

APPLICATION OF INHERENT SAFETY CHALLENGE TO AN OFFSHORE PLATFORM DESIGN FOR A NEW GAS FIELD DEVELOPMENT – APPROACHES AND EXPERIENCES

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In the past, the concept of a "safe design" for an offshore installation was one that had been provided with redundant levels of prevention barriers and mitigation systems. In addition, the lack of engagement of operations personnel in the design process often resulted in modifications of the built platform possibly giving rise to hazards unforeseen by the design team. By having process safety specialists working closely with the design team and operations personnel, the incorporation of the "inherent safety challenge" concepts as a design tool during front-end engineering (FEED) design is currently been applied to a major Greenfield offshore gas Project in South East Asia. The natural gas reservoirs are located in a remote pristine area. The Project faces unique challenges as the gas field is classified as high temperature (up to 130^{o}C) and high pressure (up to 320 bar). The concept had evolved from being initially a manned platform to an unmanned facility. The challenge during FEED was to design an "inherently safe platform". This was taken to be a platform that does not leak or break down, required few people and, as such, is inherently safe as it should not put anyone at risk. The purpose of this paper is to broadly describe the proactive approach adopted for this Project and to relate how the HSE team is championing the inherent safety approach. By involving operations personnel and design team up front, the HSE team is assisting in the delivery of a design that will be safer and more reliable. Inherent safety design examples under consideration for the Project and philosophy are provided.

Inherent Safety, NUI, Design Safety Goals, Hazard Management Plan

FOREWORD

Due to the sensitivities surrounding this Project at the time of preparing this paper, the title of this particular development could not be released. The paper has been structured to be general in nature such that readers can consider and apply inherent safety concepts contained herein to their projects.

INTRODUCTION

At BP, the HSE Policy is quite clear, "Our Goals are simply stated - No Accidents, No Harm to People and No Damage to the Environment". This statement is the guiding principle behind this major gas production development with the expectation that the "offshore facilities will demonstrate world class performance so far as HSE is concerned". This paper details how the Project is currently working towards fulfilling the HSE policy goal in terms of design safety and relays the experience gained thus far.

The Development's natural gas reservoirs are located in a very remote area in South East Asia. The offshore component includes those facilities required to produce, collect, and export natural gas and condensate for delivery to an LNG Plant. The complete offshore Project development will include the design, procurement, fabrication, installation, drilling, completion, pre-commissioning and commissioning for a series of platforms located near shore (approximately 30 kilometres).

Each platform has been designed as an unmanned facility (or Normally Unattended Installation - NUI) in a water depth of up to 60m. The wells will be drilled using a heavy-duty jack-up operating in cantilever mode. No topsides processing is proposed with all production fluids from the wells being routed to shore via individual subsea pipelines, one from each platform, for onshore processing at a Receiving Facility. The design also considers the provision of subsea power and communication cables.

The Project faces unique challenges in that the natural gas fields are at high temperature (HT, up to 130^{o}C) and high pressure (HP, up to 320 barg). In addition, the development will be located in a known active seismic area, sand waves, fast currents and be subject to tidal movements with low visibility water column.

INHERENT SAFETY CHALLENGE

THE NEED TO "THINK OUTSIDE THE BOX"

Past authors (Dalzell) have observed that the formal risk assessment approach and making a case for safety has resulted in an overcomplex and retrospective approach to risk management in design. Hence opportunities for optimising inherent safety may be missed causing risk management to be "reactive" rather than been "pro-active" in developing a safer design.

It is also the past experience of the authors that the identification and active management of technical safety issues for a new facility whether offshore or onshore, is conducted when the final design has been approved for construction, or worse, when the facility is being built. When new and complex technology is involved, this late assessment may find that risk from the operation of the facility is unacceptable, when measured against corporate and regulatory requirements. This may necessitate a re-design, major modification and/ or implementation of expensive hardware changes which ultimately leads to higher project costs, delays in commissioning, and problems in achieving product specifications in operation. There may also be additional operating costs and production interruption costs if the potential problems are not identified *a priori*, especially at the early stage of design.

A pro-active approach avoids or minimises the need to incorporate extensive safety systems to control and mitigate the hazards. Safety systems may themselves introduce additional hazards as they can increase exposure of personnel (e.g. maintenance) to the hazards. The key to providing an inherently safer design is by placing more emphasis on hazard elimination and incident frequency reduction measures (i.e. causation analyses). Dalzell argues that simplicity and inherent safety are complementary.

The approach adopted by the Project Team was to engender a culture whereby the entire team asked, "what's the hazard and what can we do to minimise the risks". This type of questioning leads the team to "not assume that the best design is one that has been achieved previously", that is to "Think Outside the Box".

By encouraging the participation of the designers and operations personnel, the Project aimed to create more opportunities to reduce the hazard likelihood, severity and consequence during the early stages of the Project.

WHAT IS INHERENT SAFETY ?

There are several definitions of inherent safety from eminent leaders in this field. McQuaid defines “an inherently safer approach to hazard management is one that tries to avoid or eliminate hazards or reduce their magnitude, severity, or likelihood of occurrence by careful attention to the fundamental design or layout.

Using Dalzell’s definition as the basis, the Project collectively developed a mission statement that defined Inherent Safety as ”delivering to Operations, a NUI and pipeline that doesn’t leak, collapse or sink and has no one on it to be killed” over the life of the facility. By this definition alone, Operations and Designers were engaged as a single team with the former group assisting in the design process.

It also meant that HSE design issues were an integral part of the discipline engineer’s decision-making process rather than been considered separately by safety engineers as has happened in past Projects.

DESIGN SAFETY GOALS AND HAZARD MANAGEMENT

A critical step in the Inherent Safety Challenge was the development and agreement of design safety goals by the Project Team. It was necessary to accomplish this early in the Project so that all team members were aligned in understanding their basis of development and the role of each goal during the FEED phase. HSE roll out workshops were used to assist in this delivery.

The inherent safety goals were expressed as zero base or minimisation base allowing the team to focus on attempting to achieve the Inherent Safety mission. These goals were based upon the generic hazards identified during pre-FEED associated with the gas development Project and unmanned facilities in general such as seismic, vessel collision, weather, hydrocarbon leak and transportation.

With reference to the Inherent Safety mission statement, the overall design safety objective was defined to be “Zero Visits and Zero Manning for the NUI”. To achieve this objective, a total of 19 Design Safety Goals applicable to the Project were identified and some of these goals are reproduced below:

- minimising inventory;
- minimising potential leak paths;
- maximising natural ventilation;
- keeping the design and intended operating activities simple;
- minimising helicopter flights;
- minimising processing;
- maximising reliability;
- minimise inspection, maintenance and intervention;
- eliminate specification breaks and relief systems;
- minimising manning requirements.

The goals are used to help develop the design options and assist in identifying and refining the most inherently safer design. The desired outcome is that instead of taking a default set of prevention detection control and mitigation measures, the Project team should actively manage the balance between prevention and cure.

In order to confirm that this approach has been adopted during FEED, the goals will be used as guidewords to review and challenge each of the design options. In this way, transparency is established that describes the progress made in eliminating hazards and, where this is not completely practical, what reductions (in order of likelihood, severity and consequence) are achievable, and what arrangements are to be put in place to control and manage residual risks.

By adopting this hierarchal approach to hazard management, the reader will observe that quantitative risk analysis has not been used to "drive the design". Through the application of inherent safety goals and effective residual hazard management, the risk assessment instead of taking precedence now becomes a tool to verify that we have "got the design right". This is illustrated in Figure 1 whereby the design team will:

- avoid active systems wherever possible;
- passive systems should be used wherever possible; and
- avoid dependence on personnel and third parties to identify, control and/or mitigate a major accident.

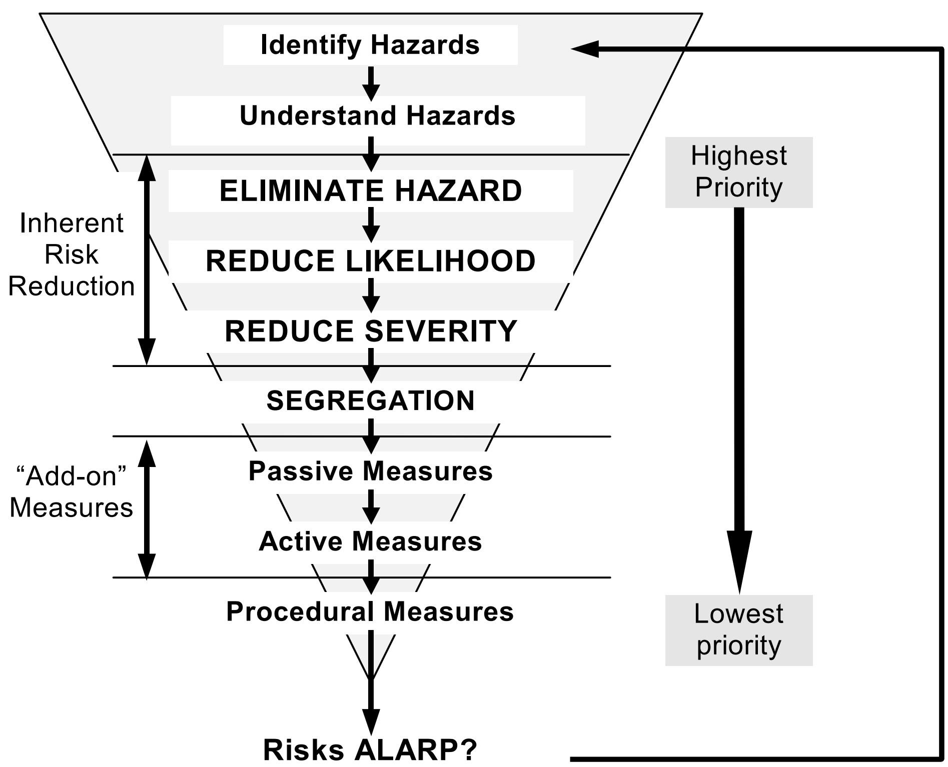

Figure 1. Risk management approach

MAINTAINING THE INHERENT SAFETY CHALLENGE

Dalzell notes that inherent safety is not a discrete activity carried out by specialists or a series of stand-alone safety studies. It is a living process where both the major decisions and the more modest contributions to inherent safety are documented and communicated to other designers and operators. This is essential so that the reasons for each inherent safe decision that establishes the design limits and operating parameters are well understood and not subject to possible revision or impairment in the future.

During this phase, the "inherent safety challenge" will be maintained through:

- Design Safety Moment at all Project meetings;
- Continuing team presentations which focuses on for example, Lessons Learnt, Achievement against Design Safety Goals;
- Safety Challenge workshops;
- Live Hazard Management Plan database.

With the latter, the Hazard Management Plans (HMP) will be designed to capture all critical inherent safe decisions and proposed measures for any residual hazards. The knowledge and understanding of the design and its hazards gained by the designers will be passed onto the operators via the HMP. The HMP will then be revised in the next phase to ensure that safety and operational management systems have been appropriately cross referenced to the design measures.

THE PROJECT EXPERIENCE

A review of the design safety goals reveals that much emphasis has been placed on "designing out" the threats or causes of a major hazard. At the time of preparing this paper, the Project had commenced FEED and the following are examples of how the Inherent Safety Challenge had been applied with preliminary results.

In developing an inherent safe design, the Project Team is always reminded of the fundamental question, "for any proposed addition or removal of an equipment or process system, does this lead us to achieving our objective of zero manning and/ or zero visits ?".

MINIMISE MANNING REQUIREMENTS – EXAMPLE 1

Issue

During the concept selection phase, it was proposed to develop the gas field through offshore dehydration with process platforms and carbon steel export pipelines. Known as the "Dehydration Case", the process would consist of separation, gas dehydration, and export, together with regeneration of the glycol. In addition, vapour recovery (compressor, vessel and heat exchanger) as well as both condensate, water treatment facilities and gas metering was considered. Accommodation quarters would contain up to 30 Person on Board (POB).

Challenge

In design reviews, the Project Team identified the following:

- Could the number of personnel going offshore be minimised?
- Could the duration of maintenance to be performed on the platform be optimised?

Achievement

The Project developed the "Minimum Facilities Case" whereby all processing equipment (and test separator) was removed and transferred onshore. The pipeline material was changed to multiphase corrosion resistant alloy (CRA) pipelines.

By designing for the facility lifetime, the original concept of a manned platform became one of an unmanned facility with minimal processing. This eliminated the need to have personnel stationed permanently offshore and minimised operator intervention. This was the design taken forward to FEED for optimisation.

Currently the design has eliminated the Temporary Refuge (TR) that removes the complexity and fabric maintenance requirements. In addition, the removal of the TR would discourage personnel to "rest" on the platform and conducting any "overnight" work.

MINIMISE LEAK PATHS – EXAMPLE 2

Issue

Standard flange joints as a means of mechanical connection for piping systems has been the automatic choice within the industry. However as a result of the high pressure and high temperature that the NUI will operate within, some of the flange sizes will be outside the ANSI range.

Challenge

Flange joints were identified as a likely leak source for hydrocarbons. The project team identified the following:

- Could the number of flanges be minimised and a better technology employed?
- Could the reliability of equipment be maximised and the maintenance requirements minimised given the environmental conditions it would be subjected to over the design life of the facility?

Achievement

The Project has proposed the use of hub connections for mechanical connections. These connections have had a good history in the North Sea for high pressure and temperature service. The team found that whilst a typical flange design relies on bolt tension for joint integrity, a clamp connector does not directly. The bolts provide the necessary tension for the clamp to act on the hubs and create a seal. Sealing integrity is unaffected by over tensioning the bolts and there are only 4 bolts (which includes 100% redundancy). As a result, the operational maintenance and bolt replacement is significantly quicker compared to a traditional flange.

The smaller overall size of the hub connection (compared to a flange) will assist operations and maintenance from an access viewpoint.

The simple design of the clamp assembly, inherent strength and integrity when installed, coupled with weight and space savings, make it the preferred selection for the NUI pipework. The Project believes that this system offers significant advantages over conventional flanges with less risk of failure requiring less maintenance. This results in less time for personnel to be on the platform.

KEEP THE DESIGN SIMPLE – EXAMPLE 3

Issue

A deluge system had been considered to provide protection to personnel evacuating from the NUI in the event of an ignited release and provide asset protection.

Challenge

Any active fire fighting system required equipment (and fuel storage) that would require maintenance and regular testing. The project team identified the following:

- Could the system reliability be maximised and the maintenance requirements be minimised?
- Is an active system necessary?

Achievement

The design team decided that an active fire fighting system was not required. The team identified that it was more prudent to place more emphasis on technical integrity (i.e. minimise leaks, optimise layout) of the NUI than to develop active systems. In addition, performance standards were to be established such that personnel could safely evacuate from the NUI before escalation could occur. In turn, this ensured the design allowed such egress and evacuation to be safely achieved.

Elimination of this system provided many benefits including

- removal of maintenance requirements (i.e. blocked nozzles) and minimises the need for personnel to visit the NUI.
- removal of congestion on the NUI arising from such equipment.
- elimination of corrosion potential of equipment as the firewater would be saltwater.

MINIMISE RELIEF SYSTEMS – EXAMPLE 4

Issue

Under abnormal condition, the potential existed for the NUI to be exposed to pressure and temperature fluctuations that may require some form of pressure relief.

Challenge

The design team identified the following:

- Was there an alternative system to control a process upset other than reliance upon a depressurisation system ?

Achievement

The team decided that topsides piping would be rated to full wellhead shut-in pressure. By setting the design limit to the maximum expected pressure, the NUI has been provided with a robustness and integrity that could withstand all expected pressures occurring during operation, shutdown and maintenance of wells.

This decision will result in eliminating the need to have an emergency depressurising system that includes associated vessels and piping and a potential leak source. This action will also minimise the congestion on board the topsides.

MAXIMISE RELIABILITY – EXAMPLE 5

Issue

Whilst equipment had been minimised, it was still necessary for the NUI to have power for monitoring systems and importantly, the safety systems, active during and throughout production. Equipment reliability, operating conditions (HP/HT) and third party intervention (TPI) were drivers for selection of the power supply for the NUI, not necessarily in that order of priority. The throughput from the producing wells each day is massive such that the cost of deferred production is a risk in itself. This meant that the electrical service will have to be highly reliable and always available.

Challenge

Electrical power supplies have been traditionally associated with rotating machineries. However these engines are maintenance-intensive pieces of equipment as they have moving or rotating components which are subject to wear and tear. The project team identified the following challenges:

- Could the need for traditional engines such as diesel for power generation be eliminated?
- Could the system be relatively impervious to unwanted TPI which has been an issue in South East Asia where solar panels have often been vandalized or stolen?
- Was the alternative system more reliable and effective than traditional power generation systems?

Achievement

The team identified that other alternative power generation techniques such as gas turbines, micro turbines and thermo-electric generators rely on fuel gas to generate the power. Since no processing was envisioned based on the "minimum facilities, normally unattended installation" concept, these technologies do not align with the project goals.

It was also identified that diesel engines introduced emission issues and from a safety perspective required bulk storage on the platform and regular tank filling. This was in conflict with the goal of zero visits by personnel.

In order to fulfil the goals as closely as possible, the Project decided to investigate the use of power transmission from the onshore facility via submarine cables to the NUI. This had the advantages of:

- removed the need for fuel storage on the NUI;
- minimised the leak paths associated with traditional systems from fuel piping connections; and
- maximised the reliability and minimised inspections of the submarine cables as these were static equipment and the cables themselves were of the "install and forget" type of infrastructure.

CONCLUSIONS

By defining a project specific Inherent Safety Mission and accompanying design safety gaols, the Project has been able to focus collectively on developing a design that will be safer and more reliable. The Project has sought to foster a culture by which all on the design team challenges each other in applying inherent safety principles to their everyday engineering activities.

The Project has recognised that to achieve the goal of "zero visits and zero manning" the design must be simple, reliable and robust enough to minimise the maintenance activities and the number of personnel required.

The role of the Project HSE team has been to assist in the championing of the Inherent Safety Challenge by which:

- All hazards will be identified and fully understood.
- Every opportunity to minimise hazards at source will have been identified in time to be implemented where practicable.
- An effective strategy will be implemented to manage each major accident (i.e. design for the incident or ensure that it doesn't happen).

The outcomes of this approach will allow the:

- Project personnel (operations and design engineers) to fully understand the hazards and risk so they may take ownership and manage them effectively;
- Designers and operators to document the hazard management process so that the latter may understand the operating limits, the hazards, the systems to manage them and their responsibilities for safe operation and maintenance
- Provision of knowledge to allow fully effective systems to be provided to prevent and mitigate the hazards.

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