Asset Management Services

Production Optimisation

Germanischer Lloyd – Service/Product Description

Production Optimisation

Service Title: Asset Management Services

Lead Practice: GL Asset Management (UK)

Contents

Service Description and Values Generated:

Reliability, Availability and Maintainability (RAM) modelling is used by Germanischer Lloyd (GL) to identify the best design taking into account factors such as:

- Equipment capacity and reliability
- Spares holding
- Maintenance strategy
- How the plant is operated
- Overall commercial targets for production

This is combined with in-house knowledge of plant design and operations in LNG, gas processing, flow assurance and asset integrity.

In addition concept/feasibility studies can be carried out for new gas processing plants and energy chains along with optimisation, troubleshooting and debottlenecking of existing plant.

RAM Modelling

Maximising the performance of an asset depends on much more than simply selecting the optimum process design based on maximum availability. Traditional availability analysis methods focussing on the failure and repair of equipment may be useful in the preliminary screening of process design options, but have limited use in predicting the actual performance of an asset. In reality, assuming a reasonable design is selected, equipment failures may not be the most significant contributor to an asset's production losses. Thus in attempting to model actual performance, a number of additional technical, operational and commercial issues should also be considered. These include:

- Production targets and system capacities
- Contracts strategy
- Operational strategy
- Production planning
- Market constraints
- Unavailability of export routes
- Production system bottlenecks
- Subsea intervention strategies
- Planned maintenance strategies
- Maintenance resourcing
- Spares holding
- Two-phase production limits

A Monte Carlo simulation package with such functionality as GL's OPTAGON™ can consider the impact on performance of these additional factors, how such issues interact and how they affect business performance. GL has developed the package over the past 15 years to specifically determine the availability of complex oil and gas facilities. This package uses the Monte Carlo approach to overcome the modelling complexities associated with such facilities. The extensive functionality of OPTAGON is such that a detailed, realistic performance model can be developed for a specific facility throughout its life cycle; from concept, through design, to construction and operation.

This approach can be used throughout the project lifecycle to give the significant savings on investment; maximised revenues through increased production; and reduced contractual penalties by optimising commercial strategy.

GL use their in-house OPTAGON software tool to analyse the performance of complex oil and gas production assets at the design and operational stage.

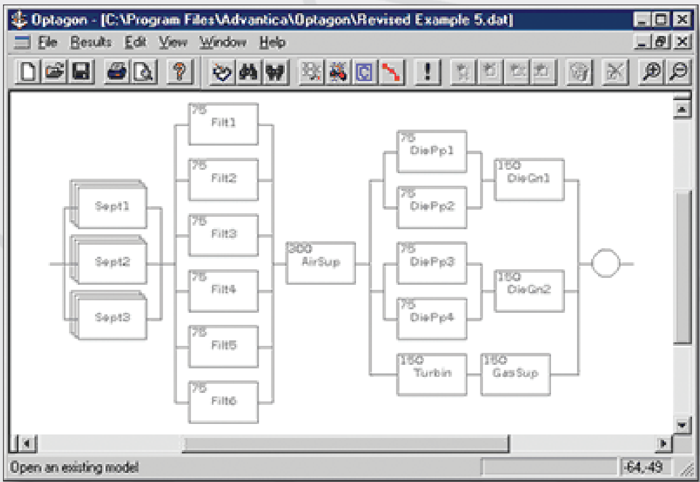
OPTAGON uses the Monte Carlo method of explicitly modelling the system, subjecting it to a typical set of events over its lifetime, and empirically observing how it performs. The nature of the model means that it is possible to include a wide variety of complex system behaviour without having to reduce them to analytical approximations. The functionality within OPTAGON is extensive and enables complex system behaviour to be incorporated into the system model. Using this approach GL has carried out studies on the following systems:

- Onshore gas processing plants
- Offshore oil/gas facilities
- Subsea facilities
- LNG import/export terminals
- LNG Port Berthing analysis
- FSU condensate loading/unloading
- Integrated assets (e.g. LNG supply chain)

OPTAGON uses the following methodologies:

a. Reliability Block Representation.

Systems to be examined are described in OPTAGON by reliability block diagrams. These show how the operation of the whole system depends on the operation of its constituent parts. OPTAGON is not restricted to simply assessing whether or not a system is working or not. Use of individual component capacities within the reliability block configuration enables a system to be analysed in various states of partial production.



OPTAGON Reliability Block Representation

b. Failures.

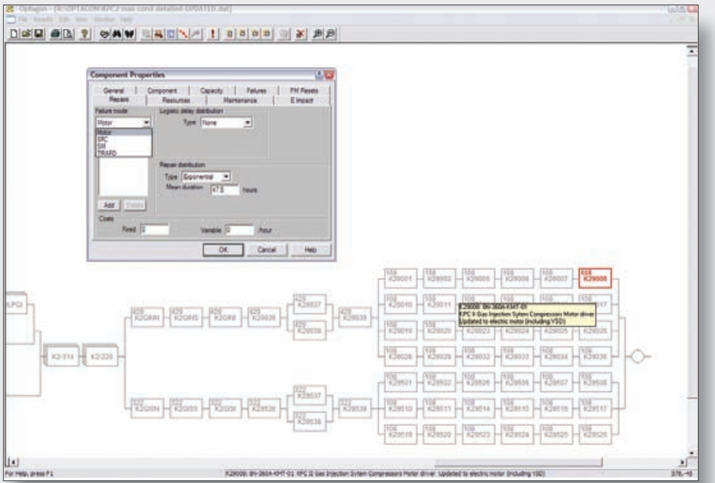
A component may have multiple failure modes, each one describing a different failure mechanism. Start-up failures have a constant probability of occurring for each start-up and non start-up failures occur at a variable frequency determined by the probabilistic distribution that best describes the behaviour of the component.

For non start-up failure modes, it is possible to specify whether the component is subject to the failure while it is running, while it is on standby, or both. Failures which affect the components when they are on standby can be defined as unrevealed.

c. Repairs.

Each failure mode can have one or more associated repair processes. Multiple repair processes can be used to model seasonal weather variation of the ease of access with different repair processes in winter and summer.

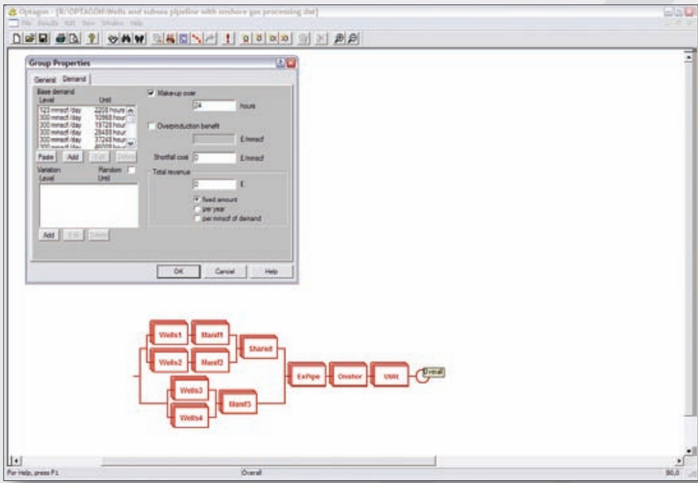
Each repair process is broken down into two elements. The logistic delay distribution represents the time taken for a repair crew to arrive at the location. The repair distribution represents the time taken to carry out the repair itself.



d. System Demand.

In OPTAGON, system demand and capacity are separate. Hence, the system does not have to run at maximum capacity. The demand on the system can be constant, or can change over a given interval.

It is also possible to operate a system above current demand to make up for earlier shortfall or for financial incentives.



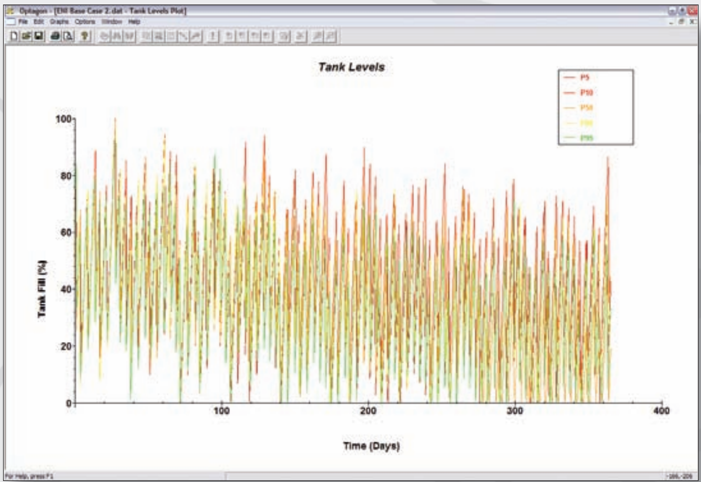
e. Multiple Revenue Streams.

In addition to modelling a single stream, OPTAGON can also model systems with multiple revenue streams. In such a system, different demands and revenues can be assigned to different outputs from the system (i.e. different delivery points or fluids). This important feature allows both streams to be analysed as it is sometimes the secondary stream that constrains capacity.

f. Tanks & Ships.

The tank storage functionality in OPTAGON explicitly models the filling and emptying of tanks within a production system. This functionality enables tank filling and emptying to be independent processes governed by the level of stock within the tank.

OPTAGON models a set of tanks as a "static storage" tank which is permanently available storage with a maximum stock level, maximum filling rate and required filling rate. In comparison, ships are modelled in OPTAGON as either arriving with stock or arriving to be filled. Different ship sizes, ship frequencies, ship delays, port restrictions, tidal limitations, demurrage penalties and ship berth availability can be assessed.



g. Key Simulation Output.

Both process and equipment shortfalls are reviewed to give the output to the system model defined by the following parameters:

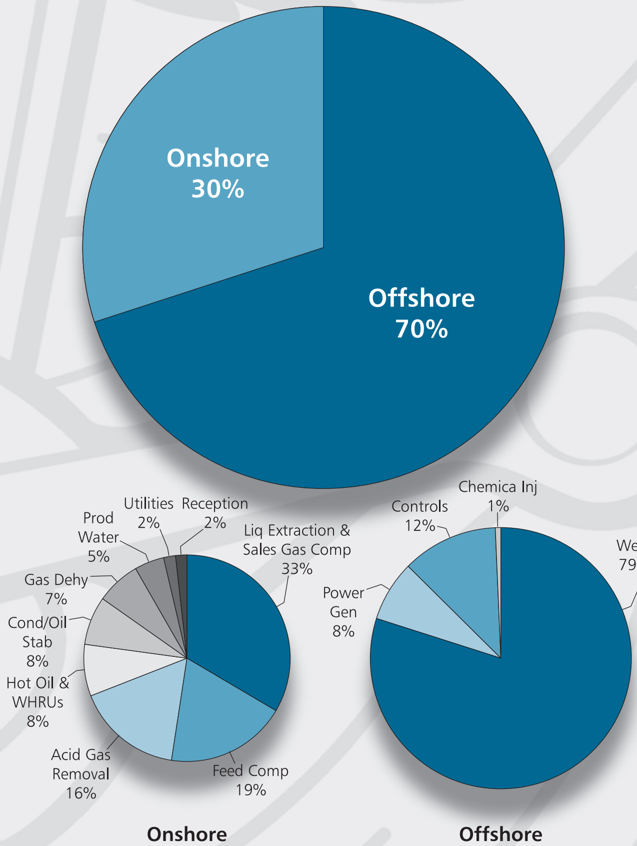
Shortfall - the proportion of total demand that is not met

Unavailability - the proportion of time when output is below the required demand level

Shortfall Contributors - shortfall events (e.g. equipment failures, weather delays, planned shutdowns) ranked by their contribution to the overall production shortfall

Total Cost - the cost of any shortfall, capital equipment, operating costs and spares holding costs

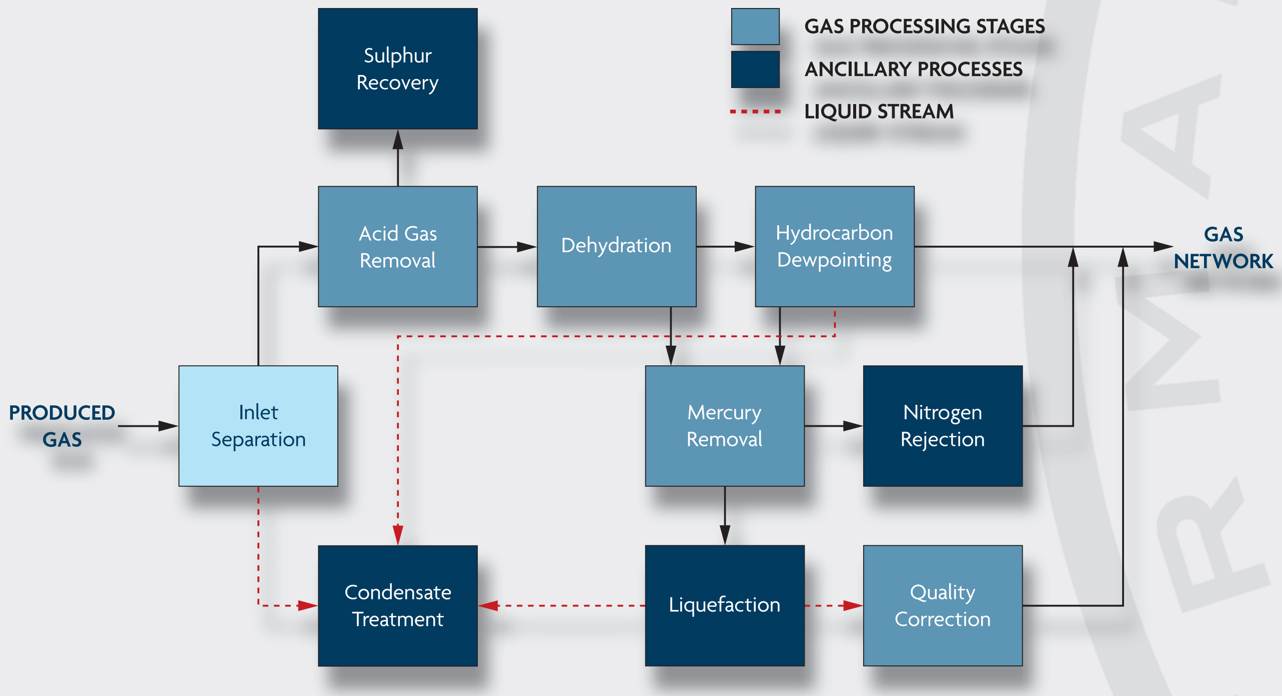
Shipping Results - ship delays, ship waiting times, demurrage times and penalties, storage tank-topping frequencies.



Gas Processing

In addition to the RAM modelling, GL has been involved in gas processing for over 35 years and has developed know-how and capabilities in all of the major gas processing unit operations including:

- Adsorption
- Solid Bed Absorption (hydrogen sulphide and mercury removal)
- Acid Gas Removal
- Glycol Dehydration
- Low Temperature Separation (dewpointing)
- Gas Quality Correction (nitrogen ballasting and LPG injection)
- Scavengers (sulphur species removal)
- Scrubbing Systems
- Major ancillary processes on gas plants:
    - Fractionation (condensate stabilisation and methanol recovery)
    - Glycol Reclamation
    - Cryogenic Processing (liquefaction and nitrogen rejection)
    - Condensate Sweetening
    - Sulphur Recovery (redox processes)



This know-how can be applied to the natural gas and syngas industries and used on offshore production units, onshore gas terminals, LNG facilities, underground gas storage sites, CO_2 sequestration, gasification plants and power generation facilities. Commercially available process modelling software such as Hysys and Promax are used to support this work.

For new plant developments, support can be provided at the pre-FEED stage. This includes:

- Process Screening - a techno-economic evaluation and/or energy chain modelling of the process options available to determine the optimal process for the application.

- Feasibility Design - evaluation of the processes selected to ensure that they are suitable to perform the required duty and meet the product specifications.

- Conceptual Design - pre-FEED engineering to determine the high level plant design requirements to enable projects to move towards sanction.

For operational plant, the following services can be provided:

- Performance Assessment - data collection on the operational plant and comparison with ideal performance as shown by process simulation. Optimisation - process modelling of the plant to identify where improvements can be made. This can be used in conjunction with the RAM modelling to identify optimum configurations. After implementation, the improvements are then evaluated to ensure the optimisation has been achieved.

- Debottlenecking - services are performed where plant throughput is to be increased to achieve capacity increase or to recover from under performance. This involves identification of the components causing a restriction and proposing a solution to alleviate this.

- Troubleshooting - services are used where there are operational issues that are affecting production rate, product specification or equipment issues. This involves identification of the problem and evaluating solutions to remove it.

GL also use their gas processing expertise to perform general studies for the industry. Previous studies have included reviews of new technologies, current status of gas processing topics and the impact of market changes on plants.

a. Onshore and Offshore Availability Study

Date: 2007
Customer: North Africa Operator
Savings: Meet future supply contracts

GL have recently carried out an availability study for a North Africa operator using their OPTAGON software. The study required the development of a fully integrated OPTAGON availability model of the onshore, offshore and LNG production facilities.

Results from the integrated OPTAGON model were benchmarked against current plant performance. The model was then used to look ahead and predict future performance over the forthcoming years.

As part of this study, the integrated OPTAGON model was used to:

- predict the future availability of LNG and domestic gas supplies
- quantify the major contributors to production losses (including major equipment failures and operational issues)
- demonstrate the potential impact on gas & LNG availability of employing different commercial modes of operation
- demonstrate the potential impact on gas & LNG availability of employing different technical modes of operation

In addition to the integrated asset model, a detailed and explicit model of LNG shipping operations was also developed using OPTAGON. The OPTAGON shipping model was used to:

- estimate tanker 'turnaround' times
- predict weather events and port closures
- predict annual demurrage
- estimate frequency of storage tanks reaching max. level
- estimate the impact of shipping operations on LNG production

Ship Berthing at Jetty

These models may ultimately form a basis for testing the impacts of future developments on the ability to meet future supply contracts. This will assist in validating the proposed developments and optimising their implementation.

b. FEED Availability Study

Date: 2006
Customer: North Africa Operator
Savings: Informed process design

A North Africa customer requested an OPTAGON availability study for the FEED phase of their project. The facilities to be modelled included a number of oil and gas production wells, a 'Normally Unmanned' offshore platform, a pipeline to shore and an onshore production facility.

The Hasdrubal offshore production facilities consisted only of free water knock-out, with the remaining produced fluids being transferred to shore via a dedicated pipeline. The onshore facilities were required to produce sales gas and stabilised condensate but also include additional equipment for the extraction, treatment and storage of LPG products.

The purpose of the study was to confirm the production and operational availability of the selected FEED scheme, highlight the main contributors to any overall unavailability and to identify any potential improvements to system availability.

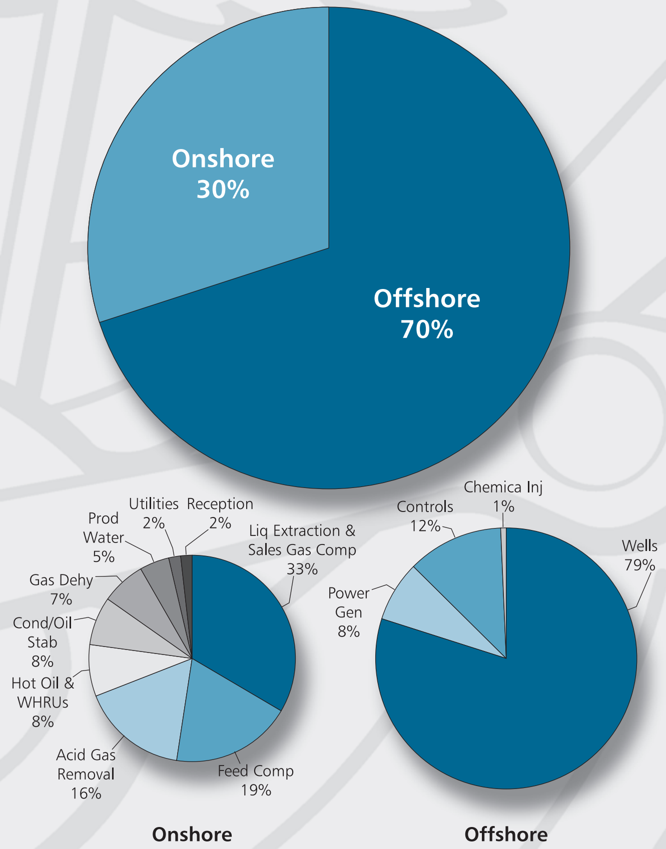
The study provided the design team with the following important results:

- Effect of onshore and offshore failures on production availability
- Major contributors to production unavailability
- Frequency of well shutdowns/re-starts
- Frequency of unplanned offshore visits
- Production dependency on availability of existing onshore facilities
- Pigging frequency
- Production make-up period

The OPTAGON Availability study was an essential component of the FEED Phase Design and it is intended that the model will be further developed and continue to add value to the project through into Detailed Design.

Results from the study allowed informed decisions to be made on the following key issues:

- Process Design
- Equipment sparing
- Product storage capacity optimisation
- Offshore operational philosophy & manning levels
- Well workover & maintenance strategy
- Mobilisation options for offshore repairs



Major contributors to production unavailability

c. Subsea Production Facilities - Availability Study

Date: Ongoing
Customer: North Africa Operator
Savings: Improved production availability

GL have continued to work with a North Africa operator in providing a number of phased OPTAGON Availability Studies to support the development of their onshore and offshore operations.

During Phase 1 of the availability modelling for this development, analysis was performed based on a field comprising six subsea wells with two export options:

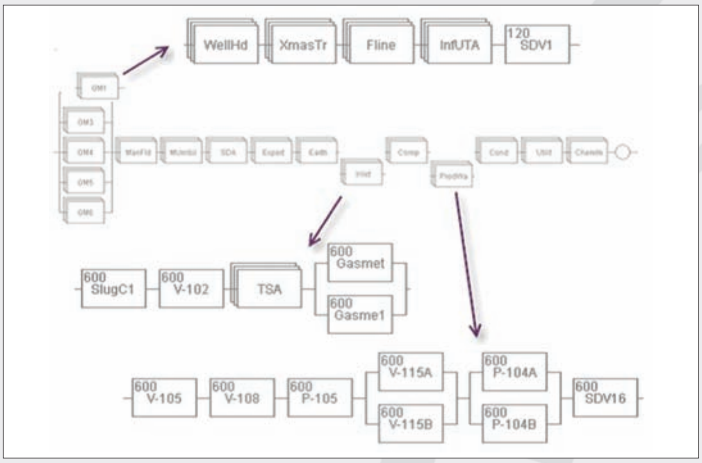
- Tie-back directly to an onshore terminal
- Tie-back to an existing nearby platform where some processing would be carried out before export to shore

Having deemed the tie-back to the existing platform no longer viable, Phase 2 of the availability analysis involved updating the onshore model to reflect various changes in configuration and operation, including production rates, hydrate inhibition strategies and well phasing.

In Phase 3 of the availability study, the analysis was based on either a 3 or 4 well tie-back to an Onshore Terminal, via a six slot manifold and 16" pipeline. Two options were considered for operation of the pipeline:

- low pressure mode (requiring onshore compression)
- high pressure mode (requiring continuous hydrate inhibition)

For each scenario, predictions of the production shortfall and operational unavailability were made, together with a detailed breakdown of the most likely contributors to production shortfall.



OPTAGON representation

In addition, sensitivity cases were carried out to determine the impact on production and operational availability of a number of different export demand (DCQ) profiles, with and without make-up capability (i.e. the plant's ability to over-produce to recover from production losses during a given period) and with both short and long logistical delays (i.e. a subsea intervention vessel on either long term charter or hired from the spot market as and when required).

- Results from the study allowed informed decisions to be made on the following key issues:
- Number of production wells to be drilled
- Optimum well configuration
- Onshore compressor configuration
- Gas sales contractual agreement (i.e. setting optimum DCQ)
- Equipment sparing
- Production make-up period
- Subsea intervention vessel hiring strategy

d. Design Review for a New Gas Processing Plant in Poland

Date: 2007
Customer: EPC Contractor
Savings: Meet design capacity

Issue:

GL have provided services to an EPC contractor on a new gas processing plant located in Poland. The project aim was to undertake a process design review of the acid gas removal, dehydration and mercury removal stages for the new gas processing plant development. Some of the treated gas from the plant was to be sent to a cryogenic plant for nitrogen rejection so the gas processing plant performance was important to ensure removal of carbon dioxide, water and mercury components that would cause operational upsets in cryogenic plant equipment due to blockage and corrosion issues.

Methodology & Results:

The proposed process design was reviewed and compared against accepted industry norms and best practice. This involved process simulation of amine and molecular sieve plants and performance calculations on mercury removal absorbent to verify expected performance. A review of the process documentation was also completed to ensure acceptable design and safe operating practice.

Benefits:

GL were able to identify issues with the proposed design and advised the client of recommendations for modification. These improvements would allow the plant design to achieve its design capacity and minimise the risk of plant operability issues that would adversely impact revenue.

e. Troubleshooting on an Operational Gas Treatment Facility in Egypt

Date: 2007
Customer: Gas Treatment Operator
Savings: Reduced operational downtime

Issue:

GL have provided services to a gas treatment facility positioned upstream of a LNG production plant in Egypt. The project aim was to identify the reasons for operational upsets on the inlet separation, acid gas removal and dehydration stages on the gas pre-treatment plant. The plant consisted of two trains each processing approximately 650 MMscfd of natural gas. The treated gas on the facility is sent to a liquefaction plant for LNG manufacture so the gas pre-treatment plant performance is crucial to avoid blockage of the liquefier resulting in unscheduled downtime and major financial implications.

Methodology & Results:

An assessment of the current operating performance of the plant was completed and process simulations were set up to allow comparison with the original plant design basis. The impact of periodic changes to the operation was also reviewed historically to help identify the root causes of the operational upsets.

Benefits:

GL identified reasons for the operational upsets allowing the implementation of mitigation strategies. Subsequent changes to operational practices and some plant modifications eliminated the operational upsets resulting in improved plant availability and revenue.

f. Study for Impact of Contaminants on Gas Processing for CO_2 Capture from Pre-Combustion Gas Flue Gas Streams

Date: 2008
Customer: GHG Study Group
Savings: Process optimisation

Issue:

GL have provided services to a study group responsible for research into greenhouse gas (GHG) issues. The project aim was to study the impact of contaminants on CO_2 capture from the pre-combustion gas from a coal gasifier and also from the flue gas from coal oxy-combustion. Each plant was envisaged to produce a nominal 750 MW of electrical power.

Methodology & Results:

Acid gas removal processes for CO_2 removal were simulated involving liquid absorption and cryogenic separation technologies. The impact of the contaminants on the CO_2 removal process were assessed and the range of contaminants included H_2S, water, mercury, metal carbonyls, COS, SO_2, NO_2 and CO. The gas processing technologies studied included a range of solid bed absorbents, molecular sieves, activated carbons, water scrubbing and liquid absorption processes.

Benefits:

GL identified the impact of gas contaminants on the CO_2 capture process by determining the gas processing plant requirements and the project economics. This information has allowed the client to assess the feasibility of incorporating contaminant removal onto CO_2 capture schemes on coal gasification and oxy-combustion type plants.

Asset Management Services

Plant Integrity Management Services

Pipeline Integrity Management Services

- **Production Optimisation (Includes RAM and Gas Processing)**

Dynamic and Steady State Simulation

Rotating Equipment Performance & Condition Monitoring including Emissions Reporting

Gas Quality and Interchangeability

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