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Construction of Petrochemical, Oil & Gas Processing Plants

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ABREVIATIONS

LNG	Liquefied Natural Gas
UVCE	Unconfined Vapour Cloud Explosion
BLEVE	Boiling Liquid Expanding Vapour Explosion
PML	Possible/Probable Maximum Loss
FCCU	Fluid Catalytic Cracking Unit
NOC	National Oil Companies
IOC	International Oil Companies
OECD	Organisation for Economic Co-Operation & Development
GTL	Gas to Liquid
CTL	Coal to Liquid
EPC	Energy Performance Contract
VCE	Vapour Cloud Explosion

DEFINITIONS

For the purpose of this paper the term "Oil & Gas" refers to all projects within the Oil, Gas and Petrochemical areas.

1 INTRODUCTION / PURPOSE OF PAPER

Introduction

In the past five decades tremendous developments have taken place in the Oil & Gas sector resulting in increasingly complex construction projects being undertaken. These projects present Insurers with many new challenges from both a size and technology perspective.

Goal and Scope of Paper

The goal of this paper is to provide the reader with an understanding of Oil & Gas Plant construction, to raise awareness of the wide variety of perils that onshore Oil & Gas Plants are exposed to during construction, Oil & Gas projects are by no means unique from other technical sectors but they nevertheless do display distinct exposures in the following areas;

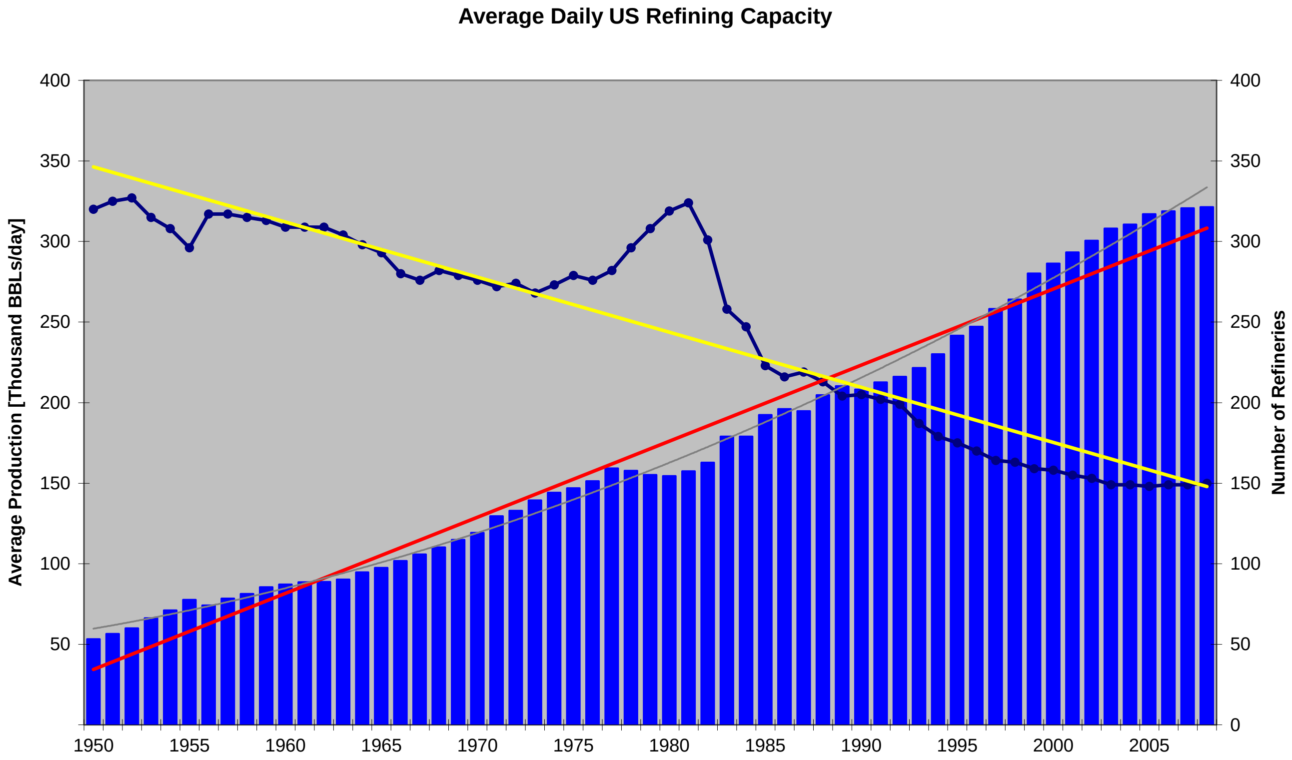
the inherent technical exposures associated with the processes,
the dynamics of a construction site,
the contractual relationships between the many stakeholders,
the environmental forces that may affect the project
the human factors that will influence the site

This paper attempts to provide the reader with a better appreciation and to enable professional risk analysis of these exposures.

History of Oil & Gas Plant Construction

The first large scale production Oil refineries were constructed some 150 years ago with outputs of just a few thousand Barrels Per Day (BPD).Outputs steadily grew to around 50,000 BPD by the 1950s , this looks small in comparison to current maximum output of around 950,000 BPD.

Whilst the diagram below only illustrates the growth in refining capacity, similar growth has been evident across all aspects of the Oil and Gas sector.



Economic Aspects

Due to an increasing demand for processed hydrocarbons, as the building blocks to economic development, the economic and industrial development of many nations has resulted in a substantial investment by national oil companies (NOC's) and international oil companies (IOC's) in the construction of new process plants . This demand has led to innovative solutions being pursued which have resulted in new processes and technologies being employed. The evolution of these new processes provides continuing challenges for Insurers.

2. DESCRIPTION OF BASIC PROCESSES

Introduction

The major components of the oil, gas and petrochemical industry can be summarised as:

- Oil refining
- Gas separation/liquefaction
- Petrochemical production.

The terms 'upstream and downstream' are commonly used within the industry. 'Upstream' is normally defined as exploration and development, whereas 'Downstream' is normally defined as the processing (refining) through to production of the final commodity.

Upstream areas include both the below ground drilling and well completion to the well head and the transportation from the well head to the refinery or separation plant. The well head 'Christmas tree' is the control system consisting of various valves and blowout preventers attached to the top of each oil or gas well.

Downstream areas generally commence at the refinery or separation plant until the production of the final product.

The processes involved in the oil, gas and petrochemical industry generally either involve separation, reaction or both. Examples of some processes are:

• Gas plant	Separation only
• Basic refinery (*e.g.* hydroskimming)	Separation only
• Sophisticated refinery (*e.g.* hydrocracker, fluid catalytic cracker)	Separation followed by reaction
• Petrochemical plant (*e.g.* ethylene, polyethylene)	Reaction followed by separation
• Liquefied natural gas/ liquefied petroleum gas	Separation followed by liquefaction.

Major Feedstocks

The feedstock for a refinery or gas separation plant is crude oil or crude gas respectively. These first stage processes either produce finished products themselves or 'intermediate' products which become the feedstocks for other subsequent processes. Subsequent processes may include further breakdown of heavy molecules to lighter ones as in a hydrocracker unit or the production of petrochemicals.

Preparation of Feedstocks

Depending upon the process being utilised, the product required and/or environmental needs, the feedstock may need to be cleaned. Cleaning is normally required so that the conversion / separation is at its most efficient; the associated impurities do not effect the reaction or 'poison' any of the catalysts or damage other machinery and/or allow pollutants into the atmosphere.

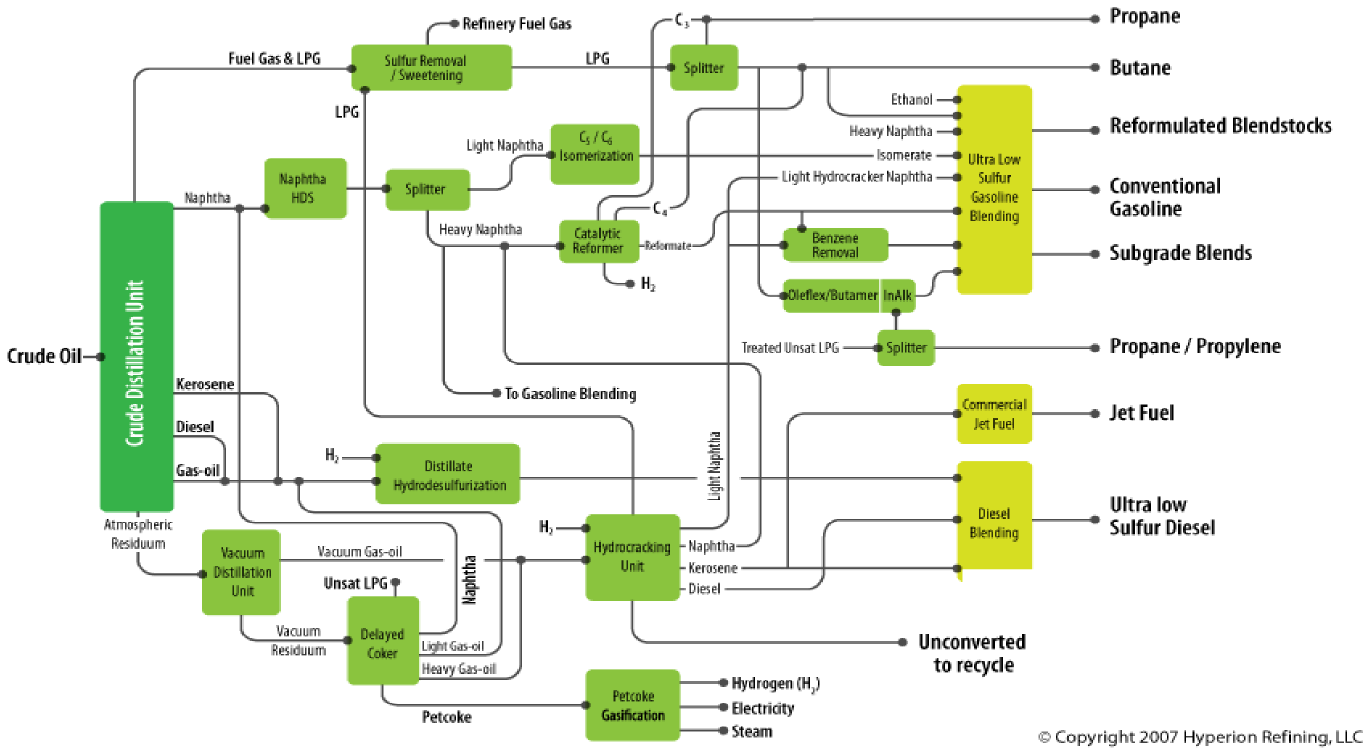
Cleaning of a feedstock may take many different forms from simple removal or separation (by weight or boiling point) to passing the feedstock through sieves (molecular or mechanical) to chemical reactions.

The purity of the feedstock required will normally depend upon the product to be produced, the reaction to be undertaken, the equipment involved in the process, environmental controls

/ limitations or economic considerations. The result of feedstock impurities passing through the processes can result in damage to subsequent machinery by erosion, corrosion, increase in wear and tear and/or poisoning, reduction of conversion rates, product impurity having an affecting on the sale price or an increase in costs of product manufacture.

Principal Processes

The majority of the processes involved in the oil, gas and petrochemical industry concern either the separation of hydrocarbon mixtures into their constituent parts, or the reaction of hydrocarbons to produce further, generally more valuable, products.



Distillation

Distillation units simply separate a mixture by heating up the liquid in a vertical column, which may exceed 45m in height. The column consists of multiple stages or trays characteristically being between 20 and 40 in number.

The constituent parts separate out at different levels throughout the column due to their different boiling points. The most common types of distillation column trays are sieves or bubble caps. Sieve trays are simply perforated plates with small holes of about 5-6mm in diameter. Bubble cap trays have an upturned cup (or cap) over each hole in the tray, which lifts whenever the pressure below exceeds the downward force of the cap. The vapour therefore bubbles up through the liquid held on the tray. The products are taken off at differing levels within the column. Heavier products fall to the bottom of the column while lighter ones move towards the top. The products are then cooled or condensed and either form a final product or become intermediates for further processing.

From a feedstock of crude oil the products produced from simple distillation are, from the top of the column downwards – butanes and lighter hydrocarbons, gasoline/petrol, naphtha, kerosene, light gas oil, heavy gas oil and residue. Distillation forms an important part of the refinery and many petrochemical processes.

Cracking

In general terms in the oil industry the larger the hydrocarbon molecule the less valuable it is. Although distillation was the first process in a refinery, the refiners soon found ways to generate smaller hydrocarbon molecules by breaking down the larger, less useful ones. Cracking is therefore the most common term used in the oil industry for breaking down larger molecules into smaller molecules. This term, however, can have a slightly different meaning in the petrochemical industry where more commonly the term relates to the breaking down of a molecule.

There are various types of cracking methods including straight heating to more than 500°C (thermal cracking) and heating in the presence of catalyst (catalytic cracking/fluid catalytic cracking). Cracking may be carried out at high or low pressures depending upon the specific process or feedstock being used.

The cracking of these larger hydrocarbon molecules means that there are not enough hydrogen atoms to go around, therefore rather than just producing hydrocarbons a by-product of cracking heavy oils/residues is pure carbon in the form of coke. This coke is removed from the process stream via the Coker unit.

As mentioned above, a result of traditional cracking methods was that there were not enough hydrogen atoms once the larger molecules had broken down. Hydrocracking was therefore introduced to obtain lighter hydrocarbons from heavier ends. This process involves the cracking reaction occurring in the presence of additional hydrogen and a fixed bed (as against fluidised bed) catalyst.

The cracking process is likely to place in more than reactor. Cracking, especially thermal cracking is used in various processes within the petrochemical industry. One major example is the production of ethylene, in the course of which ethane is pumped through tubes with diameters of four to six inches and heated to more than 800°C. Ethylene is the product of the cracking process.

Alkylation

One result for refiners of the various cracking methods mentioned above was that too many lighter hydrocarbons were produced. The alkylation process was therefore invented and this recombined lighter hydrocarbons into heavy hydrocarbons. In simple terms this process involves the conversion of a mixture of lighter hydrocarbons such as olefins and propane/butane to alkylate. Alkylate is produced by first cooling the feed, mixing this with isobutene and a catalyst (normally sulphuric acid). Once the reaction has occurred the acid is removed. The hydrocarbons are then passed through a caustic soda vessel to remove any remaining acid before being fed into distillation columns to separate the alkylate from saturated gas.

Reforming

Reforming processes cause chemical changes to occur to the feedstock generally by applying significant heat in the presence of a catalyst.

In a refinery, a major reforming process will be at the catalytic reformer where a naptha stream is passed through multiple reactors, which have a catalyst of alumina, silica and

platinum. The reactors operate at between 200 and 500 pounds per square inch (psi) and at between 480 and 525°C. The chemical composition of the feed changes as it passes through the reformer.
In the petrochemical industry one of the major reforming processes is the production of synthesis gas for the production of methanol or ammonia. The two most well used processes involve either the reaction of methane with steam (steam reforming) or by partial oxidation of methane. Both processes utilise high temperatures and pressures and therefore require substantial equipment similar to a cracking furnace.

Catalysts

Catalysts play a very important part in the oil, gas and petrochemical industries. Catalysts can vary greatly in composition, value, durability, ability to be 'poisoned', useful lifetime, brittleness and ability to be regenerated. Many catalysts are made from metals (including precious metals such as platinum). They are generally specially made for specific processes and are protected by patents.

Process Units

Large refineries or petrochemical plants consist of a multitude of pieces of machinery and equipment. Generally, the machinery and equipment is aligned in such a way that certain areas on the site are allocated to a particular type of process. The combination of the various pieces of machinery and equipment required to complete a certain process is known as a 'process unit'. Examples of process units include distillation units, crude units, Coker units, ethylene units and alkylation units. These 'process units' are made up of static and rotating pieces of machinery of varying complexity and size. These machines operate under varying conditions (temperatures, pressures and loads) depending upon the job required of them.

In general terms and as can be seen from the descriptions above, oil refineries or petrochemical plants take a feedstock and either break it down or build it up to produce useful products to sell. The art of a refinery or petrochemical plant owner is to produce a greater amount of the more valuable product and either minimise, or find ways to use, the less useful products/by-products.

Polymers and Monomers

One of the most important groups of products emulating from the petrochemical industry are polymers. Polymers are large molecules formed by the joining in a repetitive pattern one or more types of smaller molecules known as monomers. The monomers can either be attached in a linear chain (linear) or in branches (branched). Different qualities accrue to the polymer if the monomer is attached in either a linear or branches fashion. The number of repeat monomers is called the degree of polymerisation. Most useful polymers have molecule weights between 10,000 and 1,000,000.

Some common examples of polymers and monomers are:

Polymers	Monomers
Polyethylene	Ethylene
Polystyrene	Styrene
Polyvinyl chloride	Vinyl chloride

Generally, manufacturing methods for the polymer entail flammable fluids being reacted in large vessels at significant temperatures and pressures. The final product (the polymer) is generally produced as a solid before being further processed to make the final product.

Products from polymers are an important part of everyday life and therefore the methods for making them and the associated risks need to be understood.

The main methods for making plastics are:

- Separation followed by liquefaction moulding (compression, injection, blow and rotational)
- Extrusion (normally via a reciprocating-screw extruder)
- Blowing film and tubing
- Calendaring
- Casting.

Basically, the polymer is heated and/or compressed and/or injected into various types of machine. The polymer liquefies due to the temperature and/or pressure and is forced to take the shape of the mould, nozzle or rollers, etc. Therefore, other than the normal exposures to machinery which often work in corrosive environments (corrosion, natural wear and tear, etc.) the main exposure to this type of process is machine failure either from its own fault or where the power supply to that machine fails. If for instance the power supply to an extruder fails, the liquid polymer cools and solidifies within the machine leaving a nasty mess to be cleaned up. It has been said that the results of this type of loss are not dissimilar to a pot freeze in an aluminium or steel plant. However, generally, the machinery values associated with polymer production are lower.

Utilities

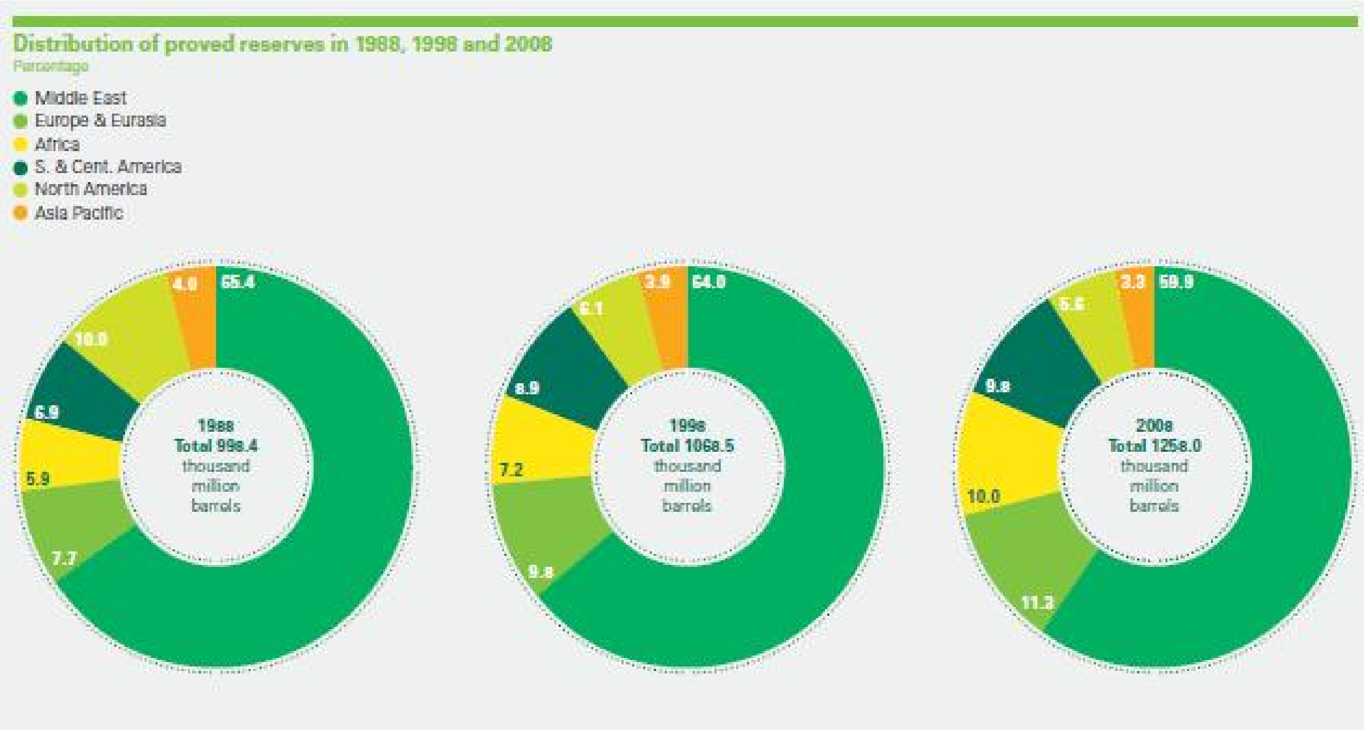
Each process unit requires various utilities (*e.g.* water, steam, electricity and air) and therefore most oil, gas and petrochemical plants have large utility sections within the site boundaries. These include gas turbines, steam turbines, transformers and boilers

3. DEVELOPMENT OF OIL & GAS SECTOR

Market Drivers

Whilst economic forecasts made in recent years, which predicted consistent growth, have been contradicted by the recent global financial crisis, the long term trend remains positive and a consistent annual increase in world primary energy demand is expected to 2030.

It is therefore expected that global Oil demand will consequently grow by 1% per year from 85 MMbpd today to 105 MMbpd in 2030 with the majority of growth coming from non-OECD countries.



In addition global Gas demand is forecasted to increase by 1.5% per year (80% of the growth by 2030 will be in non-OECD countries with the biggest rise in the Middle East area).

The Oil, Gas & Petrochemical industries will face the following trends & challenges:

- Rising domestic consumption of Oil, Gas (LNG for power generation) and refined products (transport) of non-OECD countries and Oil & Gas exporters
- Increasing involvement and influence of National Oil Companies (NOCs)
- Shift of new production sites (and associated constructions and facility upgrades) to the Middle East and Asia
- Slow response time to sharp variations of demand as investment cycles are 4+ years
- Increasing public and government pressures to reduce greenhouse gas emissions (Coal fired plants but also Polyolefins producers, Oil Sands…)

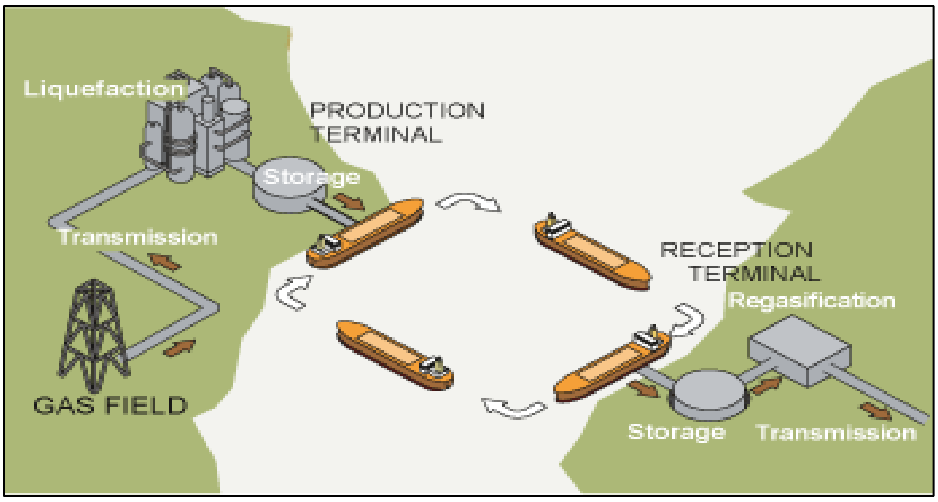
Product Demands – Medium and Long Term Outlook

Refined products
The refining industry has been a low margin business for several decades and this low return on equity is likely to persist, resulting in an increasing shift from IOCs to NOCs
In addition to the change in ownership the geographical location has also evidenced a shift, with a developing trend over the period 1998 – 2008 of North America and Europe/Russia seeing their share of the total refinery capacity reduced. During the same period, the Asia Pacific capacity has increased to represent in 2008 a total combined of 37% of the worldwide refining capacity.

There is also likely to be an increase in refining heavy and sour crude which represents 50% of the worldwide oil production, with refineries across the globe adding new processing units to process heavy-sour crude to maintain profitability, the incentive for processing heavy-sour crude is high as these crude oils are traded at a considerable discount to sweet and light crude.

Petrochemical products
Like refining, petrochemical margins have always been cyclical. The Middle East, and particularly Saudi Arabia, is now entering the top league of the ethylene industry and putting pressure on existing producers. Middle East ethylene derivative suppliers have a significant competitive advantage with production cost 50% lower than other producing countries (low priced feedstocks). Additionally, these countries have a social responsibility to provide work to their growing populations and develop local manufacturing.
The Petrochemical industry has followed the trend of the Refining industry with emerging countries setting up facilities locally to capitalise on the product added value. The majority of the major Petrochem projects are in the Middle East, and Asia. In the long term, competition to the Middle East and Asia may come from North Africa where abundant supplies of non allocated gas mean that ethane rather than refined petroleum products could be used as feedstock.

LNG
Where gas is unable to be piped to its final destination, and significant gas sources are available, major investments in Liquefaction have occurred (LNG plants). These plants liquefy the gas as the greatly reduced volume produced when compared to its gaseous form makes it commercially appropriate for shipping. At the receiving end, LNG re-gasification terminals are built so that the gas can be returned from a liquid to gaseous state and then fed into a local gas network.



Major LNG investments are only really viable where minimum gas reserves exceed 7 Tcf.
The major investment areas for LNG are Africa, Asia, Australia and PNG, Russia and the Middle East. The major importers of LNG are Japan and Korea although many European countries have now built LNG terminals to supplement their gas grids.

Unconventional Liquid Production & Associated Construction

Oil sands/extra heavy Oil/unconventional Oil
With potentially 3.6 trillion barrels of Oil in place (mainly in Canada and Venezuela), unconventional Oil represents two-thirds of the world's total petroleum resources and will de facto play an increasing role in worldwide Oil production over the coming decades.

Oil sands production is forecasted to reach 4.5 MMbpd in 2035. This increase will be mainly driven by potentially higher Oil prices and advances in production technologies (low-pressure SAGD, solvent-aided production, new or modified upgrading technologies) that will reduce capital expenditures and operating costs.

The main risks and uncertainties are Crude Oil prices, Natural Gas costs, environmental concerns (Canada), geopolitical restrictions (Venezuela) and fluctuation on required capital. Associated construction projects will be necessary for the pre-processing of the heavy Crude feedstock to fit conventional refineries projects (upgrading comprising removal of water, sands, waste and light products followed by catalytic purification and hydrogenation).

Due to the very high investment levels, Oil sands projects will increasingly be dominated by large, well-capitalized firms, notably the majors speculating on the long term value and NOCs securing access to resources

Gas-to-Liquid GTL
The demand for GTL fuels is anticipated to grow firmly to meet the world's growing demand for cleaner energy, notably for diesel fuels with the increasing emphasis and legislation for low sulphur and aromatic fuels in Europe and the US.
However, the commercial success of GTL technology is not yet fully established and returns from GTL projects will depend on the price premiums obtained for the environmental advantages of GTL-produced fuels; GTL is currently not competitive against conventional oil production as the capital costs for GTL projects tend to be in a range of double that of refineries.
GTL projects are scalable allowing application for smaller Gas deposit (not economical for LNG) or associated Gas which would be otherwise flared.
Qatar has already invested substantially in GTL projects. Australia, Egypt, Trinidad & Tobago and Nigeria are potential candidates for large scale GTL facilities. Additional small-to-medium size constructions could materialise for stranded and otherwise flared Gas.

Coal-to-Liquid CTL
CTL is particularly suited for countries that have large domestic reserves of coal (China, US, Australia, Indonesia, India, Germany, South Africa) and rely heavily on Oil imports. However, the most optimistic forecasts indicate an additional 1 MMbpd only of unconventional liquid produced by CTL process by 2030, as high capital expenditures are required and environmental impact is very negative without expensive associated carbon capture and storage.
Additionally, governments may be more inclined to conserve Coal reserves for power generation than for CTL conversion (China).Very limited construction activity is forecasted for CTL for direct and indirect CTL liquefaction before 2030.

4. RISK EXSPOSURES

The sector presents unique exposures that are driven not only by the complexity of the process engineering but also the often remote and challenging locations in which the primary feedstock of Oil or Gas is located.
Consequently the exposures that are unique to this sector can be categorised as either arising out of;

i) The Parties involved
ii) The Location factors
iii) The Technical Considerations
iv) Delay in Start Up considerations

(i) The Parties involved

Principal
The Principal usually will be the final operator of the plant and their primary interest is for the project to be completed on time, on budget and to the required specification.

Project Management Team
The complexity and size of major Oil & Gas projects is such that it is often necessary that the Principal either directly employs a Project Management Team (PMT) or outsources this task to one of the major international suppliers of project management consultancy.

Project Management is a critical part of any construction project. Large Oil & Gas projects often consist of several major process areas, each being delivered by different contractors.
It is therefore important that the PMT has the relevant Oil & Gas experience to manage the complex interfaces between all parties.

Main Contractor/EPC Contractor & Sub Contractors
The Main Contractor is the party with whom the Principal contracts with to physically construct the project. Alternatively the Main contractor may also be appointed to engineer, procure and construct the project, in which case they will be referred to as the EPC. The Main contractor will sub let contracts to specialist sub contractors, with a view to maximise both quality and price competiveness.

However the key risk consideration is that the main Contractor has the relevant experience and capability in the relevant sector.

Licensors
Process technology may be either Open Art (available without fee) or Licensed (where fees are required).

Licensors either sell existing designs, well proven but not necessarily the most efficient, or their newer, enhanced designs. For a given process, there may be a number of different designs from several licensors.

Alternative licensed processes will present different risk profiles and therefore it is important to appreciate such differences in any risk assessment.

Suppliers
Suppliers provide materials and or equipment for incorporation into the project. It is important that these suppliers are reputable and that the quality of their product is to the required standard.

Consultants
Consultants are the specialists that advise owners or EPC contractors, and provide professional advice for specific areas of the project.
These may include such services as:
QA/QC
Material Verification
Fire Protection
Heavy Lifts
Risk Management
HAZOP

(ii)Location factors

The factors that are influenced by the location of the project may be either environmental or, human these are looked at below in turn;

Environmental

Natural Perils
- Earthquake
- Flood
- Storm
- Tropical Storm
- Tsunami
- Volcano
- Hail

Site Location

Ground conditions

Oil & Gas Projects often incorporate significant structures along with large scale equipment that create both substantial static and dynamic load requirements, these are often made more complex due to the local challenges of geology, climate and seismic activity

Consequently the design of the foundations is key in fulfilling the aim of transferring load of the supported structure and equipment.

Political Considerations

The situation on site may be indirectly impacted by war, terrorism and SRCC. These may be specific exclusions within the Policy, but the secondary impact of these events needs to be considered. Such scenarios as inability to attract skilled labour, limitations of transport and prolongation of the project duration may result from these influences and result in an escalation of claims costs beyond normal levels in the event of a loss.

(iii) Oil & Gas Specific Considerations

Erection & Handling

Whilst the potential for loss arising out of erection and handling is not unique to Oil & Gas construction protects, the size, weight and dimension of many of the key process units creates the need for specific and controlled lifting procedures.

An example of a large lift at a project site

Prototype/Scale up/New Process/Materials

The constant drive for efficiency and improving returns on capital provide significant stimulus for the development of technology to achieve these aims, such improvements are therefore achieved through new materials, designs & processes and scale ups.
Whilst technical boundaries may be stretched, it is seldom that novel or unproven equipment is incorporated into plants, since the Principal will be equally concerned with plant integrity, reliability of service and output to ensure the maintenance of revenue streams. However scaling up continues to be common to many projects.

Pre Commissioning & Cold Testing

Cold testing, sometimes referred to as mechanical testing, of component parts is undertaken at convenient times during the erection/installation period. These take the form of hydrostatic leak tests on boilers, pressure vessels, columns, towers, storage tanks & piping and simple mechanical/electrical functions tests of ancillary equipment such as motors, pumps, valves, rotating process plant, electrical control and distribution equipment etc. These tests are performed as installation proceeds at levels well within designed performance and the consequences of failure of individual components involved are not severe.

Pre-commissioning is a vital phase in the overall start-up schedule. Pre-Commissioning activities can be summarised as those which bring a system from a state of 'Construction' to 'Ready for Commissioning'. These activities include:

i) Flushing, blowing, degreasing, chemical cleaning, pigging, lube oil /seal oil circulations and other cleaning operations to ensure that all components of the system meet the required cleanliness criteria.
ii) Tightness testing, leak testing, inert and drying to ensure that the system meets the criteria set for leak rates oxygen content and dew point.
iii) Functional testing and checks on instrument control loops, complex control schemes, Fire & Gas systems and Safe Guarding Systems to ensure that the control schemes within the system meet the desired intent.
iv) Dynamic testing of equipment including over speed checks, vibration monitoring and circulations on non-processing fluids to ensure that mechanical equipment in the system meets the design intent.

Given that the next phase of the project will involve the introduction of feedstock this aspect is of significant importance for Oil & Gas projects since small errors in this stage will have profound impact during hot testing.

On completion of pre-commissioning activities the system is deemed to be "Ready for Commissioning"

Hot Testing and Commissioning, Start-Up and Initial Operation

With the commencement of the hot testing and commissioning period, large quantities of combustible and explosive materials at elevated temperature and pressure levels are introduced. The types of loss events that occur in the hydrocarbon production and processing industry during the testing and commissioning phase therefore differ from those in most other industries. Explosions and fires can be larger, more extensive and longer lasting than in other industries.

Plants consisting of several dependent process units are taken into operation according to a certain sequence. Ancillary plants such as the water treatment, the steam generators, power generation or the air separation unit are taken into operation first, followed by the process units. The overall testing and commissioning period for huge plants might last up to 6 months, with some utilities being tested and operated for more than one year. Therefore the testing period should be carefully adapted to the schedule, and any operational periods for plant / equipment not taken over prior to the commissioning of the main plant could be considered as part of the testing period.

If the automatic prolongation of the testing period is required it should be limited to a reasonable duration. Any prolongation should be granted at risk commensurate terms and conditions. The increased exposure during testing & commissioning compared to the overall average exposure should be taken into consideration.

Quality Assurance / Welding

It is important with projects of this nature for the Principal, and/or his appointed representatives, to develop specific quality management, quality assurance and quality control plans. Likewise all contractors, suppliers and vendors should be required to implement and maintain quality systems that meet the requirement of ISO 9001.

Plant design for the facility should be based on international and national design standards, local regulations and statutory requirements. Pressure plant design calculations and drawings must be to a recognised approved standard and reviewed and approved by an accredited verification service provider.

It is common practice in contracting today to design the plant in 'stick built' or pre-assembled modular form with fabrication undertaken at specialist fabrication yards generally situated at location other than the construction site. Completed Pre-Assembled Units and Pre-Assembled Racks will require transportation to the contract site for assembly. This has the effect of minimising the man-hours needed at the construction site and enables mechanical work to commence whilst the site preparation and foundation works are still going on at site.

Welding is a key activity during Oil & Gas construction projects and the quality of the welding is essential due to the hazards involved; consequently it is important that a detailed assessment of the quality assurance and quality control procedures are incorporated into the project. Specific emphasis should be placed on how these procedures will actually be implemented through out the project to ensure compliance. This can mean the appointment of third party inspectors or inspectors employed by the owners in addition to the contractors own quality inspections team.

Detections / Assessment

Oil and Gas processing plants would be classified as Major Hazard Facilities, and as such must comply with National Standards for the Control of Major Hazard Facilities.

During the final design phase of the project the Owner will undertake a Hazard and Operational (HAZOP) risk identification and risk appraisal of the entire plant. This assessment shall identify the type, relative likelihood and consequences of major accidents that may occur.

This review addresses areas such as:

<u>Prevention:</u>
Minimise the potential for and the consequences of leaks
Minimise the probability of ignition
Minimise the potential for collision

<u>Detection:</u>
Provide Gas and Fire Detection Systems

<u>Mitigation:</u>
Active and passive fire protection
Explosion overpressure mitigation
Safe separation distances

<u>Control:</u>
Emergency isolation, ESD and blowdown
Hazardous area classification
Bunding, containment and drainage

As a consequence of this review a comprehensive safety management system will be established to implement control measures to reduce the effects of a major incident including likely operator errors, hardware failures and environmental changes. It is imperative that all systems be build, tested and fully functional before Hot Testing/Commissioning activities commence.

Accordingly the above tasks are considered as part of normal erection / installation risk with fire remaining the key peril.

PML

Definition

The definition of the maximum loss may be viewed from the perspective of either being the Possible Maximum or the Probable Maximum Loss. It is important to understand which definition is being applied and to recognise the differences between them.
The Possible Maximum Loss is the maximum loss that could possibly arise from a single event without any mitigating factors being taken into account.
The Probable Maximum Loss is the maximum that could arise from a single event but taking mitigating factors into account.
In the majority of cases the Possible Maximum Loss on an Oil & Gas project will arise out of either a pool fire, BLEVE or UVCE

There are a number of methodologies than can be used to calculate the resulting damage from UVCE scenarios e.g. SLAM, IOI Blue book and XOL

Whilst each will apply differing assumptions, the following points will generally be considered:

- All automatic and manual fire protection devices are in service prior to the Explosion.
- Only combustible products above the boiling temperature at ambient pressure have to be considered.
- A minimum of one ton of vaporized material must be released. It is generally acknowledged that any release less than this would not produce damaging overpressure.
- Where the products are in the gaseous state in the equipment, only gases/vapours over 30 bar are considered.
- The release is instantaneous. The leak rate is not considered.
- The material released is instantaneously vaporized and a cloud is immediately formed based on the thermodynamic conditions of the flammable gas or liquid prior to the release. Liquefied gases are assumed to vaporize completely and instantaneously with no self-refrigeration of the liquid pool.
- The cloud formed is cylindrically shaped with a vertical axis as the cloud's ceiling. Distortion due to building structures or wind is not considered
- The cloud is assumed to be of uniform composition with the vapour-air mixture being at the mid-point of the explosion range.
- The explosion potential is compared with the explosion experience of Trinitrotoluene (TNT).
- The size of the spill is based on the largest process vessel or train of process vessels connected together and not readily isolated. Shut-off valves which are automatically actuated or controlled from a remote location may be considered in reducing the size of the estimated spill. Automatic dump valves, drainage and flare systems, if safely arranged, may be considered as a factor in reducing the size of the spill. However, 5% of its content should be considered to be due to leakage.
- The existence of ignition sources may not be considered in reducing the cloud size. The total amount which might be spilled must be used in estimating the cloud size. Loss experience has shown that winds may allow the formation of large clouds without ignition by a nearby source.
- Gases or liquids used as fuels are not included since loss experience shows that they do not have to be considered.
- The failure of a storage tank is not included.
- The failure of pipelines from storage or supply facilities is not considered.

Once the cloud size has been ascertained the model will then calculate the optimum position of the vapour cloud which once ignited will cause the greatest devastation
In the example plot plan below the potential release point, vapour cloud size pressure wave diameter are shown with 5 PSI, 2 PSI and 0.5 PSI overpressure circles.

(iv) Delay in Start Up

Delay in start-up (DSU) cover can provide cover for the Principal and the Lenders only for;

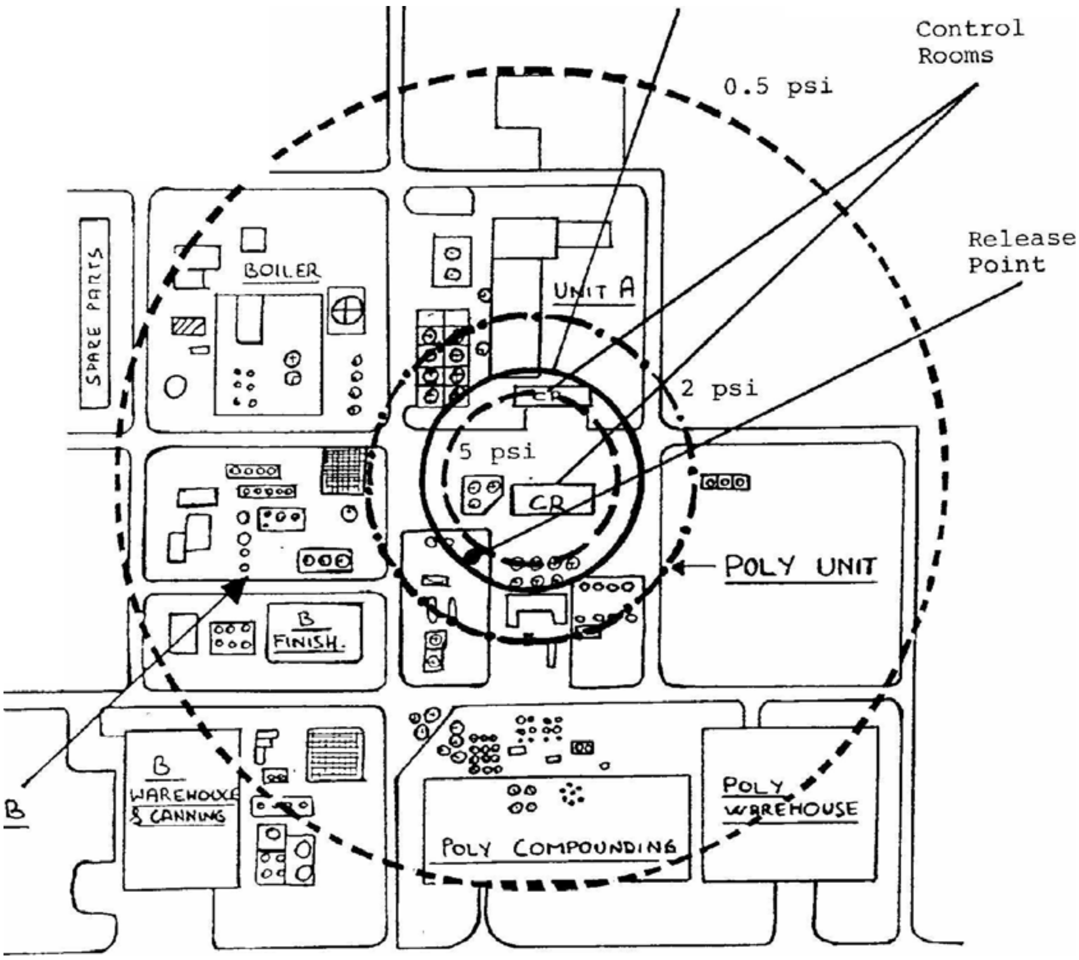
- Fixed Costs (including loan interest repayments)
- Net profit (before tax)

It provides protection against delays in achieving the scheduled date of commercial operation, arising from physical damage caused by any peril insured by a CAR / EAR policy.

Evaluating DSU Risk

A detailed understanding of the project and those hazards and exposures likely to impact on the project's scheduled business commencement date including but not limited to:

- The events that might cause physical loss or damage, specifically those towards the end of the project where lost time resulting is unlikely to be made up
- The projects works progress schedule and critical path including duration of each project phase e.g. is the project affected by seasonal weather patterns since certain works may not be feasible at certain times during the year.
- The full process of the plant including the number and capacity of primary production units and their targeted output.
- Information on suppliers and manufacturers including capability to replace or repair and lead times for key pieces of equipment and plant in the event of loss or damage.
- Contingency plans in place to reduce interruption or delay
- The contractor's and sub contractors reputation and expertise in Oil & Gas projects and availability of skilled and appropriate labour.



5. CONSTRUCTION CONTRACTS & RISK ALLOCATION

Contracting parties to an onshore energy project

Construction projects involve multiple parties carrying out many different functions and are therefore naturally complicated. The terms of the contracts governing these functions and how these contracts are managed are crucially important for the successful realisation of any project. The parties involved may include The Owner, Project Financiers, Contractors, Sub-contractors, Manufacturers, Suppliers and Vendors of materials and equipment, Licensors, Governments/Local Authorities, Engineering Firms/Consultants, Land Owners, Suppliers of Feed Stock and Off-takers, Utility Suppliers, Vessel Owners, Plant and Machinery Owners et al. Each of the parties has different drivers that bring them to the project and the basis of each of their contracts can vary significantly.

The final contracting structure will very much depend upon how the project intends structuring the company. Additionally, the project can either be treated as a “Tolling process” where the owner is simply paid for processing the feed-stock into final products or the project acts as a commercial purchaser of feed-stock and seller of final products.

Before any Insurance requirements can be fully ascertained, it is essential to both understand and appreciate the relationships and legal responsibilities between all the parties involved in the project.

These relationships can in most cases be summarised in the following diagram:-

It is important to make sure that all project parties and/or those who have influence over the project are included within the contractual diagram above and the legal implications and responsibilities of all parties involved are clearly understood and defined.

Contracting Philosophy

One of the most important factors in the owner / contractor relationship is whether or not there is a single point of responsibility for the project with an EPC contractor, or whether there are multiple contractors who have direct contracts with the Owner. A single point of contact / legal responsibility provides a much clearer contractual route, minimises disputes and means at the top level that the whole project is run between two teams of people – the Owners team on one side and the contractors team on the other. If multiple contracting parties are involved directly with the Owner this can cause more disputes especially were a problem occurs and the various contractors are unable to agree as to where the fault lies.

It is also extremely important to understand the ramifications of any “take or pay” type contracts for supply of feed stock or for the sale of any product as the effect of these need to be clearly understood in the event of any delay to the project.

Force Majeure provisions in any of the above contracts need to be clearly understood as they can have a very significant affect on the outcome of any dispute between the parties. The definition of Force Majeure in the construction contracts can vary from very limited to extremely wide. The broader the definition, the greater the ability of the contractor to obtain release from liability for costs, delays or lack of performance

Balancing the Relationships

Obtaining a reasonable balance in the contracting relationships between the parties is vital when it comes to assessing the risks/exposures that the parties have accepted and to what extent these exposures can be passed onto others via insurance.

Having a contract that is heavily weighed in favour of one party can lead to major disputes in the future. Significantly, in weak economic times, unbalanced contracts can force many contractors out of business which in the end is not in the best interests of owners or contractors. This was classically illustrated in the 1990s for North Sea contracts where the Owners eventually found it either difficult to find contractors to do work for them and/or the contractors required prohibitively high prices for doing the work. The Owners then came together and agreed upon a more balanced standard form of construction/maintenance contract – this was known as the CRINE initiative. Subsequently the Standard Contracts for the UK Offshore Oil & Gas Industry have been issued by LOGIC.

Depending upon the market cycle, contractors will either be willing or unwilling to commit to fixed priced EPC type contracts. In the recent boom years for onshore projects around the world it has been extremely difficult to find any major onshore energy contractors willing to commit to a fixed priced contract – instead they have been able to demand cost plus type contracts. This is because major contractors previously were hit with large increases in costs during the life of a project which they could not pass onto the Owner and which left them with large losses for the project.

Traditional Allocation of Risk between the Parties

Traditionally onshore energy projects are heavily influenced and controlled by the Owner. In most cases the Owner will involve significant personnel into the project team and once the project is built/successfully reached mechanical completion the Owner will take over and hot test/commission the plant. Traditionally this has therefore led to the following allocation of risks:-

Risks traditionally retained by the Owner

Commercial Risk
Delay outside the control of the Contractor
Responsibility for his own employees

Political Risks including Terrorism

Risks traditionally passed onto the Contractor

Damage to / liability arising from his own property
Including vehicles / waterborne craft / aircraft
Duty of care for works / existing property
Responsibility for own workers
Liability to Third Parties
Liquidated Damages for delay and lack of performance

Risks that can be retained by either Principal or Contractor

Elements of the Design (Depending upon whose design it is and/or how well the design is known)
Project Financing (Usually this is the responsibility of the Owner)

Traditional allocation of insurances between the parties

For Projects outside North America and Australia

Insurance coverage's to be purchased by the Owner:

- Erection All Risks / Construction All Risks / Course of Construction / Engineering All Risks / Builders All Risks
- Marine Cargo
- Third Party Liability (Excess / DIC to primary contractors cover – if any)
- Employers Liability / Workers Compensation for own personnel
- Advanced Loss of Profits / Delay in Start-up
- Damage to own Existing Property

Insurance coverage's to be purchased by Contractor:

- Contractors Plant and Equipment
- Primary Third Party Liability
- Employers Liability / Workers Compensation for own personnel
- Professional Indemnity (if required)
- Motor
- Waterborne / Aircraft (if required)
- Marine Cargo (Normally the responsibility of the Owner however certain major oil companies who do not require project financing make the contractor responsible for this)
- Any other forms of Insurance required by law

For North American and Australian projects

Due to the litigious nature of North America and Australia it is common for many of the project liability exposures to be placed all together as an insurance "Wrap" type placement covering all parties rather than separated out between the contractor and Owner.

External Funding / Financing

Projects may be funded in one of three ways, namely:-

<u>Non recourse finance</u> – Where the project lenders only have recourse against the project and its assets and do not have recourse against any other party

Partial recourse finance – Where project lenders retain recourse against the projects and its assets plus recourse against the project sponsors/parent companies until completion of the project. Upon completion of the project this would then revert to non recourse finance

Full recourse finance – Where the project lenders have recourse against the project and its assets, and retain rights of recourse against all other sponsoring parties for the duration of the loan.

Many Oil & Gas projects are financed on a Partial recourse finance basis.

Types of Contract

The type of contract in place between the owner and contractor has a significant impact on the risk profile of major construction projects.

Regardless of the contract structure, however, it is critical that the owner and contractor work as an integrated team in order to mitigate contractual issues that can be detrimental to the relationship between the two.

Turnkey EPC

A turnkey contract is generally preferred by project owners as they minimise the risk of cost overruns to the owner through agreement of a fixed price for a defined work scope. Additional work required outside of the defined scope of work is reimbursed to the contractor through change orders. This type of contract is often seen during low construction activity periods when competition between contractors is fierce.

With this type of contract, there is a risk that the contractor will try to use cheaper alternative sources of labour or materials in order to maximise their profit margin with a potential subsequent impact on quality. It is therefore important that the owner has sufficient resources in place to ensure that appropriate quality levels are maintained.

The contractor will also be driven more by cost minimisation than delivering the project schedule unless incentive payments have been agreed.

The change order process can often lead to disagreement between owner and contractor as to whether additional work activities are valid change orders or included in the original work scope definition.

Reimbursable EPC

A reimbursable contract is generally more favoured by the contractor as it passes the risk of cost overrun to the owner and locks in pre-agreed labour rates often at high levels during periods of high construction activity when contractors are in short supply. As such, project costs can quickly increase substantially above budget.

It is important therefore that the owner has adequate resource to monitor and track the contractor's activities in order to maintain control of the project costs. However, the necessary review, approve and monitoring process can adversely impact the schedule due to the longer time necessary for work to be reviewed and approved.

Petrochemical projects often comprise of a number of major project areas often with each one having a different managing contractor. Special attention should be paid to differences between the various contractual provisions between these areas and to how the owner intends to manage them, particularly through the role of the selected Project Manager which could be the owner itself, one of the contractors or an independent project manager acting on behalf of the owner.

Insurance Critical Contractual provisions

It is important that insurers have an appreciation for the contractual structure for the project in determining various parties roles and responsibilities. An EPC contract will usually contain the following conditions which should be reviewed by the insurer:

Insurance Specification
Describes responsibilities of both the owner and contractor for provision and specification of insurance and in particular who accepts “risk of loss”
In addition it often defines some terms and conditions such as cover limits and contractor retentions.

Incentive Payments
Additional payments are often agreed in order to incentivise the contractor to achieve the project schedule. Insurers should be aware of such payments in order to assess the risk of a contractor taking short cuts in order to meet the required schedule.

Warranties
Insurers should also note the provision of warranties within the contract to assess potential subrogation rights**.**

Contractor vs. Owner Controlled Insurance

Contractor Controlled
In a traditional insurance structure the project owner/principal and the contractor execute a construction contract which includes an indemnification clause expressly stating that the contractor shall hold the owner harmless for any loss arising out of the contract. In addition the project owner will also require that the contractor or contractors purchase and maintain adequate insurance coverage with specified minimum coverage and limits of liability. This project specific policy is purchased and maintained by the contractor however the cost for the policy is reimbursed by the owner as part of the contractor’s tender price.

Owner Controlled
By comparison Oil & Gas projects typically have multiple contractors due to logistics, size and project phases. And therefore in most cases Owner controlled Insurance programmes are purchased Under an Owner Controlled Insurance Programs (OCIP):

- The owner purchases insurance to cover all contractors, sub contractors and sub–sub contractors performing work at the project job site.
- The owner pays for the insurance policy and the contractors are covered under that policy for that particular project. It provides consistent and uniform Insurance coverage. Removes any potential gaps in coverage that may exist in a contractor’s or sub contractor’s policy
- The owner has direct control over the selection of the Insurer and can monitor that Insurers performance and financial solvency.
- Savings come from the elimination of contractor mark up on Insurance and the owner’s ability to obtain Insurance at a lower cost than contractors, sub contractors and other project parties.

- A key additional part of an OCIP is an integrated owner–contractor risk management program that can result in potential cost savings from improved safety, increased loss control and more efficient claims handling.
- Loss Control: By complementing the existing safety programs of participating contractors, an OCIP can help standardize safety procedures on the whole jobsite. Also, an owner can add additional safety staffing or implement a financial safety-incentive program.
- Claims: An OCIP introduces coordinated claims handling/adjusting procedures and claims management services plus assists in the elimination of coverage disputes and subrogation between contractors and insurers.

6. INSURANCE CONSIDERATIONS

Information Requirements

The basis of all Insurance contacts rest upon the disclosure and understanding of material information, it is therefore important to gain adequate and detailed information.
However specific consideration should be given to obtaining information in the following areas:

i) Participants
Principal / Contractors / Licensors / EPC Contract details

ii) Natural Hazards/Site Location
Natural Peril information including Geotechnical Report / Soil condition survey.

iii) Project Details / Scope of Work
Including Bar Charts / Flow Diagrams / inventory of hydrocarbons over 20 tonnes / Pipeline laying scope and methodology / Fire Protections / Heavy Lifts / Confirmation that no equipment is prototypical /scaled up etc. / Hot Testing duration etc.

iv) Quality Assurance / Control Aspects
QA/ QC procedures and methodology for implementation on site / Positive Material Identification (PMI) / Non-Destructive Testing (NDT) etc.

v) Transit/ Storage
Goods value, type, method of stowage, country(ies) of origin, value per vessel, place of disembarkation etc.
Location, how Stored, what Stored, Fire Protection, Security, Maximum value in any one fire zone.

vi) Value breakdown
Breakdown of the Estimated Contract Values

vii) Delay in Start Up information
List of critical equipment, alternative method of work, financial information, lead times for critical equipment (time to re-order, reship, reinstall and commission), list of spare parts for critical machines etc.

viii) Third Party Liability
What are the third party exposures to the project?

Captive Insurance Companies

Unlike other sectors, many of the larger Oil & Gas companies set up their own insurance companies known as Captive Insurance Companies (“Captives”). These Captives traditionally only underwrite the parent company’s business and/or interest in a project. Captives are traditionally set up by the parent companies either for tax reasons and/or when these companies are confident they can best manage their own risks and do not wish to be subject to the vagaries of the international insurance markets. Thus, instead of paying significant annual premiums to other insurance companies they use this money to build up

their own reserves in their own insurance company. Captives may however choose to purchase various reinsurance stop loss or excess covers from the traditional insurance companies.
In more recent times, even for the Mega Billion Dollar projects, many major Oil & Gas companies have chosen to utilise their Captives to protect their share of any project. This therefore means that there is a greatly reduced share of the project requiring protection via the traditional international insurance market.

Progress Reporting and Risk Management

Insurers will expect to be appraised frequently of progress on the project to help them to monitor the schedule and the potential for project extensions as well as identifying any potential issues impacting the project risk. Typically insurers will expect to see copies of the standard monthly progress reports prepared by the project for internal reporting.

In addition, insurers will normally initiate a risk management program designed to complement the projects own risk management activities. A typical program would normally consist of several visits to the project by a risk engineer at the key stages of project completion: civils, mechanical and readiness for start-up. Each visit will include discussions with key project personnel as well as a tour of the project site to review work practices.

These visits also give insurers the opportunity to feedback experiences and lessons learnt from other similar projects on which the insurer participated.

The visits offer an independent review of the project which often yields a number of recommendations to help improve the risk profile of the project to everybody's benefit.

Handover to Operational Insurance

The testing and commissioning phase of any facility is normally seen to be the period of highest risk as this is when any defects or faults introduced during design, manufacture or construction are likely to appear. Additionally, for the oil, gas and petrochemical industries this is likely to be the first time that flammable materials are present in significant quantities within the new facility. Operational Insurers intention is only to accept a facility once it has been fully tested and commissioned and has therefore shown it is capable of performing as planned. Meanwhile construction underwriters are looking for the project to be transferred to an operational policy as soon as the plants have been successfully tested and commissioned and the plants are now in an operational mode.

Due to various projects being transferred to operational policies too soon, and operational underwriters subsequently picking up what they deem to be construction / testing and commissioning type losses, operational underwriters imposed testing and commissioning clauses as part of the operational insurances. These clauses simply state that, if an asset has been transferred to an operational policy and a loss subsequently occurs which upon investigation is shown would not have occurred if the plant had been properly / fully tested and commissioned whilst under the construction policy, the operational underwriters will not pay the claim.

It is therefore extremely important that operational underwriters are fully briefed as to the testing and commissioning that has been undertaken whilst covered by a construction policy before any plant is transferred to an operational policy. (See Operational clause in next section)

Wordings & Endorsements

General
It is not the intention of this paper to enter into detail about policy wordings, which would be a topic on its own. We will focus on aspects of wordings and endorsements which are relevant or particularly specific to Oil & Gas projects.

Wordings for the construction and erection of Oil & Gas projects are based on standard Erection "All Risks" (EAR) forms. In some territories the construction and engineering underwriter will incorporate an element of primary liability insurance; usually this will not exceed a maximum of US$5,000,000 or equivalent in local currency. Where required, particularly where the project is being funded through non recourse finance Delay in Start Up cover is likely to be required.

Wordings will range from "off the shelf" documents used for all EAR projects and in many territories based upon a standard Munich Re, or Swiss Re forms, bespoke broker forms or for some large clients their own "standard" form developed through negotiation with insurers over the years. Aspects of all of these forms will often vary according to market cycles, in hard markets insurers will try to restrict the cover offered, while in soft markets clients and brokers will seek the widest possible coverage.

Wordings are generally also influenced by the capacity available in the market and the client's attitude towards coverage versus premium. Clearly, limited capacity brought about by either a high PML (e.g. Unconfined Vapour Cloud Explosion) or other means such as location in an area exposed to natural catastrophe may result in underwriters restricting the breadth of coverage.

Specific issues
There are a variety of issues which will influence an underwriter when considering the policy wording for the construction and erection of Oil & Gas projects:

Geographical location: proximity to neighbouring property, natural watercourses and third party persons.

Natural Catastrophe Exposure: seismic zones, tsunamis and regions exposed to typhoon, tropical storm, windstorm and storm surge.

Marine facilities (e.g. jetties, breakwaters etc): the majority of Oil & Gas plants are located close to rivers or coastal waters and facilities are required for delivery of raw materials and in some cases transportation of the end product.

Prototypical nature of aspects of the plant: some of the equipment or processes may be untried and untested.

Utilisation of used equipment: some or all equipment may have been used at another plant.

Extension of an existing plant: introduces third party exposures where contractor controls insurances and own surrounding property/ existing property where owner controlled.

Offsite fabrication: site facilities may be restricted meaning that it is necessary for some of the fabrication to be undertaken at a location nearby.

The combination of high temperatures, high pressures oil, gases and chemicals: this introduces the potential for explosions and rapidly spreading fires, consequently it is important that the project team has developed and designed a procedure and automatic solutions for preventing and fighting such fires.

Use of catalysts and feedstock: these can be lost or impaired during the testing and commissioning process.

Hydrocarbons: starting up processes must be rigidly followed, certain vessels are susceptible to cracking damage due to rapid expansion caused by overheating. Other vessels will have for example refractory linings to which heat damage is inevitable and therefore not insurable.

Testing and commissioning: It is important that there is a clear understanding regarding responsibilities and where each phase of testing and commissioning commences and terminates.

All of the above can be dealt with by the application of specific exclusions and/or memoranda / endorsements introducing inner limits, wording restrictions and special conditions.

Endorsements/Exclusions/Memoranda/Conditions/Definitions
There are a wide range of policy amendments available in the underwriters toolbox, many of these can be applied equally to a wide variety of risks. For the purpose of this paper we will concentrate on those which are particularly relevant to Construction of Petrochemical, Oil & Gas Processing Plants.

Listed below are examples of these clauses:

Hydrocarbons Clause & Catalyst Inner Limit/Limitation

The following clause is an illustration of the most restrictive form of endorsement, however this will often be modified in specific circumstances:

> As from the introduction of any hydrocarbon feedstock, Insurers will not indemnify the Insured in respect of any loss of or damage to:
>
> Reforming units due to overheating or cracking of any tubes;
> Insured Property due to:
> Overheating or cracking following or arising from any exothermic process reaction;
> An intentional deviation from prescribed procedures including those relating to commissioning, Start-up and operation

Policies will generally also exclude catalysts or a change in the chemical composition of Catalysts; however, buy back cover is available provided damage is as a consequence of otherwise indemnifiable damage. A sub limit is usually agreed between the parties in the event that the buy back is affected.

Offsite Fabrication Extension

Construction sites can often be restricted in terms of space and suitable facilities to carry out major welding operations, more so when the project involves expanding or upgrading an existing facility. It is not uncommon to find many of the larger items of plant being delivered in sections to a location close to the site for pre site fabrication. Offsite fabrication cover can usually be provided subject to a sub limit.

Own Surrounding Property Extension

If the owner arranges the insurances for the upgrade or extension of an existing plant, there may also be exposure for consequential damage to that plant. This could be handled through mutual waivers of subrogation between the construction and operational properties, however, many of the larger companies buy catastrophic operational insurances with large deductibles or self insured retentions often within captives and would prefer not to expose the captive to such losses arising out of the construction project. Alternatively they may purchase their insurances with a large deductible through an industry mutual such as OIL Insurance Ltd. Either way it should be difficult to maintain that level of deductible and pass it onto the contractor.

Fire Fighting Facilities Condition

Insurers are concerned with the significant exposures that can arise from fire, both during the construction phases when permanent protections are not fully operative and once the plant is completed and testing commences.

Accordingly Insurers will often impose conditions that address minimising the fire load during these phases as shown below:

> It is agreed and understood that otherwise subject to the terms, exclusions, provisions and conditions contained in the Policy or endorsed thereon, the Insurers shall only indemnify the Insured for loss or damage, resulting directly or indirectly from fire and/or explosion if the following requirements are fulfilled:
> 1. Adequate fire-fighting equipment and extinguishing agents of sufficient capacity must always be available at the site and ready for immediate use.
> 2. A sufficient number of workmen must be fully trained in the use of such equipment and must be available for immediate intervention at all times

Prototype exclusion

If a plant utilises equipment and or processes and the underwriter remains unconvinced about them it is likely that insurers will insist upon the application of some sort of restriction or exclusion relation to these:

> Excluding loss of or damage to works or processes of a prototype or experimental nature unless the prior consent of the company to insure such has been given hereunder.

Used/Second Hand equipment exclusion

Insurers are generally concerned about the condition and integrity of used equipment and will usually seek to exclude it at least from the commencement of testing and commissioning. Most underwriters will be reasonable in that whilst damage to used equipment is excluded, new equipment damaged as a consequence will continue to be covered. Some endorsements are more specific e.g.:

> It is agreed and understood that otherwise subject to the terms, exclusions, provisions and conditions contained in the Policy or endorsed thereon, the Insurers shall not indemnify the Insured for loss of or damage to the insured used items
> i) attributable to previous operation,
> ii) attributable to dismantling (if dismantling is not covered),
> iii) in respect of any non-metallic parts.

Piling

Much of the equipment and process units involved in an Oil & Gas plant are extremely tall and heavy. In some territories seismic and wind exposures are problematic whilst in others sandy soils are a concern. As such there is always the need for extensive piling.

Insurers consider that damage arising out of some aspects of piling are inevitable or trade risks and apply a special piling clause that clarifies and restricts the extent of coverage. The following is an example taken from the standard Munich Re clauses:

> Insurers shall not indemnify the Insured in respect of expenses incurred:
>
> for replacing or rectifying piles or retaining wall elements which have become misplaced or misaligned or jammed during their construction, which are lost or abandoned or damaged during driving or extraction, or which have become obstructed by jammed or damaged piling equipment or casings, for rectifying disconnected or declutched sheet piles, for rectifying any leakage or infiltration of material of any kind, for filling voids or for replacing lost bentonite, as a result of any piles or foundation elements having failed to pass a load bearing test or otherwise not having reached their designed load bearing capacity, for reinstating profiles or dimensions.
>
> This endorsement shall not apply to loss or damage caused by natural hazards. The burden of proving that such loss or damage is covered shall be upon the Insured.

Testing and Commissioning Definition

For the purpose of this Policy, Cold Testing, Hot Testing and Commissioning shall mean:

Cold Testing

The checking of component parts of machinery or equipment by mechanical, electrical, hydrostatic or other forms of testing under dry run conditions to ensure that the items work, but:

without firing of furnaces or application of direct or indirect heat;

without use of feedstock or other materials for processing;

in the case of electrical motors and electrical generating, transforming, converting or rectifying equipment, without connection to a grid or other load circuit.

Hot Testing

The checking of component parts of machinery or equipment under load or operational conditions:

including use of feedstock or other materials for processing or other media to simulate working conditions;

in the case of electrical motors and electrical generating, transforming, converting or rectifying equipment, including connection to a grid or other load circuit.

Commissioning

The operation of machinery or equipment under production conditions for the purpose of attaining specification requirements and/or for training operational staff:

including use of feedstock or other materials for processing;

in the case of electrical motors and electrical generating, transforming, converting or rectifying equipment, including connection to a grid or other load circuit.

Operational Policy Testing Clause

An example of a typical testing and commissioning clause attaching to an operational Oil & Gas policy:

> It is hereby noted and agreed that this insurance does not cover destruction or damage to property in course of construction or erection, dismantling or undergoing testing or commissioning including mechanical, performance testing and any business interruption resulting therefrom.

Acceptance of property hereon is subject to satisfactory completion of the following procedures:

1. Mechanical Testing.
2. Testing and Commissioning
3. Performance Testing conforming to 100% Contract Design Criteria for a period of 72 consecutive hours
4. Official acceptance by the Insured following formal hand-over certificate procedure. (It being understood that no equipment faults or punch list items affecting operational integrity of the plant are outstanding).

Proviso: This Clause does not apply to on-going maintenance/scheduled turnarounds/revamp work and for the interest of the Insured in all real and personal property (including improvements and betterments) owned, used, or intended for use by the Insured, or hereafter constructed, erected, installed, or acquired while in the course of installation, and assembly subject to the value of each such contract not exceeding an amount of USD (To Be Agreed).

7. LOSS SCENARIOS

Whilst many loss scenarios may affect Oil & Gas projects the principal difference to other projects is that they feature processes that involve large volumes of highly flammable fluids operating at extreme temperatures and pressures.

The following scenarios are unique to Oil & Gas projects

Vapour Cloud Explosion (VCE)

Vapour cloud explosions result from a release of flammable, vaporisable materials that mix with air and drift until they find an ignition source. The pressure wave resulting from the explosion of such a vapour cloud can cause large amounts of damage over a substantial area. The amount of damage depends on the type and quantity of material released, the degree of mixing with air, plant and equipment layout and congestion, and flame front speeds.

In the majority of occasions the VCE loss scenario is the governing PML event.

Boiling Liquid Expanding Vapour Explosion (BLEVE)

The most common type of BLEVE occurs when a pressurised flammable liquid storage vessel is exposed to a fire. The fire increases the internal vessel pressure and weakens the vessel shell until the vessel can no longer contain the pressure. The vessel then ruptures violently and parts of the vessel are propelled great distances. The released liquid flashes and atomises immediately, resulting in a large rolling fireball that can cause widespread damage from flame impingement and thermal radiation.

On occasions where there are no major process units that have a significant hold up hydrocarbons, the BLEVE loss scenario is likely to be governing PML event.

Storage Tank Fires

Fires in tanks containing large volumes of flammable materials, especially oil products, are very difficult to control and extinguish. Many hours, even days, of carefully planned fire fighting efforts are usually required to bring large tank fires under control. Fire fighting costs and exposure to personnel, surrounding equipment and third parties are usually very high.

8. CONCLUSION

The Construction of an Oil & Gas project is a highly complex activity which will continue to offer significant technical challenges to Industrial Insurers.

We hope this paper has provided a sound basis to better understand these challenges so that the Insurance market can continue to respond to the needs of its clients in this sophisticated area.