Asset Management Services

Gas Quality & Interchangeability

Germanischer Lloyd – Service/Product Description

GL OPERATING 24/7

Gas Quality & Interchangeability

Service Title: Asset Management Services

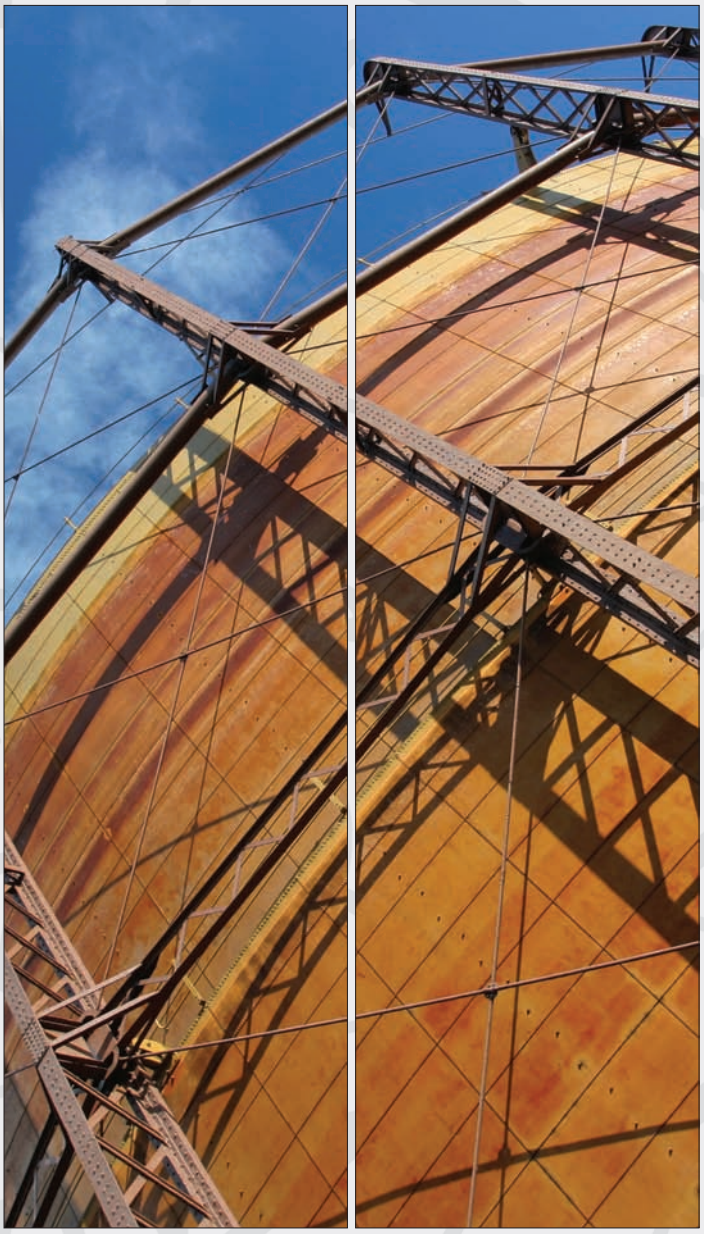
Lead Practice: GL Asset Management (UK)

Contents

Service Description and Values Generated:

International trading of natural gas is increasing through growing LNG shipment and pipeline interconnectors. Offshore operations pipeline integrity and the safety and reliability of downstream gas-fired equipment can be compromised by variations in gas quality.

Germanischer Lloyd (GL) offers a consultancy service which can identify issues of gas quality related to new LNG or interconnector projects, quantifying the zone of influence and the potential impact on downstream users. This includes network integrity, measurement of gas properties, (to meet safety and contractual obligations) energy metering and combustion issues. This service is used by clients to support planning applications, review network operations, recommend, specify and evaluate monitoring instrumentation including Rhinology practices and ensure consistent and accurate energy accounting. Expert witness services for litigation and training courses are provided, explaining the variations in natural gas from different international sources and the impact of these variations.



a. Gas Quality Issues, Prediction and Measurement

How: Critical reviews of engineering and instrumentation designs are performed for gas quality measurement installations. GL recommend equipment, develop specifications and prepare operating, calibration and maintenance procedures.

Input: User requirement specifications are needed to set the limits for gas quality.

Output: Design reviews for gas chromatograph installations.

Develop Standards

GL can demonstrate a comprehensive understanding of Gas Quality issues and their impact on the natural gas industry; both within the UK, across Europe and worldwide as the global gas industry becomes a single integrated market. Our technical expertise is sought at the highest level and we provide technical input and representation to British Standards Institute and International Standards Organisation committees. GL monitors and assesses developments in analytical techniques that are applicable to the gas industry.

Areas of expertise include the following:

- Gas quality management
- Content of natural gas
- Consequences of natural gas variability
- Natural gas quality specification
- Monitoring gas quality
- Calculation of physical properties
- Calorific value / energy and billing
- Analysis of contaminants in natural gas
- Odorisation and Rhinology

GL has a wide diversity of skills available enabling delivery projects to gas companies covering a range of topics from providing Gas Quality training, evaluating the impact of valve flush agents on downstream gas quality to undertaking extensive research studies to identify and evaluate techniques capable of detecting liquid contaminates in gas pipelines. Well-equipped laboratories are used for undertaking routine and forensic investigations of gas and contaminates found in pipelines and associated equipment and include a UK government accredited laboratory for natural gas calibration and testing.

Develop Specifications

Natural gas entering UK natural gas networks currently has to meet the minimum gas quality requirements set out in Schedule 3 of the Gas Safety (Management) Regulations 1996 (GS(M)R). One of the key requirements set out in this schedule refers to the interchangeability of natural gases. Gases that are deemed to be interchangeable can be freely used, commingled, or blended with other natural gases within a network without risk of unsafe combustion. The current methodology within GS(M)R for defining interchangeability (the Dutton Diagram) is based on methods developed by GL (then British Gas R&D) in the 1980s.

With the likelihood that future supplies via Inter-connector, LNG importation and further gas from Norway will all have higher CV and Wobbe Index specifications than current UK gas, there will be a need to challenge the current interchangeability diagram. GL has the expertise and facilities to model and predict the effects of nitrogen ballasting from LNG operations and blending strategies on downstream activities, particularly sensitive industrial processes and older domestic gas appliances.

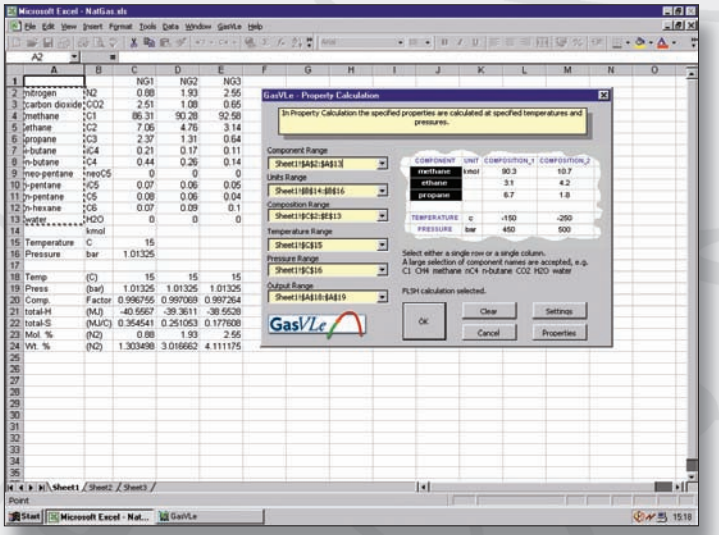
Work Towards European Harmonisation

There are a number of European Working Groups addressing the broader inter-operability issues raised by the European Commission's desire to remove technical and commercial barriers to natural gas trade across national borders. The European Marcogaz working group on Gas Quality, which GL has attended, is currently addressing interchangeability and other gas quality issues. The working group is likely to propose in the long-term movement towards unified national limits based on appliances compliant with the Gas Appliance Directive and suggesting a generic strategy or "route map" for national gas industries to follow in order make the transition. GL is at the centre of this debate and can contribute to the UK strategic position on gas quality issues, as well as provide a European and global perspective.

Continued representation at European working groups is important in order to ensure that realistic and attainable strategies emerge with no disadvantage to the UK. Government and Regulators participate at European level through the European Gas Regulatory ("Madrid") Forum and contribute to the output from the working groups.

Calculate Gas Characteristics

GL developed GasVLe™, a software package for predicting thermophysical properties of natural gas. GasVLe is a powerful software tool that is used to deliver many in-house projects but is also used for several commercial applications including calculation of the UK Gas Safety (Management) Regulation gas properties including hydrocarbon dew point within the Siemens All–in-One instrumentation and within flow computers to provide high accuracy gas property determinations to maximise meter accuracy.



Predict Hydrate Formation

The modelling of hydrates formation conditions is generally well understood within the gas industry. However for complex or uncharacteristic systems GL would as a first step:

- Search the literature for experimental measurements on similar gas compositions and conditions to validate software package models
- Test a range of software packages for hydrate prediction against this data
- In the event of unsatisfactory agreement conduct (or commission) experimental measurements of hydrate formation conditions to allow tuning of a software package for the development
- Model the hydrate formation envelopes for the full field lifetimes using the tuned package

Predictions of the hydrate formation tendency of a fluid composition can be made out using a range of commercial software packages:

- Multiflash
- HWHyd
- CSMHyd
- GasVLe (GL package)
- HYSYS
- ProMax
- Contactor - GL's own in-house code that incorporates hydrate formation kinetics into a pipeline model

Design Hydrate prevention

The resulting hydrate formation envelopes are compared with the predicted pipeline flowing and shut-in conditions throughout the field life. The requirements for gas treatment or hydrate inhibition will then be assessed and the optimum methods identified.

Different methods of inhibition are assessed against the following criteria:

- Feasibility
- Reliability
- Safety and environmental acceptability
- Impact on processing facilities
- Cost

The final stage of a typical study is identification of the means of hydrate plug removal in the event of a failure of hydrate inhibition. This will identify a means of removal of hydrate plugs located at any point of the system. Output will be a hydrate remediation philosophy and recommendations for system design to ensure that hydrate plug removal is safe and rapid.

Test Inhibitors

If necessary conventional hydrate inhibitors, KHI (Kinetic Hydrate Inhibitors) and Anti-Agglomerant Low Dose Hydrate inhibitors can be independently tested in GL's purpose built test cells under the following conditions:

- Up to 90 bar pressure
- Temperature –10°C to 50°C
- 0.5 to 1.5 litres capacity
- Recirculation rates of up to 18 litres of water per hour and 10 normal litres of gas per minute
- Stirrer speeds of up to 1000 rpm
- Continuous pressure and temperature logging
- Torque measurements
- PVM video microscopy of hydrate particles as they form
- Hydrate particle size measurements from 1-1000 microns
- Time-lapse video of hydrate formation

Tests can be run in either constant pressure or constant volume mode.

Hydrocarbon Condensate Prevention

GL has many years experience of issues relating to condensate formation, prevention and measurement. The GasVLe software was initially used to predict phase envelopes. Such predictions are critical when designing, or investigating the failure of pressure let down systems. Where significant volumes of liquid were accidentally allowed into UK interconnector from offshore, GL used GasVLe to predict the volume of dry gas required to flow to absorb and flush out the residual liquid after draining before normal operation could be resumed.

More recently GasVLe has been embedded into a Siemens gas chromatograph data collection system enabling a hydrocarbon dew point to be calculated from the detailed compositional analysis provided by the chromatograph. The Siemen/GasVLe system is now in widespread use on the UK gas transmission system ensuring gas entering the network, and National Grid operated terminals, is contractually and legislatively compliant. GL has developed a method for carrying out a performance evaluation, based on ISO 10723, of each system to demonstrate that it is operating to specification and is capable of determining hydrocarbon dew points and other properties, to within a specified uncertainty.

With the growing gas industry interest in calculated dew points and the obvious benefits over traditional techniques, the European Research Group (GERG) established a project specifically to review this topic, of which GL is the UK representative. The aim of the project is to evaluate the various software packages available to calculate hydrocarbon dewpoint, assess the suitability of commercially available chromatographic instruments and prepare guidelines for their use for acceptance by the gas industry. The final conclusion will be published as an ISO document.

During 2005 GL carried out a critical review of the instrumentation used by SASOL to determine water and hydrocarbon dew points. The review identified improvements to increase the accuracy of the software used to calculate the hydrocarbon dew point along with guidelines for calibration and maintenance of the analytical measuring instrumentation and associated sampling systems.

b. Gas Blending/Ballasting Consultancy

How: Use of SynerGEE® GL network modelling software identifies where gas mixes and how blended gases will transport through pipeline networks. Where blending is needed to meet contractual or safety specifications then the options, and costs, for gas treatment are evaluated.

Input: User/client data on gas compositions and pressure/flows.

Output: Pipeline network models showing the mixing patterns and zones of influence of blended gas mixtures. Recommendations for gas processing options to meet quality specifications and comparative costings.

GL has used a structured methodology to examine the impact of processing an increasingly diverse range of gases to current specifications prior to entering national transmission systems. In overview it can be expressed in the following flow diagram. The subsequent sections describe the proposed methodology in more detail.

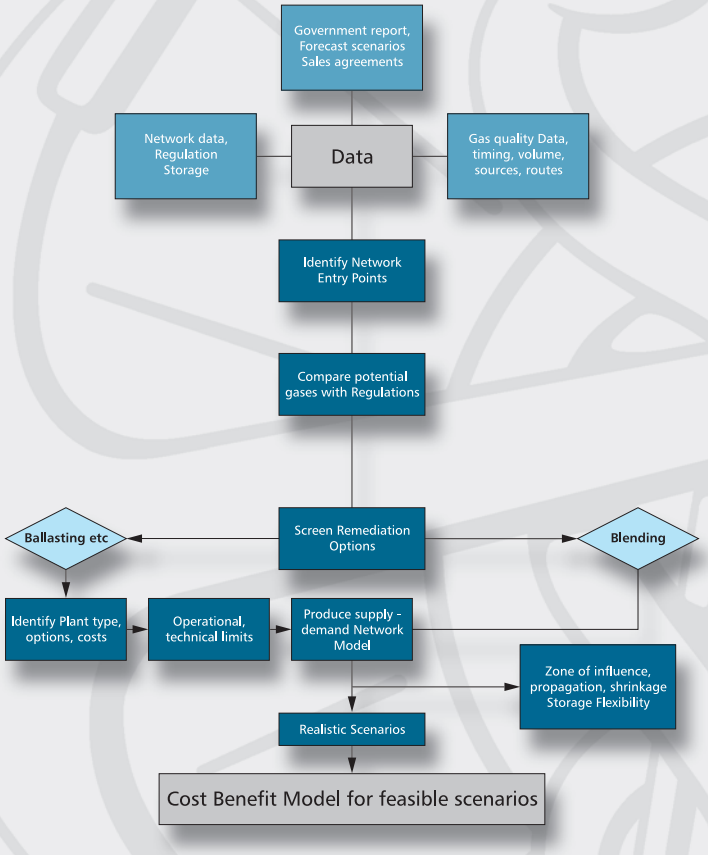


Figure 1: Flow diagram showing GL's proposed methodology

Data Capture

Detailed forecasts of gas demand, indigenous production and imported supply are produced as part of initial studies. Three scenarios corresponding to high, mid and low case forecasts may be assumed at this stage. These inputs are used to represent the boundary conditions to constrain the scope of the study. Early contacts, ranging from questionnaires to face-to-face discussions and site visits, will also be initiated with gas transmission and sub terminal operators to determine the feasibility of installing blending and ballasting facilities. These contacts are used to assess any other gas specification issues that may arise on a terminal by terminal basis.

Network Entry Points

The points of import into the network will be identified based on publicly available information. This will include LNG importation terminals, interconnector pipelines and landed gas from any significant, new gas fields.

Compare Potential Gases with Regulations

The likely range of gas compositions landed at these points will be identified based on publicly available information or when possible sourced directly from the operator. This will take into account any facilities for adjusting the composition of the imported gas that are already proposed at the landing point. The range of gases will be compared against the standard regulatory requirements.

Screen Options For Remediation

The treatment required to the landed gases to meet the requirements of the regulations will be evaluated. This may entail nitrogen ballasting or derichment (by C2+ removal) for rich gases and enrichment (LPG injection) for lean gases. Depending upon the local network facilities, local blending may be possible.

Feasibility of Blending

There may be opportunities to accept gases outside the regulations specification into the network system if there is sufficient gas available in the transmission system for blending to an acceptable quality. There are circumstances where this may be possible provided sufficient blending can be completed prior to supply to consumers.

For the supply scenarios identified, the options for blending will be evaluated and any feasible options identified. Risks associated with adoption of blending options will be identified. These options will be developed through the use of a network model of the transmission system. The network model will allow the composition of gas entering the network system to be tracked to the points of demand and allows the composition to be determined at mixing points within the system. Any reinforcement costs required to facilitate a blending option will be estimated.

Produce Supply/Demand Network Model

National Transmission Systems can be designed and developed utilising GL network modelling tools. These allow the operation of the network to be modelled under different supply and demand scenarios and the impact on system pressures, compressor power requirements, flow patterns, gas blending and gas properties determined. Any operational problems will be highlighted and any shortfalls in available mixing gas will be identified.

Identify Plant Types and Costs

The approximate scale and budgetary cost of the treatment facilities will be determined by performing a high level design of the equipment required to meet the predicted supply/demand model. Outline comments on the sensitivity and risks associated with the treatment plants including feasibility and previous experience of the technology at similar capacities; flexibility of the plants for handling variable feedstocks and plant availability and reliability information. Where capital or operating costs could be reduced by a relaxation in regulations and contractual limits, the implications on consumer safety and network operation will be addressed.

In addition, the availability of a suitable plot area at the import location and impact on extra environmental emissions for the treatment plants will be evaluated.

The study will also assess ramp-up rates to meet peak demand and limitations of blending and ballasting gas to meet peak demand.

Where it is identified that the capital expenditure (CAPEX) and operational expenditure (OPEX) of such facilities can be reduced by the opportunity for local gas blending, an indication of possible savings will be evaluated. The resultant gas quality will be defined together with an assessment of the potential safety implications where blending cannot be achieved due to operational restrictions.

Impact on Storage Facilities

The composition of imported gas and its treatment may also have an impact on gas storage and LNG peak shaving facilities. Specifically this relates to the operation costs incurred at higher levels of inerts and oxygen content. This is a particular issue as compliance with regulations may permit higher inerts and oxygen content than previously accepted by the network entry specification and hence received by the storage facilities.

The issue of gas quality and the possible impact on different types of storage facility (LNG storage, salt cavern storage, depleted oil and gas reservoir storage) will be assessed. This will be done with particular regard to higher levels of nitrogen in feed gases to LNG storage facilities and higher levels of oxygen at underground storage facilities. A high level indication of the problems created on such sites and the budgetary costs of additional treatment equipment required on the sites will be provided.

Develop Realistic Scenarios

Having screened the remediation options, understood sensitivities of regulations to these options, determined viable blending, ballasting and other treatment feasibilities based on all the previous analyses, a set of possible operational scenarios will be developed based on realistic options.

Develop Cost Model

As described graphically in figure 1, the ultimate outputs from the datasets and scenarios described will be input to a flexible spreadsheet-based cost–benefit model, which will allow the overall impact on costs of the various options to be demonstrated.

The model will account for gas quality and throughput variations at the points of import and the opportunity for blending into the network. The costs of treatment facilities and the impact on Calorific Value (CV) in the network system will be calculated by the model. The output from the model will allow the cost-benefit analysis to be made and it will be available for possible future development at a later date.

Risks

There are significant risks associated with implementing new techniques to allow development of imported routes for new gas supply. As part of the methodology of this project, these risks are identified and addressed.

Possible risks are associated with

- Availability and reliability of plant for ballasting or enrichment/derichment
- Threats caused to security of supply through non-availability of blending sources
- Feasibility of employing these techniques at network entry points which may be remote in location
- Matching regulatory gas specification on Wobbe Index (WI) with network entry requirements on CV (and 'unaccounted for' gas)
- Uncertainties in profiles for supply of indigenous gas and new imported sources

GL's methodology described above will allow assessment of risk profiles as an integral part of the project structure. In addition, GL is able to employ in-house tools such as the Optagon™ availability modelling software to determine likely reliability and capacity constraints for new processing plant.

c. Interchangeability Consultancy

How: Use of interchangeability diagrams (Wobbe vs Non-Methane %) indicate how combustion within gas-fired equipment is likely to be affected by gas quality variations. Parameters can be calculated using GasVLe. Options to manage interchangeability are to adjust equipment (eg. air/fuel ratio) or to process gas at pipeline network entry points by blending (with pipeline gas) or ballasting (with inert gas - typically Nitrogen) to obtain acceptable gas quality.

Input: Client provides gas quality composition data and pipeline network detail.

Output: Reports detailing the potential impact on gas quality of new LNG importation or pipeline interconnector. Impact is assessed as impact on pipeline integrity and downstream plant reliability/safety.

Clients require evidence to support action not to accept gas outside of the existing range or conversely to support extension of the allowable range. Rather than refuse gas, the client may be able to blend or process the gas to meet the existing specification. Volumes and costs can be estimated.

The methodology is to gather data from a variety of sources regarding the latest international views on gas interchangeability and gas quality specifications. With the growth in natural gas trading via pipeline interconnectors and LNG shipping, there is a current willingness to harmonise worldwide understanding of gas interchangeability through common definitions, specifications and contract conditions.

As markets for natural gas have opened up, there are lead regions which have developed, or are developing, entry requirements to facilitate trading. These regions include Europe, N.America and Far East where LNG trade is increasing.

Workshop & Scoping Document

Typically, the first activity within a project will be to hold a workshop to present the background to the gas interchangeability issues and to gain feedback from potential users on the required content and format of the consultancy work. Terms of Reference previously suggested by the client may be used to facilitate the workshop and to gain agreement on how the content can be tailored to meet the needs of a variety of Operations and Marketing personnel with different levels of technical and commercial knowledge of pipeline operations or LNG trading.

The output from the Workshop will be a Scoping Document for the project detailing the contents for the consultancy and a schedule of activities to meet the deadlines.

Issues Overview & Combustion Parameters

An introduction can be provided to the subject and a review of the historical R&D completed to get to the current position on gas interchangeability and gas quality specifications. This will highlight the differences between UK, European and US definitions of the interchangeability parameters.

The impact of changes in gas quality on different domestic, commercial and industrial gas-fired plant will be explained, highlighting the issues of equipment performance in terms of safety, emissions and efficiency. The sensitivity of certain industrial processes to changes in gas quality will be stressed (eg. Glass manufacture) and a discussion given on gas turbines, where rate of change of gas quality is important.

International Standards & Country Regulations

We can provide a review comparing the International Standards relating to Gas Interchangeability and Gas Quality. An indication can be given of which countries worldwide are using common International Standards.

This would include the specifications for entry points into different countries and regions, detailing local regulations and legislation which must be met.

Output

Report detailing the technical and commercial issues relating to the introduction of a new gas supply into an existing network.

Future Markets & Deregulation

An assessment of the historical, growing and future markets for LNG can be given to indicate where the opportunities for sales exist and whether gas quality specifications already exist or need to be developed.

Mature natural gas markets such as Europe are changing as security of supply becomes an issue and the need for sourcing LNG from different countries increases. Gas market liberalisation will be discussed as a driver for the move toward greater trading of natural gas across international borders.

Harmonisation of definitions, reference conditions and other limiting parameters for gas interchangeability is occurring with review work in Europe coordinated by CEN and in the US coordinated by AGA. GL is represented on these standards bodies and has also supported gas quality specification developments in UAE, Japan, China and Korea.

LNG Production & Supply

A short discussion on LNG production and supply facilities can be given.

Based on work previously completed for UK BERR, GL can provide details of the range of gas qualities to be found in LNG produced in different countries. Some background can be given on the history and growth of LNG trading and an assessment of how the trade routes may change in future as new large players such as China and India develop further.

Impacts on Upstream/Downstream

The impact of the growing international demand for LNG can be discussed from both the upstream angle, where flexibility of processing options is important to ensure security of supply, and the downstream angle, where the safety and efficiency of equipment are key to end-users.

Cargo Weathering

The loss of boil-off gas during shipment can be explained and quantified, as can the issues of consistent energy accounting during custody transfer between ship and shore storage.

Options to Manage Production, Terminal, Users

The options to gain gas supplies which meet appropriate gas quality specifications and interchangeability limits can be assessed from the three alternatives:

- At the production/liquefaction plant where gas liquids can be extracted and marketed at source as LPG
- At the importation terminal where gas CV and WI can be altered through NGL extraction or addition. Nitrogen or air ballasting to certain limits or gas blending with main transmission gas will be considered
- At the end-user point where combustion equipment can be controlled or may require conversion
- Indication of the comparitive costs and benefits between upstream gas processing options and downstream equipment conversion programmes

Development of Strategy, Final Report & Presentation

The methodology foreseen as an output from such consultancy is a decision tree for the end-user highlighting the factors which need to be considered to support the decision to approve new LNG importation and market natural gas in the local region.

d. Interchangeability Testing

Test Programme and Measurements

Generally, the client will be seeking appliance failure data either to support or object to the broadening of a regulatory or contractual gas quality specification. The ability of an appliance to burn a specific gas or blend of gases safely can only be determined by physical testing.

For the appliance performance studies, the appliances are operated at minimum, medium and maximum heat output settings according to appliance design.

Test Gas Mixtures and Supply

To assist in the optimum delivery of the test data, a combination of test gases from GL's blender and high-pressure gas cylinders can be proposed. Previous experience with specific, bespoke test gases has shown that for a limited number of tests, cylinders can be both cost and time efficient. However, with a larger number of appliances to test a parallel operation, it is usually more appropriate to set-up the gas supply from GL's purpose-built blender.

Gas Mixture Quality and Calculated Gas Properties

The gas quality of the test gas from the blender is monitored using a process gas chromatograph. If required it can be analysed by means of a UKAS accredited gas chromatograph. The molecular composition data produced can be analysed to derive:

- Wobbe Index (WI)
- Calorific Value (CV)
- Incomplete Combustion Factor (ICF)
- Sooting Index (SI)
- Relative Density (RD)
- Theoretical air requirement

Gases from high-pressure gas cylinders are supplied with a calibration certificate and the data can be used to calculate the gas properties listed above.

Visual Record of Combustion Performance

Where feasible and practical, a visual record of the flame can be recorded to provide details of the "flame picture". Any anomalies such as flame lift, light back, flame impingement, soot formation are noted.

Measurements and Calculations

The proposed test design allows sufficient time for the appliances to stabilise prior to recording test results. This includes the time taken for the emissions to reach steady state and the surface temperatures to equilibrate.

Once a steady operating condition has been established, the following measurements are made:

- Flue gas composition
  - carbon monoxide emission levels (ppm)
  - carbon dioxide emission levels (%)
  - soot and particulate matter (relative grey scale using a smoke pump assembly)
  - nitric oxide (NO) and NOx emission levels (ppm)
- Surface temperature of the appliance
  - a range of measurements covering the main sides/faces of the appliance
- Flue gas temperature

From these measurements it will be possible to calculate:

- thermal efficiency of the appliance
- combustion performance ratio (CO/CO2)
- nitrogen dioxide (NO2) emissions
- heat output

In addition, real flue emissions data can be manipulated to derive emissions to specific reference conditions, eg. dry, air free for CO.

Test Results

A spreadsheet is produced of the gas quality and properties, and the information presented on Dutton-like interchangeability diagrams in accordance with information quoted in regulations.

The test results from each individual appliance and fuel gas type are logged on engineer test sheets. These data are combined on a spreadsheet and correlations established to highlight:

- the variation in emissions with Wobbe Index
- the variation in emissions with Nitrogen content (on the assumption that these tests are undertaken)
- the variation in appliance efficiency with Wobbe Index

In addition, the correlation of appliance performance with heat output can be established and referenced to the (line gas) baseline tests to determine tentative/preliminary conclusions relating the overall change to "mass emission" when operating on fuel gas with gas quality substantially different from normal line gas. These data especially focus on carbon dioxide but in addition referencing emission to "energy used" can be considered (eg. NOx in mg/kWh and designation of appliances within specific NOx classes).

e. Expert Witness

How: Initial discussions with client to understand the issues being addressed. Written testimony to court hearings followed by court appearance and witness oral testimony. Potential challenge to and from other technical experts appearing for other parties in litigation. Important to stay with facts and known technical domain - credibility can be lost by giving personal opinion outside of recognised technical expertise.

Input: Client (or their legal representatives) briefings on gas quality issues. Other parties testimonies.

Output: Written and oral testimony.

f. Gas Quality Training Courses

How: Provided either at GL office or in clients' premises. Gas Quality Course material issued covering description of gas quality, gas composition, measurement, regulations and the impact on end users. Further information prepared to clients' specific requirements.

Inputs: Clients' scope for training. Refresher, management or specialist gas quality training.

Output: Course material and presentation to client.

a. LNG Contracts & Energy Accounting

Date: 2007
Customer: Major International Oil and Gas Company
Savings: Consistent energy accounting for LNG loading /unloading operations

---

Issue:

A major oil and gas client had concerns regarding the energy accounting of LNG ship cargo loading and unloading in its international operations. With many different contracts quoting different energy conversion standards there was concern that even small differences in energy accounting calculations could lead to large financial losses.

Methodology & Results:

Some 20 LNG gas sales and purchase agreements were analysed for the client in order to compare the standards and reference conditions being used in the various contracts. GL's GasVLe software was used to quantify the cost risk to the client in the potential misinterpretation of reference conditions in the calculation of energy flow.

Savings:

The outcome was the identification of a wide range of different energy accounting standards being used and the comparable costs which this might incur at LNG loading and unloading sites. The client was recommended to identify a suitable standard for future gas sales and purchase agreements to ensure consistent and loss-free accounting.

b. Gas Quality & Interchangeability Guidebook

Date: 2008
Customer: Major International Oil and Gas Company
Savings: Company staff time understanding the issues of trading LNG

Issue:

A comprehensive guidebook on Gas Quality & Interchangeability has been produced for a major international oil and gas company. This was needed to ensure that the company personnel understood the issues (upstream and downstream) of trading LNG internationally.

Methodology & Results:

Working closely with the client, the contents were agreed to include an overview of the issues of international gas trading (particularly LNG), detailed descriptions of combustion parameters, international standards, future markets, LNG production & supply, LNG weathering and the impact on downstream use.

Savings:

The guide gives options to manage interchangeability and completes with the development of a strategy for use by traders, marketers and operations personnel looking to open up new opportunities for LNG trade. The key savings from the project will be the savings in company time understanding the issues of trading LNG worldwide from production, shipping and importation operations.

c. UK Government Gas Quality Programme

Date: 2005
Customer: BERR UK Government
Savings: Informed decision to maintain current gas quality specifications

Issue:

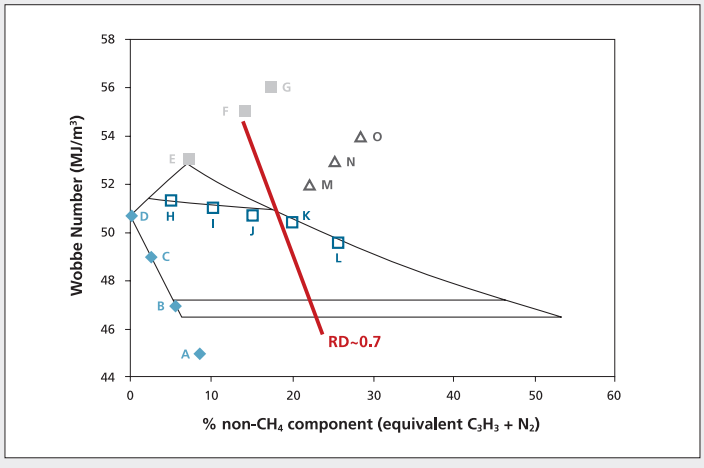
As the UK was approaching the point of being a net gas import, UK Government commissioned a programme of work to determine the extent of any problems which may arise as a result of changes in the quality and quantity of imported natural gas.

Methodology & Results:

Project 1. Options for blending and ballasting of imported natural gas

GL assessed the range of alternative measures for blending or treating imported gas streams such that they comply with a number of possible future gas quality specifications. The purpose of this study was to establish the viability of such treatment, quantify the costs of treating future gas supplies to conform to a number of possible Wobbe Index specifications and to assess the potential impact of changes to other gas quality parameters.

Costs of blending, ballasting or otherwise processing future gas supplies to meet the gas quality specifications were separately calculated for each supply and demand scenario, using a purpose-built economic model.



Project 2. Study on appliance performance with variation in gas quality

GL undertook studies and test work to investigate the impact of natural gas quality variation on appliance operation. The study initially involved the determination and sourcing examples of the most populous appliances in the overall UK appliance populations for appliance types of boiler, fire, cooker and water heater. Data was gathered on emissions of carbon monoxide, NOx and soot, and together with temperature measurements of the flue gases and appliance surfaces provided an indication of the variation in appliance efficiency with changes in gas quality. The study highlighted several issues relating to the operation of the appliances. The output of the study also provided potential remedial action necessary to maintain good appliance overall operation if the gas quality of the supplied gas alters.

Savings:

The results and conclusions of these two projects enabled the BERR to quantify the impact on the UK of varying gas import scenarios and shaped the UK Government decision to maintain the existing Gas Quality specifications for the foreseeable future, (Gas processing costed at £0.5billion vs equipment conversion at £2-14billion).

d. FERC Expert Witness

Date: 2006
Customer: LNG Coalition (BP, Shell, ConocoPhillips, ExxonMobil, Chevron)
Savings: Minimal gas processing requirements for gas entry to Florida/US

Issue:

As part of the planning consent for new LNG importation terminals in the US, there are occasionally objections raised by gas suppliers and end-users. These objections centre on the safety of the consumer and the integrity of gas distribution networks when vapourised LNG is mixed with normal pipeline gas. In particular, rapid changes in gas quality can potentially affect downstream gas-fired equipment such as gas turbines for power generation or furnaces for glass manufacture. Expert witness support was provided in the US to an LNG Coalition (BP, Shell, ConocoPhillips, ExxonMobil, Chevron) who were applying for LNG importation permits in the State of Florida.

Methodology & Results:

The work involved analysis of the gas-fired equipment likely to be affected by the LNG importation in Florida and presentation of results to a FERC (Federal Energy Regulatory Commission) court hearing in Washington, US. Expert witness written testimony was first given to the court, following by verbal testimony and challenge by a number of third party attorneys.

Savings:

The outcome was a small adjustment to the proposed gas tariff/gas quality specification which the US LNG Coalition was happy to accept. The impact was a minimal requirement for gas processing of imported LNG prior to vaporisation and entry into US gas transmission networks.

e. Singapore Natural Gas Conversion Masterplan

Date: 2003
Customer: PowerGas and City Gas, Singapore
Savings: Informed decision to defer an £80 million expenditure

---

Issue:

PowerGas (the gas transmission and distribution company of Singapore) was considering converting its 500,000 customers from existing gas to a natural gas supply through a new pipeline from Indonesia. In order to assess the technical and commercial feasibility of the project, PowerGas selected GL (over 7 other international bidders) to produce a conversion Masterplan for presentation of this high profile project to the Government of Singapore.

Methodology & Results:

GL based a multi-disciplined team in PowerGas' Singapore office, delivering:

- Marketing study based on sampling of all current gas appliances, with assessments of the existing network load and growth potential
- The building of an integrated SynerGEE model of the transmission and distribution gas network in Singapore from PowerGas' SmallWorld GIS record system and the allocation of demands to this network using customer billing data from CityGas (the supplier)
- The development of a sector-by-sector plan by experienced network analysts to enable the conversion from towns gas to be carried out effectively, maintaining supplies to the existing towns gas customers whilst providing sustainable supplies to the new natural gas customers
- Production of a conversion programme and detailed costing
- Design of the gas tariff structure and cost recovery mechanism
- Recommendation of appropriate metering and regulator designs
- Production of a marketing plan for future public awareness campaigns
- Appliance testing of typical Singapore equipment to ensure safe operation
- Production of work packages for the upgrade of the network

Savings:

Based on the comprehensive study performed by GL and the detailed cost modelling and tariff recovery mechanism, PowerGas was able to make an informed decision to defer some £80 million expenditure, as the economic viability of the project was questionable due to increasing gas supply prices.

f. Peak Shaver LNG Enhancement Project

Date: 2005
Customer: National Grid
Savings: Best value tender specification for metering refurbishment

Issue:

All peak shaving LNG plants were required to upgrade site metering and gas quality monitoring systems to be compliant with the Network Entry Agreements that were put in place following the sale of distribution networks.

GL was requested to undertake audits at each site to determine the suitability of current assets and recommend upgrades or replacement as appropriate.

Methodology & Results:

Audits were undertaken at each LNG facility to assess the existing metering, calculate the meter uncertainty and compare against fiscal standards / industry best practice. Gas quality monitoring systems, if present were assessed against the requirements of GS(M)R appropriate for each site. Based on the findings for each site and a cost benefit analysis, recommendations were presented for the retention of existing equipment, upgrade, or new instrumentation as necessary.

The recommendations were presented as a comprehensive report that was then included in the National Grid Gas Measurement Enhancement Tender Specification. GL supported the tender process by attending presentations to, and attending site visits with potential suppliers to clarify technical issues. During the tender review process GL experts reviewed and commented on tender submissions to ensure they were consistent with the technical specification.

Savings:

GL added value to the process in two areas:

1. GL's technical expertise and market knowledge ensured that the chosen solution for each site was the most economic, technically appropriate option.

2. Through participation in the tendering process, GL helped to ensure that all tenderers fully understood the requirements and the successful tenderer provided a technically robust proposal.

g. Technical Evaluation of On-Line Moisture Detection Equipment

Date: 2007
Customer: International Oil and Gas Producer
Savings: Raised client's knowledge to that of informed buyer

Issue:

A major international gas and oil producer with operations in the UK, Trinidad, Russia, Egypt and Tunisia sought recommendations for "fit for purpose" on-line moisture measurement equipment to meet the specific requirements of each asset.

Methodology & Results:

Identified the specific requirements for on-line moisture measurement for each asset based on information gathered from each asset. Carried out a review of the types of measurement technique available, identifying the advantages and limitations of each. Recommended options of on-line moisture analysers commercially available, together with estimated CAPEX and OPEX, with particular consideration of the relevance and suitability for each asset.

Savings:

This project provided the customer with a comprehensive review of instruments commercially available and specific recommendations for the most appropriate instrument for installation at each asset.

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**

Germanischer Lloyd Industrial Services GmbH

Oil and Gas
Steinhöft 9
20459 Hamburg, Germany
Phone +49 40 36149-7700
Fax +49 40 36149-1781
glis@gl-group.com

www.gl-group.com/glis

Germanischer Lloyd does not warrant or assume any kind of liability for the up-to-date nature, accuracy, completeness or quality of the information provided. Liability claims against Germanischer Lloyd arising out of or in connection with material or non-material loss or damage caused by the use or non-use of information provided, including the use of incorrect or incomplete information, are excluded unless such loss or damage is caused by the proven wilful misconduct or grossly negligent conduct of Germanischer Lloyd.
All offers are subject to alteration and are non-binding. Germanischer Lloyd expressly reserves the right without notice to change, supplement or delete parts of the pages or the entire offer or to stop the publication temporarily or definitively.

Issue no.001 15.05.2008