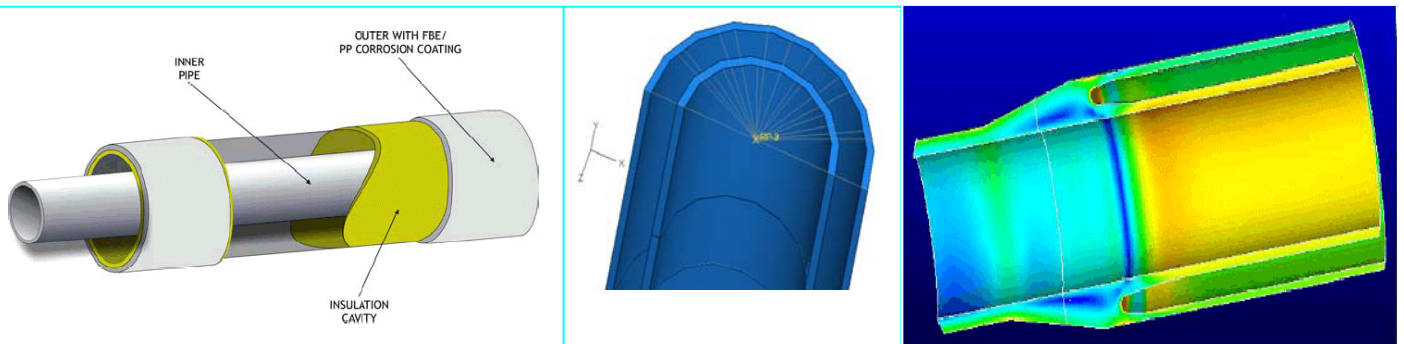


Pipe-in-Pipe

Pipe in pipe systems allow a range of advanced and highly efficient insulation materials to be used to achieve Overall Heat Transfer Coefficients less than $1 \text{ W/m}^2\text{K}$.

These systems are important components of subsea developments where untreated well fluids may have to be transported large distances and wax and hydrate problems have to be managed.

However, as a result of this efficient insulation, thermal expansion challenges are increased and techniques such as probabilistic analysis, upheaval buckling design, snake lay or cooling spools employed to mitigate high expansion loads.



CHALLENGES

High Temperature Well Fluids

High temperature well fluids increase the overall levels of energy in the system increasing the risk of uncontrolled buckling of the flowlines and increasing project costs through the use of pipeline anchors, rockdump or trenching, more exotic materials and the concern that the predicted design temperature is outside the range of applicability of existing design codes.

Wax/Asphaltene/Hydrate formation within product stream

In heavy oils or multiphase pipelines excessive cooling of the product during transportation can result in drop out of high molecular weight waxes and asphaltenes. Increasing the operation increasing the operational pigging requirement of the system, increasing OPEX. In wet gas systems hydrate formation during startup or blow-down conditions can block pipelines.

Long distance tie-backs

Long tie back from a subsea facility to the host platform increases the length of time that the production fluid is subjected to heat loss through the pipeline wall, increasing the risk of flow assurance issues, particularly in the event of shutdown condition and extended residence time of the fluid in the pipeline.

Low OHTC value requirement ($<1 \text{ W/m}^2\text{K}$)

For long tie backs or production fluids with high critical temperatures the Overall heat transfer Coefficient requirements of the system can be onerous. Requiring conventional wet insulation thickness in excess of practical thicknesses for application or installation.

SOLUTIONS

Use of Cooling Spools

There can be significant cost benefit from cooling the product stream from very high temperature wells to minimise the thermal expansion forces and then maintaining this lower temperature for through efficient pipeline insulation reducing the volume of post lay rock dump or trenching required or enabling more conventional materials and analysis techniques to be employed.

Pipe In Pipe

Installing a second pipeline around the product pipeline isolates the carrier pipeline from the seawater surrounding it and creates a dry chamber around the pipeline that can be engineered to accommodate a range of advanced insulation techniques.

Materials

Typically pipeline insulation must be able to withstand the stresses imposed as a result of the installation methods and also be strong enough to withstand constant external pressure and function effectively when submerged and saturated.

The dry, load-free environment within the annulus of the pipe allows non-typical insulation materials with much lower thermal conductivities to be applied subsea than has historically been possible e.g. rock-wool systems etc.

CAPABILITY

Bulkhead Analysis

Bulkheads in a fixed system maintain the concentricity of the system and transfer installation and expansion loads between the inner and outer pipelines. Bulkheads are modelled using detailed Finite Element to ensure that the design is sufficiently robust to accommodate the stresses imposed by combined high temperature, temperature cycling, bending and pressure.

Materials

At high temperatures the behaviour of materials can be uncertain and beyond the limits of applicability of commonly used design codes. J P Kenny is an active participant in Joint Industry Projects and design code reviews developing techniques and guidelines and can tailor these studies to generate an effective and robust engineering solution.

Probabilistic Analysis

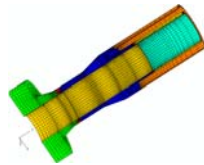
The application of Structural Reliability Analysis (SRA) methods within limit state codes such as DNV OS-F101 can have significant safety and cost benefits. For single pipe and pipe-in-pipe systems JPK have applied SRA to key design areas such as pipe burst capacity (Pipe survival following HIPPS failure), controlled lateral buckling response of pipelines and the confident mitigation of buried pipeline upheavals.

Lateral and Upheaval Buckling Analysis

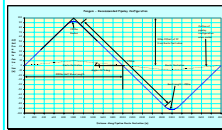
Higher thermal expansion loads are incurred as a result of the highly efficient insulation systems used. To mitigate this J P Kenny is able to carry out advanced upheaval buckling analysis, and snake lay design using advanced non linear soil modelling techniques, to minimise requirements for post-lay rockdump and trenching saving millions in installation costs.

Materials Testing

Detailed knowledge of the achievable performance of the system is vital prior to the installation of the system. J P Kenny is experienced in the specification and supervision of the physical testing of Pipe in Pipe systems and the reaction of the soil-pipe interface ensuring that the system will behave as predicted and perform to specification throughout its design life.



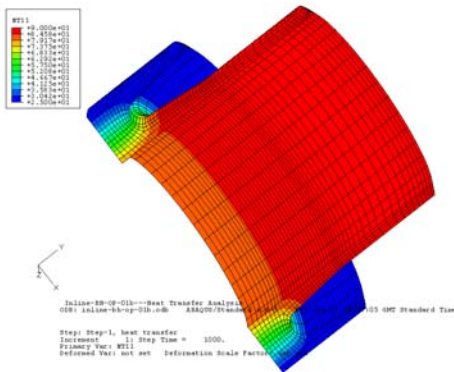
FE network model of a PIP bulkhead – artificial colour scheme identifies bulkhead component parts.



Snake lay design and routing can result in significant savings through reduced Rockdump and trenching requirements



Physical Testing of PIP insulation systems ensures confidence in the performance of the design in-situ.



Finite Element analysis of PIP Bulkhead system showing temperature distribution.

EXPERIENCE

BP - Rhum

J P Kenny Ltd is undertaking the subsea field development of the Rhum Field.

The design scope of work includes design of the following PIP components:

CRA lined 16"/22" x 43km insulated pipe-in-pipe including a fortified section close to the platform, c/w insulated single pipe spools at either end.

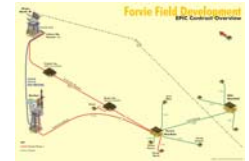
Three 8"/14" insulated reeled pipe-in-pipe flowlines, each with a piggy-back 2" wellhead vent lines, c/w insulated single pipe spool at the manifold and bare single pipe cooling/heating spools at each wellhead. Analysed reeled Pipe in pipe constant and residual stress impact on the pipeline operating response.



TOTAL - Forvie

J P Kenny Ltd. has been awarded the Detailed Design of the North Forvie main production pipeline (pipeline flange to pipeline flange) running from the Forvie Production Manifold to the Alwyn North 'B' Platform for circa 32 km including two in-line tees; Grant and Triassic. The scope excludes the infield flowlines, tie-in spools, manifolds and protection structures.

The design has been carried out in accordance with DNV OS-F101 load-controlled criteria.



Shell - Penguins

Detailed Design Scope on this longest ever PIP tieback included the following elements:

- 10"/16" snaked lay insulated PIP System at Drilling Centre 2 (DC2) to the tie-in Spool flange at DC3;
- 16"/22" snaked lay insulated PIP System at DC3 to the tie-in Spool flange at Brent C.
- Snaked lay PIP pipeline systems designed to DnV2000 using HOTPIPE calibration guidelines.
- Probability analysis of buckle formation was also assessed;



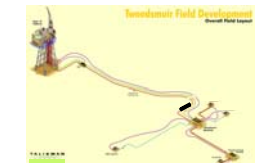
Talisman - Tweedsmuir

JP Kenny have undertaken the conceptual and detailed design of the full lined pipe in pipe flowline system.

At concept stage, this involved a review of options including cooling loops, snake laying, mid-line spools before selecting a trenched and buried solution after extensive risk assessment.

The detailed design has included full assessment of burst criteria, upheaval buckling performance, lined pipe material specification and performance testing.

The scope has included tie-ins design and interface management and control.



BP - Rosignano LNG Import Terminal

Conceptual design of 5km of twin 36" LNG off loading pipelines for BP in Italy. This will be the first buried, cross country LNG pipeline.

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