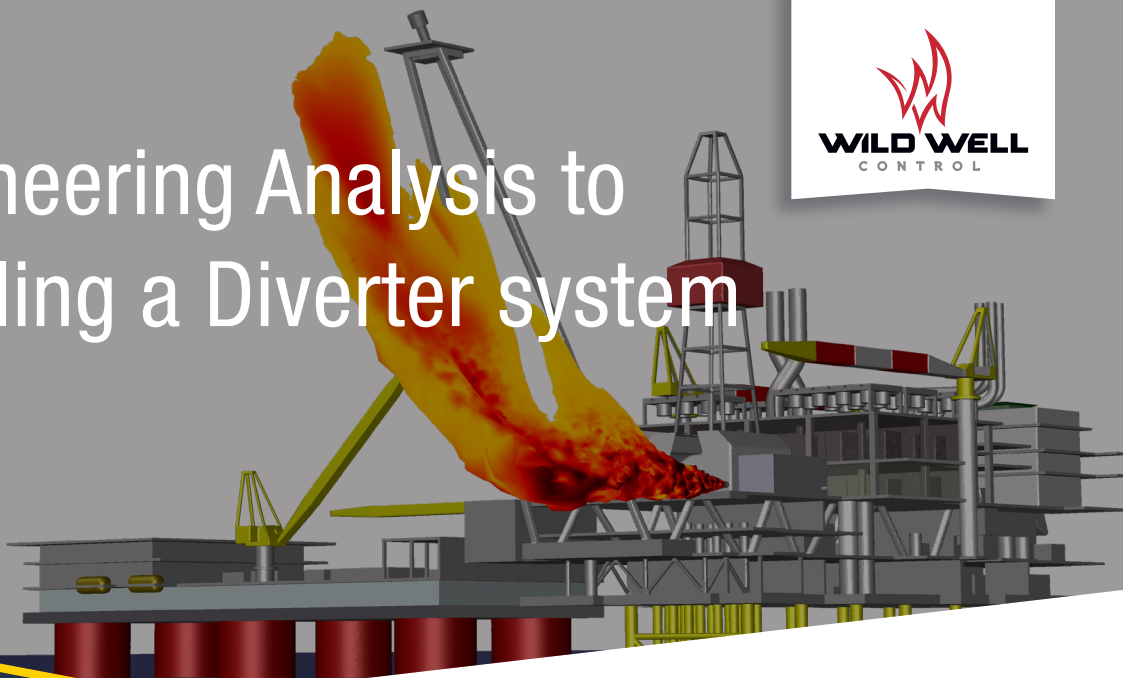


Using Engineering Analysis to Design Drilling a Diverter system

Case Study



BACKGROUND:

Diverter systems are a necessity for drilling wells with potential shallow gas hazards. Conventional diverter designs usually specify that the diverter lines discharge in at least two different directions to account for wind conditions, and that the vent lines have zero or minimal bends and turns to reduce erosion. However, when installing a diverter system on an existing platform, the vent line path may have to deviate significantly from what is considered to be ideal. An engineered solution is therefore required to ensure that this critical well control component is fit-for-purpose should the need arise.

DIAGNOSING THE PROBLEM

Wild Well Control was commissioned to provide a comprehensive design of a diverter system or a drilling campaign on a shallow water gas production platform in South East Asia. The positioning of the existing production facilities and platform flare and the proposed position of the tender assist barge, along with the seasonal wind patterns, complicated the design of the diverter system. The analyses used to deliver the solution included: worst-case discharge estimates for shallow gas, survey and 3D laser scan of the platform, gas dispersion studies, radiant heat studies, erosion analysis and a blast/explosion study.

KEEPING CONTROL

The diverter system is the annular blowout preventer, vent line(s) and vent line valves. It is commonly used in the initial stages of well construction for diverting an uncontrolled flow of hydrocarbons and associated fluids from a drilling rig in situations where the wellbore and the formation lack sufficient integrity and cannot be safely shut in. The most common application for a diverter is in the shallow sections of a well where the surface casing has yet to be run.

A large diameter diverter system allows closure of the drill pipe and preferably includes venting in two directions so as to compensate for wind directions, while diverting wellbore fluids and gases away from the rig. In some cases, line pipe as large as 16 in. is used to vent the flow.

In situations where a shallow pocket of gas is located during drilling, for example, shutting in the well may lead to a 'broach', causing the formation to fracture and flow to occur outside of the wellbore. The closure of the annulus with the provision of an open outlet directs flow from the wellbore in a safe direction. The purpose of a diverter, therefore, is to limit or avoid a significant build-up of pressure at the surface – if addressed, a build-up can lead to

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hydrocarbons breaking through the short casing and surrounding sediments and reaching the surface, with uncontrollable and potentially disastrous consequences.

AN ENGINEERED RESPONSE

The gas platform off shore South East Asia also serves as a pipeline compression station, thereby significantly enhancing its risk profile. The platform jacket was in a water depth of no more than 200 m.

Wild Well Control's specialized engineering team focuses on the deployment of computer-aided engineering, computational fluid dynamics (CFD) and finite element analysis (FEA). Prior to this latest project, the group had performed approximately 20 – 30 gas dispersion studies related to off shore platforms. The platforms in the studies were located in all continents except Antarctica and nearly every major operating off shore basin, including the North Sea, the Gulf of Mexico, Africa, the Middle East and Asia.

The design and layout of the asset in South East Asia presented a significant challenge for the creation of a fit-for-purpose diverter solution. A first set of wells had been drilled using a tender assist rig, and the proposed position of the vessel eliminated one of the options for the diverter system's vent line flow path. In the opposite direction lay the flare boom, which appeared to present an obvious potential safety concern for venting gases. A third direction was subject to prevailing winds for most of the year – another major impediment to the direction of the vent line path. This triple combination of limiting factors represented an extremely rare and complex challenge.

The solution was to design a diverter system that would identify the safest flow path route for the vent lines. Neither of the two available options – proximity to the flare boom or in the face of the oncoming wind – would normally be considered ideal.

TECHNOLOGY

The first phase of the project began with an estimation of flow rates and a physical site survey of the platform. Worst-case discharge rates were calculated based on the formation porosity, permeability and pressures. Hundreds of 3D laser scans of the entire asset were

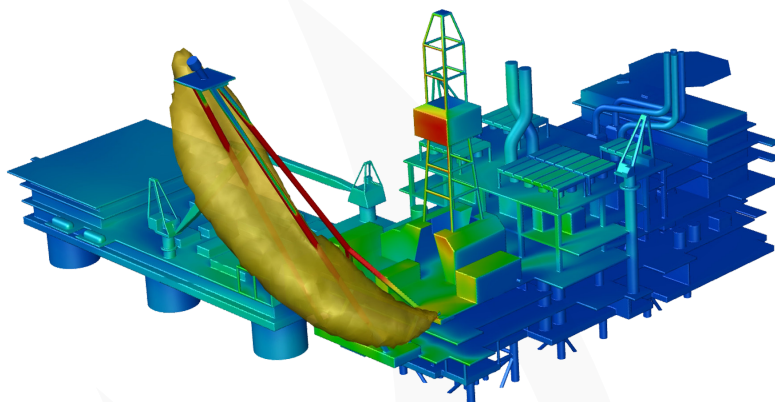


Figure 1. Prediction of radiant heat impact on platform from a jet fire.

taken to create a complete digital visual representation of both the layout and any potential issues, including the positioning of the rig's equipment, the wellheads and the existing production facilities. This, and access to the rig's entire geometry from the computer-aided design (CAD) models supplied, helped to ensure the planned diverter infrastructure would be placed in the optimal position to avoid interference with equipment already in-situ. Providing access to the survey online also allowed for a wider range of expert inputs to determine the most appropriate route for the diverter system's flow path.

A 3D model of the platform was then developed. Flame Acceleration Simulator (FLACS) CFD was among the soft ware deployed to create atmospheric dispersion modelling, explosion simulation and other test scenarios. Erosion rate calculations were made using ANSYS Fluent and from 5D bend erosion studies.

ANALYSIS

Atmospheric dispersion analysis uses calculations and/or simulations to predict the propagation of gas clouds from a blowout, leak or flare. Gaussian plume analysis or CFD determined the concentration of flammable or toxic gases from the source as gas is dispersed by wind and atmospheric turbulence.

Wind speed, temperature, humidity and atmospheric stability are accounted for. Results from the analysis can be used in the planning of safe zones and exclusion zones for well control

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operations, relief well operations and the overall risk of exposing the surrounding areas to a gas cloud.

Wind speeds were provided by the client in a site-specific metocean report. Winds at the site were generally consistent from a prevailing direction for most of the year, with a seasonal monsoonal shift whereby the wind direction generally reversed.

Explosion analysis provided a study of the severity of an explosion should a gas cloud ignite. Such analysis aims to quantify the risk to personnel, equipment and infrastructure. Explosion analysis can include both high-level assessments as well as detailed CFD analysis. This analysis is often followed up by an assessment of the effects of an explosion on the surrounding structure.

DETAILED DESIGN

In line with the relevant standards at the time (e.g. API RP 64, Recommended Practice for Diverter Systems Equipment and Operations 2nd edition) a FEED study was undertaken. This included

an exploration of the optimal diverter line sizes and calculations of potential erosion rates to determine the optimal position for the diverter.

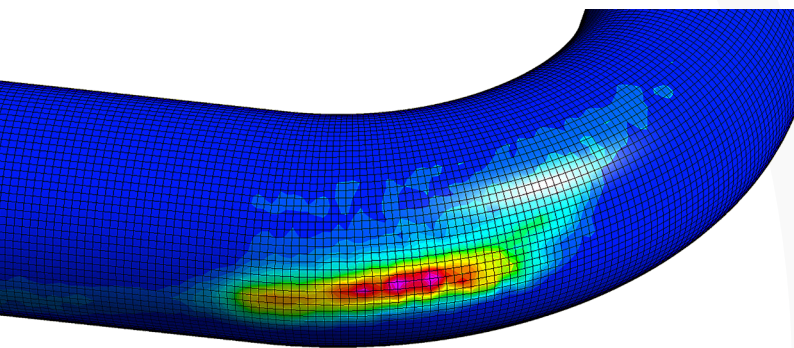


Figure 2. CFD erosion analysis.

Erosion analysis used CFD to predict the erosion rates in pipework, and equipment carrying particle-laden fluids to assess the integrity of the system.

If a fluid flow contains solid particles, then erosion of the walls bounding that flow may occur. This can cause a wide range of problems and is likely to either raise the costs of developing equipment – so that they may withstand erosion – or raise the costs of operating equipment, because of the need to repair and replace worn-out components. It may even cause both to occur. Erosion can also have significant implications for safety and the environment if the failure of a component or pipeline leads to loss of containment of hydrocarbons.

The preferable design for a diverter is for the vent line path to be as straight as possible, in order to reduce the potential for erosion. A surge of shallow gas can contain a range of highly abrasive materials – including rock, gravel and sand – that can cause significant damage to the diverter system. However, the complexities of the topsides layout on this occasion meant that a considerable number of bends and turns in the system would be unavoidable. It was therefore important to fully understand fluid and gas flow rates, and design a system that was able to withstand the anticipated erosion impact.

The next phase of the project included a detailed design of the system. Again, extensive gas dispersion and erosion modelling was undertaken along with radiant heat modelling – to estimate its impact on the platform – and additional thorough structural calculations.

Radiant heat analysis uses calculations and/or simulations to determine the magnitude of radiant heat energy generated by a fire. Results of this analysis can be used to determine the level of risk to personnel and/or equipment that are in proximity to a fire or flare. This analysis is often followed up by an assessment of the effects of the fire on surrounding equipment and structure to examine the potential for an event to escalate.

CFD modelling enabled a range of calculations to be made, including: a safe location for the diverter vent line exit points, erosion rates at all points along the diverter flow path, how far the diverter line would have to be set from the diverter annular, the impact of sand cuttings on bends

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from the diverter housing into the line, the assessment of potential erosion bends along the line pipe, the required wall thickness of the pipe in critical sections and the impact of back pressure on the system.

Detailed drawings and material recommendations were made for all the vent line sections. With multiple well slots and 16 in. line pipe to take into consideration, the focus was on creating a system that would avoid the unnecessary movement of equipment. This was achieved by designing a fixed section for the diverter and connecting that to each well bay, using as few pieces as possible to reduce the potential for erosion.

Where there was not a unique line for every well slot, Wild Well Control designed the pipe segments. With support from the client, the company also advised on sizes for the diverter (approximately 29 in.), the annular diverter and the valve on the diverter line. The line was designed with 16 in. SCH 30 pipe (16 in. outer diameter [OD] x 15.25 in. inner diameter [ID]) and 18 in. SCH 120 (18 in. OD x 15.25 in. ID) in the high erosion areas.

As well as a comprehensive study that included fabrication and manufacturer recommendations, the detailed design incorporated safety assessments as well as personnel evacuation and shut down times, in compliance with the client's own safety processes and procedures.

Guidelines were provided to the client for the setting up of the diverter's control system and its correct use by the drill crew in the event of a 'divert and desert' situation.

APPROVED SOLUTION

Analysis determined that for this particular platform, while the two venting options of towards the wind or towards the flare boom had initially appeared less than ideal, allowing the diverter line to be vented in the direction of the prevailing wind and on the flare boom side were actually both within acceptable risk parameters.

Gas dispersion modelling provided reassurance to the client that the diverter line path would be located at a safe distance from the flare

boom and that any gas concentration levels would be insufficient to enable ignition. The analysis demonstrated that the combination of gas concentrations and wind speeds represented a negligible risk.

As a result of the analysis and design work undertaken, the client was able to safely and confidently proceed with the diverter system.

CONCLUSION

The layout and positioning of a shallow water gas platform in South East Asia presented a unique challenge when it came to the design of a safe diverter system. Initially, conventional wisdom suggested the only two available vent line paths appeared to carry significant risk. However, by application of an advanced engineering simulation, it was demonstrated that a safe diverter system design was achievable.

