

3.3.3.4 Pipeline Design Considerations

- Keep the pipeline as short as possible.
- Use 304/316L stainless steel.
- Externally coat the pipeline.
- Bury pipeline at 6 foot depth to use ground temperature to prevent gas hydrates from forming.
- Utilize redundant instrumentation.

3.3.3.5 Safety Issues Identified and Mitigated

- Ensure mechanical integrity of entire mechanical and instrumentation systems - use redundancy.
- Use emergency shutdown dump valves for compression and wellhead safety.
- Use an overly-tall emergency flare with 4 pilots and more than adequate fuel gas for burning. Focus on complete combustion of H_2S.
- Continuously monitor H_2S concentrations in ambient air.
- Installation should include multiple blowdowns, blowbacks, and sweet natural gas purges.

3.3.4 Wet Gas Sulfuric Acid Process

An alternative to the Claus process, or acid gas injection into a depleted field for dealing with the high H_2S residual gas, is a process called wet gas sulfuric acid (WSA). WSA uses a catalytic process developed and patented in the late 1980's by Haldor Topsoe. This process converts the H_2S in the saturated residual gas, into commercial quantities of sulfuric acid. The process also generates a large quantity of super-heated steam that may be used in other processes that may be collocated with the WSA facility to take advantage of the steam by product. The WSA process recovers over 99% of the sulfur in the residual gas stream. The sulfuric acid is useful in many industries, such as fertilizer production. A process flow diagram is detailed in the figure below.

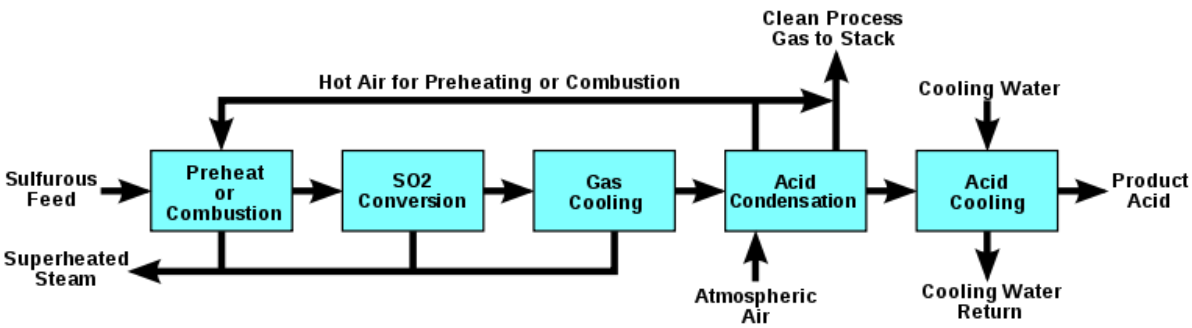


Figure 3-8: Wet Gas Sulfuric Acid Process Flow Diagram

4 Best Practices

For AGE to operate effectively in the world market and to encourage investment in Afghanistan, it will be advisable to adopt the best practices of the midstream gas sector. Some of the most critical best practices are described in the following sections.

4.1 Safety

Best practices are founded in safety. The safety of the facility and all workers needs to be at the forefront of all design efforts. All designs should have appropriate safety factors built in. Safety during construction should also be a prime consideration in the design of the facility. Some of the key safety practices are:

4.1.1 Personal Protection for Workers

- Safety glasses should be worn at all times while on the job. Dust, scale, flying projectiles, weld spatter and grinders can cause damage to eyes.
- Eye wash stations should be located on each site to minimize discomfort and damage in the event that particles or irritants get into workers' eyes
- Hard hats designed for construction should be worn at all times while working in an area where work is occurring overhead, such as construction sites.
- Safety shoes - As a minimum, closed-toe shoes should be worn at all times when on any construction site. It is preferable that shoes with either steel toes or steel toe protectors be worn to protect toes and feet from damage due to falling objects
- Long-sleeve and fire resistant clothing made of cotton or other nonflammable fabric should be worn at all times where working in an area that may be subject to fire. This includes working around any gas piping or liquid storage tanks.
- H_2S and other gas monitors (personal) – When working in areas where H_2S is present in the gas piping, all personnel must wear personal H_2S monitors. When entering the work site, each worker should be trained to look at the wind sock and make note of which way the wind is blowing prior to entering the site. When monitors register an unacceptable level, workers need to leave the area immediately and go to an area that is upwind of the piping or plant. A supervisor should be immediately notified and the area closed off to anyone until either the gas can be blown down and purged from the piping or personnel with appropriate "air breathing packs" can go in and repair the leak. Never attempt to save a fallen worker by holding your breath to go in after him.
- When working on areas where sour gas is likely to be released, always have a fully charged air pack at the work location in case of emergency need. When there is a known leak in sour gas piping, always wear an air pack while making the repair.

4.1.2 System Safety Design

Design of pipelines, compressors, treating plants, electrical and all facets of gathering, treating and transporting natural gas should be prepared with the safety of the workers, the general public and the equipment as primary considerations. The designer should always consider how the equipment or piping could possibly fail and design safety devices to prevent injury or loss of life in the event of failure. Some of the safety devices that should be considered include:

- Emergency shutdown equipment
- Emergency blow down for facilities
- Fire monitors with appropriate shut down logic
- Flammable gas monitors to detect gas leak in enclosed areas
- Proper electrical grounding systems
- Relief valves where appropriate
- Wind socks

- Alarm beacons
- Computer alarm notifications to operating personnel
- Design to include evacuation route
- Design to eliminate piping traps where only one way in and out could trap a worker in the event of a discharge or fire
- Design of all materials and components with appropriate safety factors for the area or installation

4.1.3 Safety Training

Best practices dictate that safety training be an integral part of any operations. Personnel learn by repetition. When an emergency situation occurs, a trained worker knows what to do and as importantly, what not to do. Regular safety training and management enforcement of safety procedures encourages a culture where accidents are limited, because the workers employ safe practices. When accidents do happen, the regularly trained worker knows what to do.

Management needs to adopt a strict safety policy, both in word and in fact, emphasizing that:

- ALL ACCIDENTS ARE PREVENTABLE!
- IF A JOB CANNOT BE DONE SAFELY, ANTOHER WAY NEEDS TO BE FOUND TO DO IT!
- ANY WORKER WHO SEES AN UNSAFE SITUATION DEVELOPING HAS THE DUTY AND THE AUTHORITY TO STOP THE WORK SO THAT THE ISSUE CAN BE ADDRESSED!

Safety training needs to be regularly scheduled and documented. It is particularly helpful if the start of each day or work shift begin with a “safety moment” or “safety meeting” where some aspect of safety is highlighted to remind the workers to keep working safety on their minds. These safety meetings generally only take 10 to 15 minutes and should be documented as to when they occur and the subject(s) covered. Workers are encouraged to point out any potential safety issues that need to be addressed at these meetings. Establishment of incentives, either extra money or some small awards for periods of safe operation can go a long way towards establishing safe practices.

4.2 Design Codes and Standards

Best practices require the adoption and adherence to safety and design codes. There are a number of internationally recognized codes related to pipelines and pipeline facilities. Some of the most utilized pipeline safety and design codes include the following:

Table 4-1: International Design and Safety Codes

COUNTRY	TITLE
United States	Title 49 CFR Part 192 Transportation of Natural and other Gas by Pipeline – Minimum Federal Safety Standards”
United States	ASME B-31.8 Gas Transmission and Distribution Piping Systems
United States	ASME B-31.3 Process Piping
Canada	CSAZ 662 – Oil and Gas Pipeline System Code
Australia	AS2885 Australian Standard: Pipeline – Gas and Liquid, Part 1 Design and Construction
British Standard and European Standard	BS EN 14161 Petroleum and Natural Gas Industries-Pipeline Transportation Systems
International Standard	ISO 13623 Petroleum and Natural Gas Industries – Pipeline Transportation Systems

In addition to the above codes, International Standards Organization (ISO) has appointed a technical committee, ISO TC67, which is devoted to the harmonization of international standards in the natural gas and petroleum industries. The standards under review by this committee include line pipe, coatings, valves, actuators cathodic protection, and mechanical fittings.[1] It is highly recommended that AGE, in consultation with subject matter experts, select one of the international standards and then prepare exceptions where warranted. An appropriate set of standards will solve most design, construction, and safety issues and save a great deal of time and effort.

4.3 Subject Matter Experts

Best practices suggest the requirement for obtaining assistance from outside experts where AGE does not have the expertise for a particular task or design. Utilization of qualified expert is the prudent way for AGE to design, procure equipment and materials, construct, commission and train operators of systems of equipment. It is suggested that AGE technical personnel actively work with the experts to learn as much as possible for future design and especially for operating and maintenance of the facilities being designed and installed.

4.4 Procurement

One of the more important best practices that AGE can benefit from is the establishment of an efficient procurement process.[2] Procurement of materials, supplies and equipment and shipping into Afghanistan is difficult. Individual suppliers, particularly in other countries, are reluctant to extend credit, or in many cases to fabricate or custom design equipment to be shipped to Afghanistan without payment in advance. This can be very difficult under AGE procurement practices.

It is suggested that "master service agreements" be established with preferred suppliers for procurement of maintenance and operating supplies, such as oil, glycol, amine, filters, small tools and other items that may be required on a recurring basis. It is also recommended that several logistics specialist vendors be researched and put on a preferred shipping vendor list. These logistics companies should have a demonstrated record of shipping material into Afghanistan and surrounding countries.

Best practices further suggest that AGE develop a transparent procurement management process and associated principles in a defined handbook that covers:

- Accountabilities and responsibilities
- Policy, procedures and expectations
- Business ethics and code of business conduct
- Procurement processes
- Commercial issues

[1] Countries participating in the development of this ISO TC67 committee process include the following: Argentina, Australia, Austria, Belgium, Brazil, Canada, China, France, Germany, India, Indonesia, Iran, Islamic Republic of, Ireland, Italy, Japan, Kazakhstan, Republic of Korea, Malaysia, Mexico, Myanmar - Correspondent Member, Netherlands, Norway, Qatar, Romania, Russian Federation, Ukraine, United Kingdom and United States. Observing countries are Denmark, Finland, Poland, Saudi Arabia, Serbia, Slovakia, South Africa, Spain, Sweden and Switzerland.

[2] As a State Owned Enterprise, AGE must comply with the requirements of the Procurement Law and Regulations. This government procurement system is administered by the Afghanistan Reconstruction and Development Services (ARDS). ARDS has substantial expertise in procurement practices and provide very helpful guidance in this area.

4.4.1 Purchase Orders and Request Documentation

The purchase order (PO) is an instruction to a vendor to provide equipment, materials, goods or services. This instruction is conveyed to a vendor by means of a formal PO with attachments covering material and/or equipment specifications, inspection and documentation requirements. The order is a standalone document which when accepted by the vendor constitutes a legally binding contract. Although the PO has been issued, procurement involvement is still considerable and the principle actions through to delivery and close-out of the PO are described in the following sections.

4.4.2 Procurement Sourcing Tools

The choice of which document to use from either a request for information, request for quotation (RFQ), or purchase order (PO) depends on what a company needs between information, a firm proposal, a detailed price bid, or just a quotation. In some cases such as procuring large, expensive equipment, the choice may be all three document types. In other cases, it may be just the issuance of a PO based on a requested vendor quotation.

A Request for Information (RFI) is a method of collating information from different suppliers prior to formally sourcing products or services. It is normally used where there are many potential suppliers and not enough information is known about them. It is a structured process where a long list of potential suppliers can be reduced to a short list of those organizations that are willing and able to fulfill the requirements. An RFI should include:

- Introduction and purpose of the RFI
- Explanation of scope
- Abbreviations and terminology
- Template to complete
- Details of next steps – RFQ

Why use an RFI?

- To compile detail about potential suppliers and their capabilities
- To advise potential suppliers of the intent to source this product or service competitively
- To demonstrate fairness and inclusion of all participants
- To gather information in a way that decides the next step

A RFQ is a competitive bid document used when inviting suppliers and subcontractors to submit a bid on projects or products. An RFQ is suitable for sourcing products that are standardized or produced in repetitive quantities. A technical specification must be provided as well as commercial requirements.

A PO is the final purchasing or procurement document issued by the operating company procurement department and can be thought of as a definitive contract. The PO includes but is not limited to the following: PO number, date, detailed pricing per item, total cost, ship to address, freight payment terms, payment/commercial terms and conditions, detailed technical scope of supply and description, quantities, and delivery dates and conditions.

The RFI, the RFQ and the PO are all tools that can be used separately or in combination to achieve a successful sourcing solution.

4.4.3 Amendments after Initial PO Issuance

PO amendments or change orders are issued to record agreed contractual changes both technical and commercial. It is essential that such changes are kept up to date to facilitate control and accounting activities. A request from a vendor for a relaxation or minor change to a specification and which does not have contractual implications would normally be dealt with by a concession request procedure. In these cases, although no formal amendment is issued, it is essential that a record is kept to such concession requests. In the event that the concession request is acceptable by all parties concerned (i.e. gas processing plant, technical, commercial etc.), a signed approval should be issued to the vendor, who is to ensure that the original copy is included in the final data dossier. If a concession request is unacceptable to any party, then the vendor must be instructed to comply with the issued PO and its attachments. The buyer is responsible for the coordination of any technical or commercial queries which may arise after the order is issued.

4.4.4 PO Quality Services

Professional services covering all aspects of Quality Assurance (QA) and Quality Control (QC) are required to support and complement the total procurement activity. The PO quality assurance function is to ensure that all necessary vendor procedures are in place and are implemented effectively such that the required plant and materials are fully defined. Audits may be carried out on the vendor during the life of an order, to check compliance with the relevant codes and standards. The procurement quality function ensures that the equipment ordered is supplied in accordance with the PO specification, that it meets all the quality requirements and is only released after a satisfactory final inspection. The quality function ensures that all quality plan stages are witnessed or verified to be “as specified” and that all such stages are signed off. Documentation and certification are reviewed and accepted at the manufacturer’s works. Documentary evidence of the achievement of quality service objectives is provided by means of completed quality plans, audit reports, inspection reports, release notes and manufacturer's certification.

4.4.5 Document Control

The importance of documentation and documentation control has grown as both operating company and statutory requirements have been developed and adopted. Document control groups have been established to ensure conformity with requirements. The responsibility of document controllers is to ensure that all drawings, data and test certificates are supplied by the vendor on the due dates as specified within the order and agreed at the pre-production meeting, to this end they work closely with expediters. The document controller also monitors and coordinates the flow of documents for approval and comment within the processing plant to ensure speedy responses are sent to the vendor so that no delays are incurred, thus maintaining delivery requirements.

Lastly, this function has the responsibility of ensuring that all retained documentation and certification have been checked, validated against orders, and specification requirements, so that full traceability of material to valid documentation is maintained. Progress payments can be considered on certain orders as an incentive for early submission of required documentation.

To ensure that full and final submission of required documentation is issued by the vendor in a timely manner, it is prudent to have 10% retention of the total invoice value held against receipt and approval of all final documentation. This may not initially be possible where materials are being shipped from another country into Afghanistan.

4.4.6 Expediting

Although a vendor which has accepted an order is contractually bound to meet material and documentation delivery requirements, experience has shown that without monitoring and vigorous expediting, slippage is likely to occur. To minimize this and to ensure timely completion by the vendor of the order requirements, it is essential for office and field expediters, in conjunction with the buyer to monitor and expedite the vendor throughout the life of the order.

Their role is to obtain information from the vendor, covering for example, raw material availability, sub-order issue, production schedules and documentation issue in conjunction with documentation control. Receipt of such information will enable the identification of possible project delays caused by material delays.

4.4.7 Transportation and Logistics

The responsibility for delivering materials and equipment to the processing plant site may either be taken by the plant, or arranged by the respective suppliers. Deliveries within the country of origin should be left in the hands of the supplier since it is their responsibility to make all the logistical arrangements and take all the risks until the goods arrive at site. However, if delivery is of paramount importance or special handling is considered necessary, the processing plant may well decide to take over the risk and responsibility of making all delivery arrangements from the suppliers works to site. Whoever is finally responsible for delivering materials to site must comply with all relevant customs formalities, taxation laws and national and international regulation governing the movement of goods. Delivery of materials or equipment to site following inspection must be accompanied by a copy of the relevant "inspection release note."

4.4.8 Settlement of Claims

In most cases, companies issue POs, receive as required, and settle invoices without difficulty. However, on occasions, claim discrepancies need resolution, which can take up considerable time. Establishing relevant facts at such a late stage in the life of a PO is sometimes difficult, but this action is assisted when good comprehensive records are maintained.

4.4.9 Close-out and Payment

On completion of delivery of spare parts and equipment, receipt of all documentation and settlement of claims, an order close-out report should be compiled finalizing cost reconciliation and commenting on vendor performance. It is imperative that POs are closed out in a timely manner and that payment is made based on the PO commercial terms and conditions. Plant personnel should take the necessary steps and follow the procurement procedures so that payment of POs will occur as soon after goods and documents are delivered. Payments are normally made to the vendor or supplier within 30 days after paper work is finalized.

4.4.10 Procurement Management Personnel and Processes

Building the right team is critical to the success of the procurement management process. The best procurement manager has the breadth and depth of knowledge to execute:

- Leadership of a skilled and diverse team
- Procurement of materials (both domestic sourcing and low cost country sourcing)
- Execution of strategic cost management on the supply chain
- Oversight internal materials management
- Decisiveness about produce sourcing methods

In order to do these tasks successful, the person assuming the role as procurement manager must have the skills necessary to oversee or actively cooperate with:

- Material Managers
- Transportation Directors
- Strategic Sourcing Consultants
- Production Managers
- Vendor Partners

Procurement and inventory management staff on the team must be quick to embrace new methods for procurement management optimization. Understanding the needs and requirements of internal and external customers is the key to success. They must understand the metrics for measuring internal inventory efficiency such as inventory turnover rate, and make sure that procurement system tools, inventory management systems, and other inventory and payment systems all tie in together. Without the right data at the right time, any gains from selecting the best strategic sourcing methodology is lost in execution.

4.4.11 Purchasing Procedures for a Well-run Procurement Department

In a well-run procurement department there is always a quality set of purchasing procedures. The purchasing procedures are usually incorporated in a formal document or manual that details each of the specific purchasing procedures. The manual also sets out the division of responsibilities for the processing plant personnel and procurement departments' personnel in the purchasing cycle. Standard purchasing procedures that are inherent within most purchasing departments include:

- Purchase from Key Suppliers. This is procurement from a normal set of suppliers that all have Master Service Agreements. This procedure can often be executed automatically by a computer system.
- Ad hoc Purchases. In times of unusual selling activity or when an unusual item is required there may not be an agreement with a supplier to supply these items. This procedure allows the processing plant personnel to make these unusual requests.
- Large Purchases. There may be a time when a large piece of machinery is required. In this case, the purchase is usually put out to tender and several companies are requested to bid for the opportunity to meet this requirement. This procedure is not used often but is usually very well defined due to the potential risk to AGE and the high costs involved.
- Change of Purchase. Sometimes purchases are made but then have to be changed for some reason. This is particularly true when standard POs are placed and some change occurs.
- Goods Received. Procedures should be in place to ensure that the purchased goods are received, counted and stored in the correct manner.
- Goods Damaged or Short. There are times when the materials that are received are not that which was ordered. There may be damages or shortages. The vendor or supplier must be

notified to allow them to deliver the material shortage and to allow them to return and replace damaged goods.

- Payment. Vendors and suppliers want payment on time per the commercial terms and conditions agreed in the PO. Computer systems can deal with the actual payment, but the procurement procedures to approve payment have to be met by the purchaser.
- Logistics and Delivery. The plant and the procurement department should have procedures in place to monitor vendor and supplier delivery and should have logistical/transportation companies identified for use to execute the delivery if it is the processing plant's responsibility.
- Warehouse. Once all purchased items are delivered to the plant site, the warehouse person should be involved so that the purchased items checked against the PO, reach the warehouse, and are placed in the appropriate bin.
- Contracts and Contract Renewals. All suppliers provide their best terms when there is a contract in place. This can often be established through a master service agreement, which has to be put into place, managed by procurement, and eventually be renewed.

4.4.12 Vendor and Supplier Management

"Vendor and supplier management" has a number of definitions. Some companies believe that it is the management of vendors in order to achieve better prices and terms. Others believe that vendor management is building a relationship with vendors in order to obtain mutually beneficial interactions. There is also an increasing prevalence for purchasers to allow vendors to manage the procurement process as in vendor managed inventory systems. In this procurement process, used by many large retailers, the vendor interfaces with the purchaser's sales and inventory accounts and delivers new products on a "just in time" basis. Vendor management includes processes to select a vendor and then undertaking regular and frequent reviews using detailed evaluation methods. During the vendor selection process, a period of vendor analysis is undertaken to find the vendors who will provide quality products at pricing with advantageous terms. Each vendor is matched to a set of vendor selection criteria to find the most appropriate vendor for the purchasing company. Large vendors may often have vendor ratings assigned to them from reputable consultancies that greatly aid the process. The entire purchasing process and management of several vendors is assisted by a set of tools, technologies and services. Vendors align themselves with their customer's vendor management system building an efficient and profitable procurement relationship for both companies.

4.5 Spare Parts and Material Inventory

Best practices for the operation of a Natural Gas Processing Plant (NGPP) require the plant to operate on a continuous basis 24 hours per day seven days a week. In order to keep a NGPP in operation the management of spare parts is extremely important. Without spare parts, the NGPP will eventually shut down, gas will be flared, and revenue, as well as customer good will, will be lost.

Spare Parts are defined as any part or piece of equipment or consumable that is required to keep a NGPP operating in good working order. Therefore, spare parts management is an integral part of the overall maintenance program for the NGPP and directly affects the reliability and operability of the NGPP. Effective spare parts management will minimize the time for AGE to perform or execute a maintenance repair and thus minimizes any loss in revenue to AGE.

Having spare parts on hand is still not effective if they cannot be readily retrieved for use. This requires inventory management. Inventory management is a collection of interdisciplinary processes that include a full circle from supply chain management to demand forecasting, through inventory control and including reverse logistics.

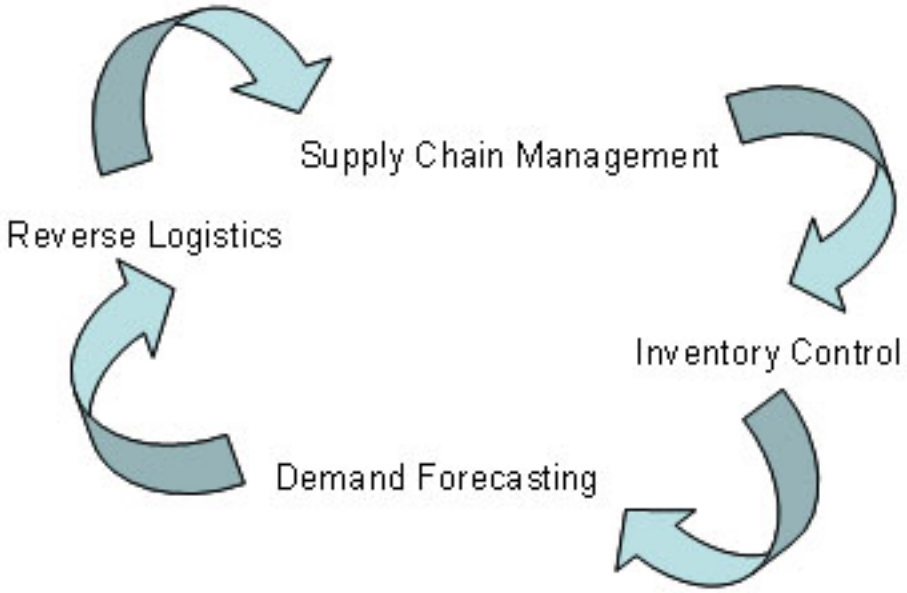


Figure 4-1: Inventory Management Cycle

4.5.1 Spare Parts Inventory Management

Inventory management starts and ends with supply chain management because many of the opportunities to improve efficiencies start with shortening the time from order to receipt without incurring additional cost. However, other stages of the inventory management cycle have just as much importance in attaining overall efficiency. Given that inventory in all its forms generally represents one of the top three expense lines for nearly all companies, there is a universal need for applying the right discipline to each step in the process.

Inventory management in its most efficient form incorporates many different technical applications of inventory management models. Such concepts as safety, stock, economic ordering quantity, cost of goods, inventory turnover, customer managed and vendor managed inventory, and a whole spectrum of underlying inventory management tools play a critical role in inventory management.

While the key principles of inventory management remain the same across all industries, the areas which require emphasis vary from sector to sector. As an example, the logistical issues involved with shipping and receiving materials in Afghanistan present a unique situation regarding potential lead time. Learning to apply the right inventory management tools is part of executing inventory management. By applying lean practices to all aspects of the inventory management cycle, AGE can reduce investment in standing inventory, shipping costs and reverse logistics while maintaining or improving operating and in-stock metrics on critical inventory and fewer unscheduled shutdowns of equipment.

Spare parts inventory management shares many traits with standard inventory management, but requires an extra layer of cost consideration. Whether AGE chooses to have a central maintenance department or one internal to each gas plant, or providing maintenance services to a group of plants, efficient spare parts inventory management plays a critical role in reducing costs and maximizing plant running time.

The five steps below result in the collection of the information that AGE needs for each plant to have effective spare parts inventory management.

Step #1: Understanding existing (or projected) consumption. Because repairs normally happen due to system failures, rather than as part of a reliability based maintenance plan, many maintenance managers or logistics professionals overlook consumption predictions. Spare parts consumption can be based on either actual historic consumption, or projected based on original equipment manufacturer preventative maintenance recommendations and/or historical records for the system.

Step #2: Calculating system failure costs associated with revenue. In-stock levels and the size of on-site inventory should be directly linked to costs of system failure or “down time.” Every piece of equipment or equipment service in a gas plant plays a role in determining failure costs. Most equipment services in a plant have installed redundancy, like 50% or 100% sparing for pumps and compressors. Some full equipment sparing (i.e. spare pump) may be located in a warehouse. Non-critical services not associated with revenue impact, may have equipment that acts as a single point of failure for the entire non-critical service.

Step #3: Estimate soft cost impact of out-of-stocks. It is a picture familiar to many industry professionals: small spare parts hoarded in toolboxes, a spare motor under a desk in the maintenance supervisor’s office, or the "secret stash" closet located away from the warehouse leads to an additional inventory of thousands of dollars’ worth of parts. Reducing inventory dollars on the books as part of spare parts inventory management may lead to an off-books rise in inventory costs.

Step #4: Work with vendors for cost-reduction and in-stock improvement. In many instances, leveraging vendor relationships will allow reduction in overall inventory dollars and keep better in-stocks. Rather than using time and resources to monitor spare parts usage, establish reorder points, and project parts required for preventative maintenance, the manufacturer can often provide a starting point for stocking levels.

Step #5: Calculate costs (hard and soft) of expedited orders. It is sometimes impossible to maintain a spare parts inventory for every contingency. The key is to establish an expedited spare parts ordering process and understand the costs involved. This allows subordinate managers and maintenance person to make good decisions on what to expedite and what to order on standard orders.

These five steps are just the beginning to achieving optimum spare parts inventory management. Cost reduction, increased system availability, and improved moral because workers have the tools they need to do their jobs are just some of the benefits.

4.5.2 Material Control of Purchased Spare Parts Inventory

The material control function commences at the PO stage. Material control at the plant site warehouse or central warehouse ensures that:

- Materials are thoroughly checked on receipt, segregated and stored securely under optimum conditions
- Materials are only accepted into the warehouse when they have passed a thorough “receiving inspection.” Anything failing this inspection is held in a special 'quarantine' area until the reason for rejection has been resolved.
- Documentation and certification supplied with materials and equipment is recorded and filed in such a way that traceability can always be verified

- Special arrangements are made for the reception, handling and storage of hazardous materials
- The integrity of delicate equipment (e.g. instrumentation) is maintained by providing heated storage or similar care
- Manufacturers storage instructions for such items as rotating machinery and electric motors are followed
- Materials are only issued for construction against any authorized materials requisition
- Detailed records are maintained at all times

Material control provides a systematic and orderly approach to the acquisition and assembly of thousands of different components needed to maintain the reliability of a gas plant to operational specifications. The continual reconciliation of all materials against original material requisitions, POs, specifications, etc. will assist in the identification of any material shortages or surpluses which may be available for disposal. In order to provide a complete management tool for the proper execution of the plant, it is recommended that a computerized material control system (MCS) is employed from the outset. The MCS will enable the position of materials to be tracked at any time and the availability of materials for maintenance issue to be determined.

4.6 Maintenance of Equipment

To maximize productive running time and to minimize costly repairs, it is a best practice to maintain equipment in accordance with the manufacturer's recommendations. Changing oil, filters and coolant at specified intervals and using the proper oil, filters and coolant are critical to the efficient operation of the compressors and to maximizing the run time without major repairs.

Glycol for dehydration and amine for acid gas removal must be sampled and tested on a regular basis to ensure that the dehydration and gas sweetening are operating at peak efficiency. Regular or constant checking of the output dew point and the parts per million (ppm) of H_2S and CO_2 in the outlet stream of the gas sweetening plant is critical both to the efficiency and longevity of the pipeline downstream of the sweetening plant, but also to the operation of the gas plant.

4.7 Integrating Quality Assurance/Quality Control (QA/QC) into Operations

Gas companies that follow best practices have integrated QA/QC into their daily processes such that quality becomes a critical component of operations. The ability to integrate QA/QC seamlessly into daily operations is actually a fairly advanced concept. It is generally achievable in companies that have a clearly defined corporate culture dedicated to being incident free.

In the case of a company that is conducting gas processing that might still be working to develop this corporate culture, such as AGE, QA/QC must be more overt and the subject of discrete actions by dedicated personnel. Developing a corporate culture of quality and safety does not just happen overnight. Founded in best practices and then monitored/administered by a robust QA/QC program, this culture can be developed. That said it is very easy to circumvent processes and procedures in order to ensure that gas production is maximized, but the experienced operator using best practices understands the difference between maximization and optimization. The latter implies the greatest production of quality natural gas under the safest and most controlled conditions. QA/QC is the driver of optimization and more specifically gas processing optimization. The absence of QA/QC not only results in suboptimal production, but guarantees that a tragic incident will happen in time.

4.7.1 Differentiating between QA and QC

QA and QC are often considered similar activities in gas processing. The majority of the time, they are discussed together, however; they are two distinct types of activities. QA is a planned system of review procedures that can be conducted by a dedicated processing division or as a part of daily operations. Quality control is a system of routine technical activities implemented by a gas company to optimize processing and ensure compliance with all safety procedures. Simply stated, QA is the audit process. QC is the generic set of processes that define and guide all activities.

4.7.2 QA/QC as Applicable to Natural Gas Processing

A gas processing QA/QC plan is the nucleus of the QA/QC system. The plan informs the company (AGE) as to specific personnel requirements, activities and relevant scheduling. Typical personnel in a QA/QC department include the following:

- Coordinator
- Inventory Lead
- Category Leads
- Outside experts (when required)

The coordinator is directly accountable to the highest levels of the company for implementing all aspects of the QA/QC plan. The inventory lead reports to the coordinator for specific QA roles and is responsible for ensuring that audits occur as scheduled along with proper deficiency tracking and corrective actions. The category leads are responsible for the individual components of processing QA/QC. For example, there may be separate leads for each processing function (such as safety, separation, purification, dehydration, compression, environmental, etc.) that oversee the QA/QC process in each of their respective areas. Typically, the category leads are experienced and experts in their field who are entrusted by the QA/QC coordinator to ensure complete compliance with the QA/QC plan. The category leads make recommendations when standards are not met or there are deficiencies noted on audits. In order to be effective, the QA/QC must be divorced from the profit arm of the company so that their analysis can be independent.

4.7.3 Benefits of QA/QC

As discussed earlier in the processing section, natural gas is typically classified by its chemical composition and in a broader basis by the liquid and sulfur content. Specifically, natural gas that provides for a large amount of natural gas hydrocarbon liquid recovery, measured in gallons per million cubic feet (MCF), can be classified as rich or wet. Lower production of hydrocarbons results in a classification as lean or dry. In terms of sulfur content (typically H_2S), gas classification as either sweet or sour depends on the molar volume of H_2S. Gas containing high volumes of H_2S is classified as sour and in the presence of water is extremely corrosive to carbon steel. Gas with lower volumes of H_2S is classified as sweet. While the amount of acceptable H_2S varies, the typical value to meet the sweet gas criteria is less than 4 ppm. Pipeline-quality is measured in grains per standard cubic foot with values around 0.25 (equates to 4 ppm).

When evaluating the classification of natural gas, the term quality can be applied to the control, measurement and optimization of the processing as well as the final output. A solid QA/QC program applied to the processing element will guarantee a finished product that meets all quality standards. While it is true that there is some level of QA/QC that occurs downstream of the processing plant, QA/QC should be inherent in all processes to ensure that operations occur safely and the greatest amount of revenue to AGE can be realized.

4.7.3.1 Immediate, mid-term and long-term requirements

The QA/QC system, as adopted by modern gas companies, is not currently practiced by AGE. Outside expertise will most likely be required in order to fully meet this requirement, but the adaptation of a functioning QA/QC system can be conducted in an iterative manner. Ideally, a robust QA/QC department would be established prior to executing the first commercial offtake agreement that had the requisite amount of autonomy and capacity to provide quality input to the whole value chain. However, should this be proven not possible, AGE would benefit by focusing on the subset of quality that addresses safety and standards compliance as an immediate solution. Mid-term emphasis on QA/QC to ensure process optimization for maximum production/profit and continuous process improvement in the long-term is the typical order of QA/QC adaptation.

4.8 Training of AGE Personnel

In order for AGE to follow Best Practices, its personnel must first be trained in Best Practices. In addition to training already discussed in this report on Safety, Design Codes and Standards, Procurement, Material and Inventory, Maintenance of Equipment and QA/QC, all of which are necessary for the ongoing operations and maintenance of AGE's midstream system, AGE must provide training for its construction personnel in, as a minimum, the following:

- Construction Management
- Pipeline Welding
- Weld Inspection
- Compressor Operator Training

4.8.1 Construction Management Training

Companies that follow best practices employ management personnel who are skilled in management of construction projects. They regularly survey their existing personnel and provide training to have demonstrated the aptitude to be good project managers. AGE needs to develop these competencies to allow for both planning for and construction of future projects that will make AGE into a viable and profitable midstream pipeline company.

It is recommended that AGE work with experts to determine courses and training opportunities that will allow AGE project management personnel to learn how major and minor projects are planned and executed by world class pipeline/midstream companies.
Once AGE's project managers have received training, they should work in tandem with experts to develop the skills to manage projects.

4.8.1.1 Welding Codes and Standards

A quality, audited and fully compliant welding program is a core competency of a natural gas company. It is suggested that as a best practice, AGE adopt "API Standard 1104 Welding Pipelines and Related Facilities" latest edition, as the standard for pipeline welding in Afghanistan. This specification is the generally accepted standard to assure that quality and safe welds will be made on pipelines and pipeline facilities.

API 1104 allows two types of welder qualification:

Single Qualification: Requires the welder to make a test weld joining two "pipe nipples" or pieces of pipe in a single butt weld. The welder is required to make this weld using a qualified procedure that dictates the sequence of the weld and the welding rod, number of passes around the pipe, and other critical variables (an example sample procedure specification form is included below). The test is normally made on the largest pipe to be welded on the particular project. Once the weld is made it is cut out and straps (strips of pipe including the weld) are cut, which are stretched until failure to ensure that the weld has become stronger than the parent material on the pipe. The weld may also be tested by nondestructive test methods (ultrasonic or radiographic inspection) instead of cutting out the weld for testing.
Multiple Qualification: Requires the welder to make two tests with the first being a butt weld as described for the single qualification and the second requiring the welder to lay out and fabricate a full size branch connection. Both of these tests must be on pipe that is 6.625" (168.3 mm) or larger. The results of the tests are reported in a "coupon test report" (example report form included blow).

API 1104 also defines the limits for imperfections, such a slag inclusions, porosity, inadequate penetration, incomplete fusion, internal concavity, undercutting, cracks and burn through. Some of these imperfections may be repaired by grinding out the weld and re-welding, others such as burn through and cracks in the root bead require that the weld be cut out and replaced.

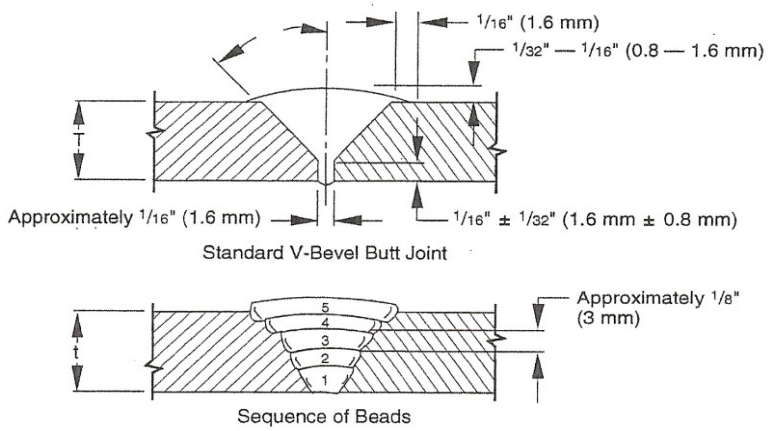
Currently, AGE possesses a small group of welders who have been trained by master welders. These welders have received a small amount of outside training and a significant amount of training on the job. Although it normally requires several years of training and apprenticeship to become a pipeline welder, AGE has several welders who possess the skills to successfully produce code-compliant butt welds when working under the direction of a welding expert. For fabrication, until significant additional training is provided, it is advisable to bring in expert to perform this work.

Reference: API Standard 1104, 5.2

PROCEDURE SPECIFICATION NO. _____

For _____ Welding of _____ Pipe and fittings
Process _____
Material _____
Pipe outside diameter and wall thickness _____
Joint design _____
Filler metal and no. of beads _____
Electrical or flame characteristics _____
Position _____
Direction of welding _____
No. of welders _____
Time lapse between passes _____
Type and removal of lineup clamp _____
Cleaning and/or grinding _____
Preheat/stress relief _____
Shielding gas and flow rate _____
Shielding flux _____
Speed of travel _____ Plasma gas flow rate _____
Plasma gas composition _____
Plasma gas orifice size _____
Sketches and tabulations attached _____

Tested _____ Welder _____
Approved _____ Welding supervisor _____
Adopted _____ Chief engineer _____



Note: Dimensions are for example only.

ELECTRODE SIZE AND NUMBER OF BEADS

Bead Number	Electrode Size and Type	Voltage	Amperage and Polarity	Speed

Figure 1—Sample Procedure Specification Form

Figure 4-2: American Petroleum Institute (API) 1104 Welding Procedure Sample

4.8.1.2 Welding Competencies Needed

The following are competencies in the field of welding that AGE needs to develop:

- Develop and adhere to welding standards for pipeline and gas plants.
- Develop auditing and inspecting procedures and processes.
- Establish apprenticeship and journeyman programs.
- Develop an in-house welder training program or contract with an outside supplier of welding training services.
- Liaise with local donor organizations or seek investment in vocational technical programs designed to train natural gas pipeline and gas plant welders.
- Continue to source and maintain modern welding and associated safety and test equipment.
- Develop nondestructive test requirements and develop an organic capability possibly through "train the trainer" data collection programs coupled with independent analysis.

There are a number of companies in the Middle East that are dedicated to welding and associated natural gas industry training. While funding is always a constraint, due diligence must be performed when selecting a training entity as welding on natural gas pipeline and in natural gas plants is very specialized.

While the welding skill set is heavily reliant upon hand-eye coordination and concentration, it typically takes years for a welder to master the ability to consistently produce specification-compliant high pressure pipeline quality welds. Furthermore, when planning for welder training, attrition should be contemplated as not everyone that commences training will satisfactorily complete the program. The following, additional excerpt from a typical welder training statement of work serves as an example of some of the logistics concerns and training methods.

COUPON TEST REPORT

Date _____ Test No. _____
Location _____
State _____ Weld Position: Roll ❑ Fixed ❑
Welder _____ Mark _____
Welding time _____ Time of day _____
Mean temperature _____ Wind break used _____
Weather conditions _____
Voltage _____ Amperage _____
Welding machine type _____ Welding machine size _____
Filler metal _____
Reinforcement size _____
Pipe type and grade _____
Wall thickness _____ Outside diameter _____

	1	2	3	4	5	6	7
Coupon stenciled							
Original specimen dimensions							
Original specimen area							
Maximum load							
Tensile strength							
Fracture location							

❑ Procedure ❑ Qualifying test ❑ Qualified
❑ Welder ❑ Line test ❑ Disqualified

Maximum tensile _____ Minimum tensile _____ Average tensile _____
Remarks on tensile-strength tests _____
1. _____
2. _____
3. _____
4. _____
Remarks on bend tests _____
1. _____
2. _____
3. _____
4. _____
Remarks on nick-break tests _____
1. _____
2. _____
3. _____
4. _____

Test made at _____ Date _____
Tested by _____ Supervised by _____

Note: Use back for additional remarks. This form can be used to report either a procedure qualification test or a welder qualification test.

Figure 2—Sample Coupon Test Report

Figure 4-3: API 1104 Sample Coupon Test Report

4.8.1.3 Radiographic Weld Inspection

Nondestructive testing of field-made pipeline welds, both for pipe butt welds and fabrication welds is a critical best practice in the midstream pipeline industry. Welds need to be checked both for the operability of the system, but more importantly for the safety of the operations and maintenance personnel and the general public that may be in the area of a pipeline or pipeline facility.

The most common type of inspection in the pipeline industry is radiographic inspection. This inspection, commonly called "X-Ray" uses a radiation source and a film to look through the weld and determine if there are imperfections that are not allowable by the welding code.

There are two types of radiographic inspection:

- X-Ray: Used with an internal source and a film wrapped around the outside of the pipe, so that the entire weld is inspected in a single exposure.
- Gamma Ray: Used on fabrication, short sections of pipe and small diameter (12.75" (325 mm) outside diameter and smaller) long distance pipelines where internal source equipment is not practical. It normally requires two to three (2-3) separate exposures, since it must be shot from the outside of the pipe. Gamma ray radiographs are also typically not as clear as x-ray radiographs, since the gamma ray must pass through both outside walls of the pipe.

Both radiography methods require a radiographic source, which may be difficult to bring into Afghanistan. Although these sources contain only a small amount of radiographic material, their protection and utilization is highly regulated.

Use of this equipment requires skilled technicians to operate it and develop the films and additional skilled inspection personnel to read and interpret the films. As this is the most efficient way to nondestructively inspect welds, it is recommended that AGE move towards acquiring the radiographic technology and train operators to run the equipment and other inspectors to interpret the film. There are a number of companies in the Middle East that offer such training.

4.8.1.4 Ultrasonic Weld Inspection

Due to the difficulties in importing radiographic inspection sources and qualified technicians to operate them, ultrasonic inspection equipment has been used to inspect welds on recent AGE projects.

Ultrasonic inspection equipment was purchased and given to AGE for future inspection use. The equipment is capable of inspecting welds and meets API 1104 standards. It does require an operator with significant training to interpret the results of the scans. There is currently no qualified operator for this equipment either to make the scans or to interpret them in Afghanistan. It is suggested that initially, AGE send several technicians to classes to learn how to operate the equipment and to use experts located outside of Afghanistan to interpret them via internet file transfer. It should be an additional goal of AGE to develop in-country personnel with training to interpret the ultrasonic scans.

4.8.2 Compressor Operator Training

Training for compressor operators should encompass the full scope of activities/tasks required to keep the compressors operating at peak performance for as long as possible. AGE labor and engineering must focus on the fact that every minute that the compressors are not operating is equivalent to a volume of gas that will not be consumed or sold. The training received by AGE personnel at Khoja Gogerdak was designed to develop a team of operators that were able to perform the following tasks:

- basic maintenance functions
- safe start up and shut down
- fluid level checks
- error code reading and recording
- monitoring inlet and outlet pressures
- monitoring temperatures
- monitoring and recording Caterpillar engine parameters
- monitoring and recording parameters on the Adem III display
- documenting both preventative and unscheduled maintenance tasks
- documenting tool box inventories
- completing a daily operations logbook
- performing a risk analysis
- managing the supply chain
- ordering consumables

Ideally, AGE would require 12-18 months of hands-on operator and maintenance training utilizing a combination of theory and practice in a classroom as well as out on the equipment. The installed compressors are significantly automated. Basic knowledge of the control systems and adherence to standard maintenance and operating procedures can be learned rather quickly. Learning what to do in non-standard situations requires a more detailed understanding of the equipment and instrumentation. Strict adherence to factory recommendations and maintenance schedules should be developed as a best practice for operation of the compression equipment.

4.8.3 Dehydration Plant Operator Training

Operation and maintenance of the glycol dehydration unit and subsequently installed subunits requires a level of knowledge and experience on the part of AGE personnel to establish best practices. The dehydration plant is solely for the purpose of removing water from the gas stream. Its operating principles are included in this report. The principal output of the dehydration plant is natural gas with a water content of less than 7 lbs. per MCF. This is the threshold that is normally accepted in the pipeline industry as being dry or pipeline quality gas. Removal of the water from the gas causes it to burn better and become more resistant to forming hydrates in the pipeline due to low temperatures. Also, removing water stops it from pooling in low areas, which impedes pipeline flow, and minimizes the opportunity for internal corrosion due to water mixing with trace amounts of CO_2 or H_2S.

Dehydration plant operators need to be familiar with the following:

- System start up and shut down
- Replenishment of Triethylene Glycol when required
- Dew point measurement
- Emergency procedures
- Boiler relight and temperature regulation
- Electrical connections and pump operation
- Use of stripping gas to increase efficiency
- Glycol storage and waste disposal
- Regulating glycol flow in the system
- Operating temperature regulation
- Liquid knock out
- Filter maintenance
- Pressure differential and settings
- Operational logs and records

In the case of dehydration operations, there is no substitute for the training that can be provided by an experienced operator at the job site. It is the day-to-day adjustments in process controls and reacting to changes in gas flow that will be the difference between just learning theory and truly becoming a commercial operator. Time and oversight will be required to ingrain the best practices in dehydration plant operations.

4.8.4 Amine Sweetening Plant Training

Training of AGE personnel in the safe operation of the amine gas sweetening plant is critical to both the operation of the plant and the health and safety of AGE personnel and anyone who may be in the area. As discussed previously, H_2S in the gas stream and particularly concentrated in the residual gas from the plant is deadly with only a very short period of exposure. In addition to training on how to operate and maintain an amine gas sweetening plant, workers must be thoroughly and repeatedly trained on the use of personal protection warning monitors, the use of safety air packs for breathing air while working in environments where H_2S is present, or is likely to be, training on the maintenance and refilling of the breathing equipment and the proper handling and disposal of waste material from the gas sweetening operation. Due to the inherent risks of dealing with the H_2S, it is recommended that experts be brought in to commission and perform final testing on the plant and to direct operations and training at the amine sweetening plant for a minimum of six to twelve months after the plant is commissioned. Specific areas of training may include:

- Work with experts to develop pre-commissioning" punch list" (final inspection list)
- Complete installation of new flare pilots and fuel gas to the flare
- Work with experts to develop initial purge and commissioning plans
- Work with experts to verify pump alignment
- Testing to ensure that all reassembly connections are leak tight
- Verify completion of electrical generator and wiring
- Amine) testing and balancing
- A storage
- Operation and maintenance of the reverse osmosis(RO) water system
- Operation and maintenance of the electrical power generator
- Operation of the flare system.
- H_2S monitoring systems in line and atmospheric
- Develop safety training schedules
- Emergency procedures
- Frequent safety drills including rescue procedures
- Blowdown and purge procedures
- Operation and maintenance of the fuel gas system
- Regenerator relight and temperature regulation
- Liquid slug catchers and handling of liquid byproducts
- Filter maintenance
- Pressure differential and settings
- Plant security
- Operational logs and records

4.8.5 Training Delivery Options

Training can be accomplished in a variety of methods again consistent with available funding and necessary timeline. The following methods are applicable and ranked in order of most effective to less effective:

- Services contract designed to provide turnkey operations and maintenance with a requirement to provide hands-on rigorous training
- Construction services with associated training
- Embedded training conducted on-site in Sheberghan, Afghanistan
- Outsourced training either in Afghanistan or outside the country designed to “train the trainer”

Areas that should be addressed immediately and in advance of execution of any gas purchase agreement with a commercial off taker include:

- Safety
- Operations procedures, processes and reporting
- Maintenance, both scheduled and unscheduled
- Procurement
- Spares and consumables Inventory management
- QA/QC

5 Design

Best practices for design always should be based on the safe operation of the natural gas pipeline, compressor station, dehydration, treating or other facility for both the operators the general public and the environment. Due to the wide variety of locations where natural gas is produced and transported, best practices will vary somewhat between locations and must take into account the population density, safe operation, security, environment, availability of replacement parts, availability of personnel, emergency reaction time and the availability of alternate fuel sources in the event of system down time.

5.1.1 AGE Design Standards

While design standards that are custom designed for the location along with that location's known risk factors should offer the best outcome, custom design standards can be difficult and expensive to prepare. Therefore, in most cases, design standards that are in effect at other locations may be the better solution. There are many sets of these standards and construction specifications that exist within the natural gas pipeline industry. Some of the suggested construction specifications are as follows:

Table 5-1: Suggested AGE General Design Specifications and Standards

Pipeline Design and Construction		Station Design and Construction
General Pipeline Work	Pipeline Survey	General Station Work
Right of Way	Archaeological Survey	Meter and Regulator Stations
Unloading, Hauling, and Storage of Pipe and Equipment	Environmental Survey	Demolition
Clearing and Grading of Right of Way	Directional Drilling and Trenchless Installation	Grading Drainage, Clearing and Landscaping
Pipeline Ditching	Road and Railroad Crossings	Station Excavation and Backfill
Pipe Bending	Welder Qualification	Stress Reliving
Pipe Welding	Cathodic Protection	Automatic Welding
Pipeline Corrosion Coating	Joint Coating	Station and Fabrication Welding
Internal Pipe Coating	Concrete Weight Coating	Pipe Supports
Rock Shield and Padding	Laying and Lowering In	Station Valves, Fittings and Appurtenances
Backfilling	Ditch Breakers	Carpentry
Pipeline Anchors	Major Water Crossings	Concrete
Small Stream Crossings	Block Valves	Station Piping
Pig Launchers and Receivers	Hydrostatic Testing	Buildings
Blowdowns	Hot Tapping	Painting
Purging and Filling Pipelines	Lock Out-Tag Out Procedures	Instrumentation
Pipeline Tie Ins	Final Cleanup	Electrical Work
Weld Repair	Smart Pigging Pipelines	Start up

5.1.2 Design Safety

As part of the design process, the safety of the facility and all workers need to be at the forefront of all design efforts. All design should have appropriate safety factors. Safety during construction should also be a prime consideration in the design of the facility. Some of the key safety issues are as follows:

- Personal protection for workers such as:
  - Safety glasses
  - Hard hats
  - Safety shoes
  - Long Sleeve and fire resistant clothing
  - H_2S and other personal gas monitors
- Design of automatic shutdown/blowdown systems
- Fire and gas monitors
- Electrical grounding
- Electrical design to appropriate codes
- Emergency evacuation routes
- Sizing of all materials with appropriate design or safety factors

5.1.3 Calculations and Design Drawings

Calculations for all major components should be documented in writing noting who made the calculations and when. All calculations should be checked by a second party to reduce chances of calculation error.

Drawings for construction should clearly define the work to be done with sufficient detail so that there is no doubt as to the intent of the drawing. Where possible, both English and metric dimensions should be included. Drawings should reference materials and include a separate material list with sufficient detail to specify and order each piece of material or equipment and the quantities required. Drawings that are “approved for construction” should be clearly stamped and dated. Preliminary drawings should never be used for construction.

5.1.4 Material Specifications

In addition to the material lists included with the drawings, a master material list must be made with which to order materials. Standard materials such as pipe and fittings may be identified by description and the specification. Other materials or systems will require detailed specifications. Some of the specific details to be included in material specifications follow:

- Operating pressure range
- Volumes of gas flow range
- Maximum allowable operating pressure
- Operating temperature range
- Ambient temperature range
- Composition of gas analysis
- Condition of gas (water content, H_2S content, CO_2 content)
- Electrical power availability and voltage
- Site conditions
- Location of the installation within facility: hazardous vs. nonhazardous area
- Compatibility design requirements with other materials or systems
- Spare part requirements

6 Risk

As the natural gas sector matures in Afghanistan, it is imperative that the concept of risk and management of risk becomes a driver of all activities both at the operational level (AGE), the managerial level (AGE and MoMP).
Consider the following statement:

"Operations involving natural gas drilling, processing, transmission and distribution are inherently dangerous"

While this statement is alarmist in nature, the fact remains that it is a true. It is only because of the great advances in safety, standards, specifications, best practices and risk mitigation activities that the dangers are not routinely observed. It is the result of sound risk analysis and related mitigation activities that a dangerous operation can be managed to the point where it is perceived as being safe. Obviously, this is a very positive outcome of the years of advancement and industry maturation. In developing nations such as Afghanistan, where access to the latest technologies and best training is sometimes lacking, the risk of a catastrophic incident occurring in time is elevated.

A detailed analysis or root cause analysis of some of the most notorious disasters in the natural gas industry can be distilled down to very simple concepts:

- Routine or even occasional disregard for best practices, standards, specifications, procedures
- Long-term, systemic organizational problems such as:
    - Managerial failure
    - Focus on the "wrong things" such as profit over safety
    - Corruption resulting in failure to adequately source requirements for safe and consistent natural gas operations and maintenance
    - Poor corporate climate
    - Weak safety culture
    - Ill-prepared employees
    - Substandard training and qualification program
- Failure of QA/QC
- Disregarded or undeveloped system of check and balances

While the act that ultimately causes a disaster typically comes down to one unlucky individual or a critical failure of a component or material, the true root cause is always traced back to some level of managerial, supervisory or organizational failure. All of the advancements in the industry alone cannot protect against a gas company or its associated management/regulatory oversight that chooses to cut corners for profit or other gains. While the results may not be immediately catastrophic, it is a guarantee that a catastrophe will happen in time when risk is not managed.

The development and incorporation of international best practices, standards, specifications, etc. remains the primary focus of most advisors to AGE and MoMP. While this is the absolute correct approach, such organizational changes caused by the adaptation of these practices will be temporary if the concepts and application of risk analysis and risk management are not developed congruently. In its mature form, the concept of risk and risk management should be incorporated not only into the operational component of the Afghanistan natural gas industry but also incorporated into the full spectrum to include pricing, commercial/contractual decisions and even extending to reputational risk.

6.1 Operator Risk

When most people think about risk management in the Afghan natural gas industry, they immediately focus on the operational and maintenance activities associated with AGE. In terms of prioritization, AGE should first define areas that pose the most risk in terms of safety and continuity of operations and immediately institute process changes designed to mitigate those risks. To make the transformation that is required in AGE, a risk analysis should be performed on each of AGE's functional areas and decisions made as to the type of changes required. The changes required may vary from outsourcing the particular task to a contractor or even discontinuing the activity altogether. The following figure is a representative list of AGE functions that should be analyzed with a list of potential high-level risk mitigating activities:

Sample AGE Functions
Gas processing
Maintenance
Gas sampling
Metering
Welding
Construction
Gas Purging
Transmission
Distribution

Potential Risk Mitigation Solutions
Services contract
Discontinue function
Embed subject matter experts
Joint venture with more experienced
Sub contract
Gas field services contract

Figure 6-1: Sample Risk Analysis Based on AGE Operational Functions

The preceding figure represents the process that should be conducted by an outside entity and it is not intended to be all-inclusive. Due to the requirement for the Government of Afghanistan and AGE buy-in, the method for conducting the risk analysis and establishment of risk acceptance levels is considered outside the scope of this report.

6.2 Reputational Risk

In time, AGE will enter into a gas purchase agreement with a commercial consumer of natural gas. The consumer will demand that the natural gas be priced fairly and expect that AGE can reliably deliver gas that is consistent with the specification defined in the contract. Although the majority of future business will be bound by gas purchase agreements, there is a component of good business practices that is defined by a company's reputation. Typically companies that have good governance, transparent practices and practice corporate responsibility in areas such as the environment and community support will have little concern with their reputation as being deleterious to their business processes. A company that fails at being transparent, environmentally conscious, or perceived as being less than an industry leader is positioned to have their business practices affected by their reputation.

Companies that want to do business with AGE, especially in industries where natural gas feedstock is a large driver of their profit and loss profile will certainly consider AGE's reputation in the industry as a part of the gas purchase agreement negotiation. An entity with a solid reputation for transparency and adherence to best practices is in a much better position to: a.) Attract international and regional business, and b.) Negotiate for the highest gas price possible. Conversely, an AGE perceived as being less than a stable partner will drive a potential consumer's risk profile to the point where either they will take their business elsewhere or they will require a lower gas price in order to mitigate the risk.

Granted that the concept of reputational risk tends to be more qualitative and certainly subjective, but AGE must understand that just about every component of its operations, from how it treats its employees to how it treats the environment, contributes to a complicated reputational calculus. Some positive inputs to reputation follow:

- Safety record which shows minimal lost workdays due to injury or incidents
- Corporate responsibility
- Transparent practices
- Auditable processes
- Fair treatment of employees
- Reputation for quality control and routine compliance with best practices
- Favorable community relationships

In contrast, the following attributes are classic examples of corporate characteristics that serve to increase reputational risk:

- Mishaps or injuries (regardless of cause as most incidents are classified as "preventable")
- Environmental impact either through emissions or non-compliant disposal of materials
- Allegations of unfair and/or corrupt practices
- Allegations of waste, fraud or other practices interpreted as not aligned to the natural gas industry

The fact is that it is much easier to drive reputational risk upward (make the risk higher and the situation worse) than it is to keep reputational risk low. The norm is that a gas company will be dedicated to best practices and act transparently. Even the slightest appearance to the contrary serves to drive risk and this fact must be routinely addressed as AGE develops and transitions to an entity that is aligned with standard business metrics.

6.3 Pricing/Commercial Risk

A slightly different, but inherently related risk component is a gas company's commercial risk. Commercial risk should be addressed in the following representative areas:

- Gas pricing
  - Production costs versus sales price
  - Taxes/fees
  - Escalation
  - Inflation
  - Allocation versus price
  - Spot pricing
  - Other pricing models
- Purchase agreement specifics
  - Take or pay
  - Firm or variable demand
  - Quality
  - Nomination
  - Metering
  - Sales point
  - Force majeure
  - Insurance
  - Guarantee
  - Other terms and conditions
- Regulatory
  - Compliance
  - Impact on cost of operations
  - Environmental constraints
  - Transparency
- Supply/demand and balancing
  - Delivery requirements such as pressure, quality, etc.
- Competition
- Capital improvement

In Afghanistan, the focus of the gas industry is always on the ability of AGE to safely and reliably produce gas for supply to commercial and domestic consumers. The supply component is obviously just half of the equation, and it is imperative that commercial risk metrics are also applied to the consumer. While many of the risk areas overlap and culminate in the negotiation and due diligence that precedes the execution of a gas purchase agreement, the consumer risk analysis must begin as early as possible in the AGE maturation process. Some example risk categories as applied to the natural gas off-taker include:

- Ability to pay
- Creditworthiness
- Nomination
- Transparency and company ownership/influence
- Delivery point
- Licensing
- Financial status, profitability, etc.

It is likely that in the near-term and coincident with AGE's critical development stages, there will be a misalignment between supply and demand. Simply stated, any commercial risk analysis must address the fundamental issue at a minimum; the ability for the consumer to pay for the gas it uses should be proportional and ideally equal to the capacity for AGE to safely and reliably meet demand. If this is proven to not be the case, AGE and natural gas industry in Afghanistan as a whole will be unsustainable until either a larger operator is incentivized to begin natural gas sales or some other significant event occurs to change the balance.

6.4 Other Risk

Unfortunately, the political and developmental environment is a major concern and risk driver for both AGE and future consumers. Much of these risks cannot be controlled by either party and it will be important that all activities contemplate potential impact from insurgents, political interference, corruption, improper influence, etc. While this category can be classified as "other risks", it must be understood that realization of these risks can have a catastrophic outcome to the future of AGE as a business entity and in the classic sense as a contributor to a natural gas-related disaster. Until the environment increases in stability, these "other risks" will need to be addressed across the full spectrum of operations and business functions. In the case of a gas purchase agreement, for example, force majeure terms can be seen as a solution to some of the above. However, force majeure applies to those events which are unforeseen/unpreventable and the onus on AGE and its advisors will be to ensure an ongoing realistic assessment of the security and political environment is used to inform daily and future operations/capabilities. As applied to AGE operations an example of the "other risk" category would be the analysis and options available should AGE or its advisors not be able to access a gas plant or construction site due to security concerns. In this current environment, contingency plans for AGE employee security, continuity of production, business operations, etc. must be developed and the effect of realization of these "other risks" understood in advance.

6.4.1 Strategic Risk

It is recommended that risk be analyzed at two levels: strategic and functional. The first level is more germane to MoMP and for AGE's management team along with its advisors to conduct. This first level of risk should encompass all of the strategic risks associated with the natural gas industry in Afghanistan and would include such high-level issues as:

- Risk to the timeline and execution of any AGE development and capacity building program
- Risk to consumers (reliable and specification-compliant supply)
- Attracting international as well as domestic investment
- Risk to Afghanistan

6.4.2 Functional Risk Analysis

The next, or "lower-level," risk analysis would be conducted at AGE and should utilize international experts in concert with AGE's employees and focus on the operational and maintenance functions. This level of risk analysis would not only inform specific capacity building efforts (high consequence, high likelihood areas) but it would also serve to highlight and perhaps prioritize specific functions that are in the worst shape. Lower-level risk should not be interpreted as being any less important than the strategic level. This level of risk is designed to be pervasive and will ultimately quantify the risks associated with operations and maintenance. The following example will serve to demonstrate the methodology for dissecting each function into a separate listing of risk areas.

Table 6-1: Sample Risk Analysis of Gas Processing Function

Task: Gas Sampling
Associated Activities (Risk): • Safety • Accuracy • Methodology • Repeatable
Potential Consequence: • Safety- Personnel may be exposed to high levels of H_2S and other harmful chemicals • Accuracy-Process must be accurate or consumer may receive off specification gas • Methodology- Chosen method must be acceptable by the consumer and in accordance with best practices or gas purchase agreement compliance will be not auditable • Repeatable- Gas sampling must be consistent for AGE and similar to results obtained by consumer or consumer may request make up gas due to non-compliance with specification
Mitigation: • Safety: Personal protective equipment, training. • Accuracy: Training, lab processes, equipment calibration • Methodology: QA • Repeatable: QC

Obviously, there will be overlap particularly in areas of safety, occupational health, process, training etc. The point of the activity is to fully understand the risks associated and then to prescribe specific actions to mitigate the risk.

Over time, consultants and advisors would guide AGE to perform this type of analysis for all functions necessary to operate as a natural gas company. This analysis should not be performed as a managerial task or independent analysis; rather capacity building efforts should focus on the introduction and maturation of self-auditing as a means of doing business. Once this concept is embraced, risk analysis not only becomes an inherent part of every activity, it begins to form the basis for AGE development. It is much more effective for the Afghan laborer, who is responsible for storing processing chemicals; as an example, to be taught the right way to do things and then how to perform a risk analysis than it would be for an outside consultant to simply teach proper chemical storage in a classroom environment. Even more conducive to development would be an expert that is responsible for chemical storage who works side-by-side with his Afghan counterpart. After months of this type of relationship, it would be most interesting to have the AGE employee not only critique the process but evaluate the process for risk and possible measures to optimize. In this manner, the AGE employee not only becomes part of the process but the early stages of continuous process improvement are ingrained.

6.5 Example Risk Analysis (5x5 and 10x10 Matrices)

The genesis of the discussion of risk analysis process definition is to demonstrate that capacity building at AGE must conform to a very dedicated and targeted scope of work. While many developmental experts have taken a rather 'broad brush' approach with the conclusion that AGE needs to be restarted from the ground up, a more efficient approach is to utilize risk analysis to scope capacity building activities. Standard risk analysis tools are useful in looking at specific actions and assigning a consequence and probability or likelihood of occurrence. This fits perfectly in the natural gas sector where some events can be very unlikely but can have very serious consequences. Conversely, some events can be highly probable but result in minor consequences.

Regardless of the risk-based analysis, the focus must be on mitigation. Ideally, analysis of AGE functionality or desired functionality would highlight those areas that are of moderate to high likelihood and moderate to high consequence ("yellow" and "red" risks) and dedicate risk reduction methods such that at the end of the particular program or mitigating action, residual risk is at the "yellow" to "green" measurement.

AGE will benefit through an application of either 5x5 or 10x10 risk matrices, as depicted in the figures below:

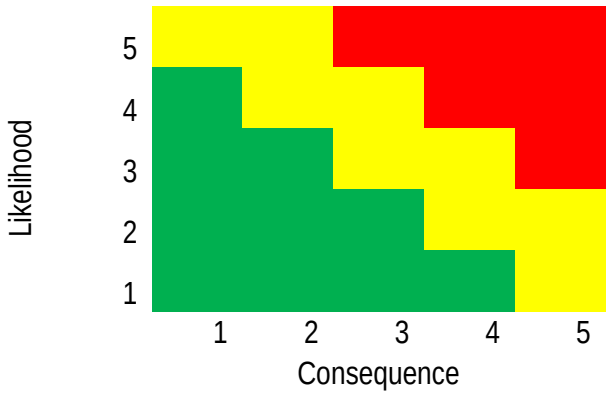


Figure 6-2: 5x5 Risk Matrix

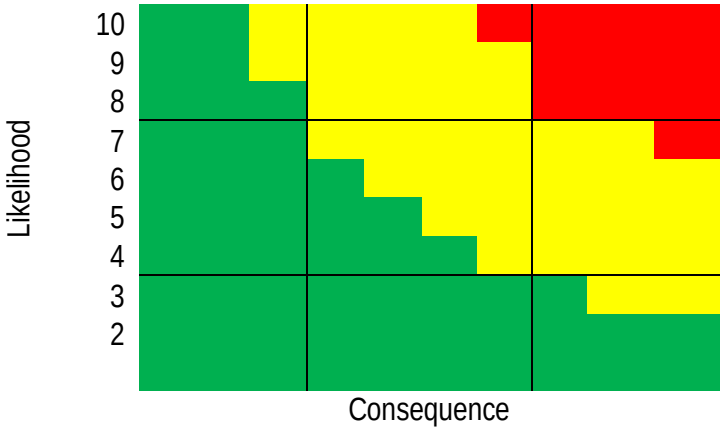


Figure 6-3: 10X10 Risk Matrix

The 5x5 and 10x10 matrices detail the same type of analysis with the later allowing for more detailed analysis and closer tracking of metrics. To demonstrate the power of this type of analysis, let us continue with the example of gas sampling. The following figure provides an estimate of the current standing of this process within AGE. While it is somewhat of a subjective metric, it is quite apparent that at this time, AGE cannot routinely and predictably sample gas and therefore cannot enter into a gas sales agreement. As the risk analysis shows, training in accepted methods, QA, safety and repeatability drives (or trends) 'yellow' risk to a 'green' risk; with a lower consequence and likelihood.

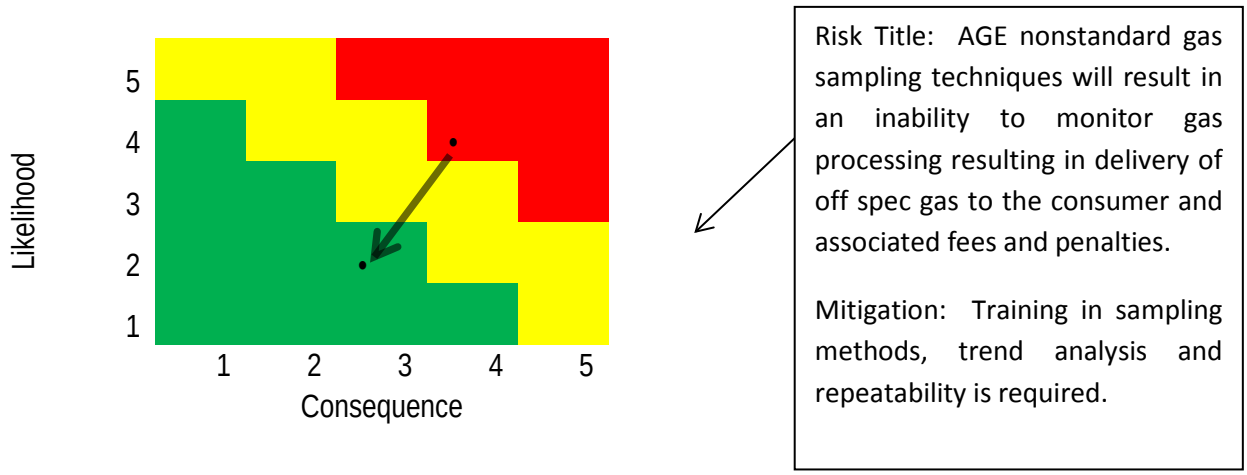


Figure 6-4: Gas Sampling Risk Analysis

6.6 Definition of Risk

Once all risks are identified and classified, AGE will need to develop a discrete plan for addressing each item. The figure below shows a very simple risk metric scheme and in the early stages of developing a plan of action for AGE, this is the suggested approach. As AGE begins to effectively address its most critical issues, greater fidelity in risk ratings will be helpful to inform and refine specific control measures and capacity building tasks.

Table 6-2: Example Risk Definitions and Treatment

Risk Rating	Degree of Risk	Risk Treatment
	Minimal	Acceptable Risk. No further action or additional controls are required. Risks at this level should be monitored and reassessed at appropriate intervals.
	Low - Moderate	Risks at this level range from marginally acceptable to potentially acceptable depending on AGE risk acceptance. If not acceptable, additional controls need to be put in place.
	Significant - High	Unacceptable level which requires immediate action. Control measures must be put in place immediately to limit consequence. It is possible that multiple control measures are required.

6.7 ISO 31000:2009. The International Risk Standard

Risk and the associated analysis of risk in program and process management are regarded as an international best practice. The point is to not be risk averse, but rather to fully understand a gas company's risk exposure and develop specific processes and activities to reduce risk to an acceptable level. The "acceptable" level must be deemed appropriate by the Government of Afghanistan and be consistent with international best practices. To help guide and inform this process there are many standards and specifications such as those established by program management professionals and other international standards such as ISO 31000. While it is not necessary to adopt a particular risk assessment standard, AGE would be best served by adopting the fundamentals defined in ISO 31000. Key components of this standard include:

- Establishment of risk policies aligned with an organization's function and objective
    - Assignment of specific activities
    - Creation and maintenance of records and supporting data
    - Development of methods for monitoring and reporting progress
- Aimed at those responsible for implementing and overseeing risk management practices
    - Policy development
    - Managing risk
    - Assessing risk mitigation effectiveness
    - Establishing organizational standards
- Risk management process is clearly defined in multiple steps
    - Identification
    - Assessment
    - Treatment
    - Monitoring
    - Review
- Risk management is relevant to an organization achieving its objectives
- Risk management must be embedded into the management processes
- Risk management should be applied across all activities, strategies and decisions, operations, processes, functions, services, projects and assets.

6.8 Cursory Midstream Risk Analysis

The following table is an example risk analysis for AGE's midstream functionality. It is not designed to be all-encompassing; rather it serves as the type of analysis and rigor that should be applied to all functions. This type of analysis should be performed by the company that is responsible for assisting AGE and it should be clearly delineated in the statement of work.

Table 6-3: AGE Midstream Risk Analysis

Risk Category	Risk Title	Consequence (1-10)	Likelihood (1-10)	Risk Level	Mitigation Activity
Security	Insurgent activity disrupts processing functions and gas supply is disrupted.	7	7		Close coordination with government. Support from APPF. Utilize MoMP Protection Force
Safety	Failed safety program at AGE will cause an explosive incident or injury/death to personnel	10	10		Outsource operations and maintenance. Incorporate requirement for on the job training. Change AGE corporate climate. Develop internal auditing process.
Quality	Close control and monitoring of gas quality will be required for execution of gas purchase agreements	6	5		Gas chromatography training. Proper gas sampling techniques. Establish AGE sampling process and measurement guidelines.
Consumables	AGE must establish a standard supply chain to ensure consumables are on hand or midstream operations will be interrupted.	8	2		Develop inventory process. Link maintenance and operations to warehousing plan. Establish supply chain and auditable/transparent procurement process.
Procurement	AGE must have a procurement process for spares, personal protective equipment, capital equipment, etc. or the midstream will not mature.	6	3		Continue to develop supply chain. Work with MoMP to define procurement process.

Risk Category	Risk Title	Consequence (1-10)	Likelihood (1-10)	Risk Level	Mitigation Activity
Training	A training program is required to ensure all AGE personnel understand best practices or equipment damage or personnel injury/death will occur in time.	8	8		Develop an auditable training program designed around a services contract. A sound program with traditional apprentice and journeyman level tasks is required. The training program will be a QA/QC function.
Occupational Health	Failed occupational health program will result in injury or death.	9	9		Develop and implement occupational health process, training and auditing in all facets of midstream operations.
QA/QC	QA/QC process is required to ensure purchase agreement compliance and for safe and consistent operations	9	8		Define and then incorporate industry best practices. Develop mature QA/QC set of 'checks and balances'. Ensure process is auditable within AGE and by the regulatory body. MoMP should be involved in this process.
Cost control	Failure to understand process optimization will result in decreased AGE profit and slow capital improvement.	7	6		Adopt industry best practices. Incorporate into QA/QC process. Develop lab facilities. Coordinate gas quality requirements with midstream process controls.
Technical	Increase technical ability across midstream value chain or catastrophic incident will occur in time.	8	8		Outsourcing of midstream operations and maintenance is required in the short-term especially with respect to the gas sweetening plant.

7 Capacity Building Strategy

As a complement to the risk analysis, an analysis of the required/planned AGE functionality versus observed must be conducted. This is the only way that a true capacity building program can be scoped. This gap analysis should inform the capacity building effort and be cross-referenced with the risk analysis discussed in the preceding section. The goal is to apply capacity building in the correct areas such that high consequence items are addressed immediately and the capacity building output remains focused on developing core functionality. The gap analysis which is detailed in the following paragraphs should be utilized to inform a capacity building program.

7.1 AGE Functionality Gap Analysis

7.1.1 Assessment Rating of Core Capabilities

The core capabilities of AGE were qualitatively assessed based on a comparison of existing capability versus capability expected of a company that conforms to international best practices in areas of midstream operations, pipeline and plant construction and business operations. The analysis was based on observation of AGE practices as well as interviews with personnel responsible for the specific areas. The following qualitative assessment categories were assigned to each core area:

Table 7-1: Assessment Rating Scale

Assessment Rating	Definition
	Demonstrates consistent ability to perform
	Either incomplete ability or not possible to ensure enduring compliance
	No observed capability

7.1.2 Midstream Functions

The following table details the expected core capability of a midstream company and AGE's specific performance in each area. Given the required capacity building effort, the defined success metrics will ensure that AGE can safely and consistently produce natural gas that meets requisite specification for delivery.

Table 7-2: Midstream Processing Assessment

Capability	Assessment (Current)	Required Capacity Building	Success Metric
Safety	AGE does not currently adhere to specified safety standards	Management commitment to a culture of Safety: Formal safety training as applied to processing Implement safety programs at AGE Gas Plants at Khoja Gogerdak and Yatimtaq Implement a reporting program to monitor safety compliance and incidents	Safety Division of AGE focused on Gas Plants Adherence to safety policies Demonstrated reduction in accidents
Maintenance	Soviet compressors, dehydration plant and amine plant are no longer serviceable or maintained New compressors, dehydration and amine plant on-site	Maintenance training from operating company Scheduled maintenance program Troubleshooting training	AGE follows scheduled maintenance program Monitoring of facility up-time and preventable repair occasions
Gas Processing Standards for Transmission and Distribution	AGE will need to develop standards in order to deliver consistent quality of gas	Assist AGE to develop standards to deliver consistent quality Formal training in gas quality measuring and analysis (chromatography, Drager Gas Detector Tube) Laboratory practice schedule and procedures monitored	Approved and published procedures for gas quality monitoring with ability to affect production.
Compressor Operations	Soviet-installed compressors failed Limited ability to operate new compressors	Continued formal operator training Unscheduled and scheduled maintenance training	Ability to ensure consistent "up time" through scheduled and unscheduled maintenance Adherence to operational schedule
Dehydration Unit and Amine Plant Operations	Soviet-installed equipment failed Limited ability to operate newly installed equipment	Formal operator training Implement operations schedule	

7.1.3 Pipeline and Gas Plant Construction

As the AGE looks towards expansion (consistent with increasing offtake), it is expected they it will be able to expand natural gas infrastructure. If AGE ultimately decides that infrastructure expansion is outside of its planned work scope, the assessment and corresponding capacity building requirements detailed in the following table are necessary for safe and sustained natural gas production.

Table 7-3: AGE Construction Assessment

Capability	Assessment (Current)	Required Capacity Building	Success Metric
Welding	AGE has 4 welders capable of welding to rated maximum allowable operating pressure of line pipe.	Ad-hoc journeyman program started Formal and On-the-job training Training sustainment plan	4-6 qualified welders with ability to pass API-1104 (or AGE-specific) test. Established journeyman program
Weld Inspection	AGE does not have access to NDT and will require training to use equipment Requires training on general understanding of process	Provide formal NDT training Develop AGE weld inspection standards Train/procure ultrasonic weld inspection equipment	Adequate technical capability to assess weld inspection services Potential for in-house UT capability
Construction Standards	No standardized construction process	Assist AGE to develop construction standards, inspection process for pipeline & gas plant. Standards to include pipelines, compressor stations, treating facilities, dehydration , metering, instrumentation, electrical, civil, corrosion control and all facets of construction and operation of a Midstream Operating Company	Approved and published standards for pipeline and plant construction Adherence to Construction and Maintenance standards.
Inspection (QA/QC)	No inspection capabilities inherent to AGE	Implement inspection program designed to ensure construction by AGE labor or external company conforms to AGE standards. Program to include instruction, safety, operators, environmental, etc.	3-4 construction inspectors General adherence to AGE construction standards
Safety	AGE does not currently adhere to specified safety standards The U.S. Department of Defense has provided ten guidelines for pipeline rehabilitation	Occupational Safety and Health training based on U.S. standards AGE to develop safety standards and safety monitoring program Subject areas include H2S awareness, confined space entry, gas detecting, explosive levels, etc.	HSE department with a minimum of 4 employees In house safety training and adherence to own process Monitoring and compliance program with safety incentives

7.2 Corporate Operations

AGE is currently not set up to operate as a profitable business and does not possess any of the business attributes typical of a functioning gas company. A similar analysis of the expected capabilities was performed in this area, however; success metrics were not identified as these will have to be determined by the Government of Afghanistan once a final decision is made as to AGE's structure. The assessment is included in the following table:

Table 7-4: Corporate Operations Assessment

Capability	Assessment (Current)	Required Capacity Building
Management	Managed as a State Owned Enterprise with no motivation for profit or understanding of financial loss	Advise AGE on developing optimal management and manpower structure Assist in the preparation of job descriptions and management training
Business Plan	No observed capability	Assist AGE in the development of a business plan
Procurement	Limited procurement capability No discretionary budget	Coordinate with Government of Afghanistan Implement AGE procurement process Assist AGE in developing procurement relationships with regional vendors for supplies and equipment
Personnel	Revised labor chart required for a corporatized AGE	Assist AGE with the development of an HR process Develop a hiring plan and job descriptions Advise on the development of compensation and incentive packages
Financial Management	No observed capability	Assist AGE in the development of a transparent financial system that at a minimum implements financial controls, asset management, payroll, taxation, cash flow, operations, and other administrative matters
Marketing	No off-take from Sheberghan-Mazar pipeline except to NFPP	Assist AGE in expanding its gas sales in developing commercial and private markets

8 Concluding Comments

It is unrealistic to capture decades of change, technical maturation, standards, practices, specifications, etc. in a set of reports. Like most industries that have the potential to promote industrialization and to bring large-scale revenue to private sector companies and governments, industry leaders in the natural gas sector abide by volumes of best practices whether steeped in formal law, specifications and standards or simply as a result of years of harsh lessons learned. While it is true that the AGE has marginally functioned to supply gas to several consumers over the past decades, it is also true that the AGE has had to endure budgetary and management constraints that would not be tolerable by other companies. AGE should be lauded in that they were able to overcome real challenges with limited, modern equipment and training. However, great and rapid change is required in areas of safety, best practices, optimization, etc. to decrease the likelihood of a natural gas-related catastrophe and to enable the leveraging of natural gas production and sales.

Over the past three years, AGE has demonstrated an ability to embrace modern natural gas welding techniques, gas plant and pipeline construction, limited maintenance and operation practices, and some understanding of safety. The organization obviously has many challenges ahead, but should funding be identified for continued capacity building, there is an opportunity to continue the momentum that currently exists in the AGE midstream and pipeline divisions. Continued focus on best practices and development of a corporate culture of quality and safety must follow if AGE is to supply natural gas to commercial consumers. Experience has shown that AGE personnel respond well to hands-on training and an ideal approach to continued capacity building would be bringing in a small team that is required to operate and maintain the midstream and transmission components. This team should also be required to restructure and train AGE management, engineers and technicians in all areas of natural gas best practices with an understanding of risk, risk management, and the most applicable standards and specifications. To ensure the success of such an undertaking, the AGE will require short-term and stabilized budgetary support to provide for the procurement of spares, consumables, safety, construction and capital equipment at a minimum.

Afghanistan and the AGE have great potential to mature the natural gas sector with the associated benefits to the country. Development must be done correctly and methodically with a focus on the end state. This end state must be agreed upon by MoMP and other stakeholders, but one component is certain-- a complete dedication to safety, quality, and best practices so that the AGE or its successor rapidly become world leaders in the natural gas sector.

9 References

Information contained in this report is based on the references as follow in this section. All documents referenced have been obtained from the public domain and are generally available for downloading from the internet. Additional information was included in this report based on the knowledge and experience of SME Professionals, LLC personnel.

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