

**Closing Statement of Peter Waite, Entec on behalf of the Minister for  
Communications, Energy and Natural Resources to An Bord Pleanála oral  
hearing in respect of the Corrib Gas Pipeline – 30 September 2010**

## **Purpose**

This statement has been prepared to assist the Oral Hearing and the DCENR in reaching a conclusion on whether the proposed pipeline and its design incorporates a suitable level of safety in order to protect the public.

## **DCENR Process**

The DCENR has commissioned Entec to undertake a technical appraisal of the Plan of Development (PoD) and EIS submitted as part of the application for approval under Section 40 of the Gas Act 1976, as amended. Entec is examining the public safety issue and some of the technical aspects relating to fitness for purpose. Entec will issue a report giving its recommendations to the Department on whether the Minister could issue a permit for construction, and if a positive recommendation is given, what conditions would be appropriate. The scope of the assessment is the whole pipeline from well-heads to the terminal at Bellanaboy.

## **Issues Raised at the Oral Hearing**

### **Stages of Assessment by the DCENR**

The DCENR safety assessment will not be complete until either the Department advises the Minister to issue a permit to operate, or the Department hands responsibility to CER who will be responsible for issuing a Safety Permit under the Petroleum (Exploration and Extraction) Safety Act, 2010. However the Department will also advise the Minister as to whether a permit to construct can be issued based on the PoD, EIS and further information requested during the technical assessment of these submissions. At each stage the Department may impose conditions to ensure that the design, construction and operation of the pipeline will be within the limits and to the standards described either by the operator, or determined during the assessment.

### **Design Codes**

The Design Codes being used for the Offshore and Onshore Sections of the pipeline are entirely consistent and indeed the Offshore Code DNV OS F101 references other codes, particularly ISO 13623 or more stringent national requirements.

The main features resulting from the design codes are:

- i) the pipeline is capable of withstanding the well head shut in pressure throughout its entire length from the well heads to the terminal, having a uniform wall thickness of 27mm and is manufactured from a consistent grade of steel;
- ii) the entire onshore section to be constructed from the current termination of the offshore pipeline will be tested to 504 barg prior to commissioning.

The use of pipeline codes on the pipeline project is in line with the recommendations of TAG and the NSAI.

## Safety & Reliability of Pressure Protection (Shutdown System)

Notwithstanding the pipeline's ability to contain the maximum well head shut in pressure it is intended to install pressure protection systems offshore and at the LVI to ensure that the Maximum Allowable Operating Pressure (MAOP) of 150 barg at the LVI and upstream of it, and 100 barg downstream is not exceeded. The reliability of these systems has been specified as equivalent to or better than systems elsewhere which protect pipework which may not withstand the maximum pressure in the well. There is also a considerable margin (greater than normal) between MAOP and design pressures both onshore and offshore.

SEPIL has described the reliability assessments of the systems to shut the valves offshore and at the LVI in the event that the pipeline limits approach the MAOP of the onshore pipeline. The LVI valves and offshore valves, together with their control systems are the subject of independent verification by suitably qualified organisations and personnel. The reports are currently undergoing detailed review by Entec staff with suitable qualifications from accredited training.

Note that the "operational valve" which controls flow (and therefore pressure) under normal conditions (i.e. below 93barg at the terminal) is the choke valve which does not form part of the pressure protection system (the valves in this are the SCSSV, master valve, wing valve and well isolation valve).

The offshore shut-down valves are designed to close under fault conditions such as loss of the umbilicals, loss of hydraulic or electrical power. Hydraulic or electrical power is necessary to hold them open against springs which would close them. However even if the offshore valves failed to close and the terminal inlet valve was closed so that the pipeline pressure would ultimately rise to the well head shut-in pressure the pipeline wall thickness is such that it would contain the maximum well head shut in pressure (initially 345 barg), which is less than the hydrostatic test pressure of the onshore pipeline (504 barg).

## Corrib Onshore Gas Pipeline is not Unique

It has been claimed that the composition and pressure of the gas in the Corrib line makes the pipeline unique. However Peter Waite referenced two pipelines designed in the 1980s which show that "raw gas" (i.e. gas that is not to sales gas specification) has been carried in onshore pipelines for many years, at least one at considerably higher pressure:

The Miller Gas St Fergus to Peterhead pipeline (18 km) is a sour gas line, designed to handle hydrogen sulphide content up to 1000 ppm, carbon dioxide up to 25% and free water up to 1 lb/mm<sup>3</sup> (million standard cubic feet). The facility at St Fergus (essentially a complex LVI) has to drop the pressure from a maximum 174 barg in the offshore line to provide pressure protection to the onshore line with an MAOP of 34 barg. (There are also heaters at St Fergus to cope with the temperature cooling associated with this pressure drop). It has an outside diameter of 26 inches and a wall thickness of 11.13mm. It was built to the CP 2010 series of codes which were the predecessors of BS then PD 8010 current up to 1992.

CATS Pipeline on Teesside runs onshore from the beach valves at Redcar about 8 km to the treatment terminal at Seal Sands, including a crossing beneath the Tees Estuary. It is 36 inches in diameter, with an onshore wall thickness of 33.9 mm and a MAOP onshore of 125 barg (offshore 179.3 barg and wall thickness 28.4 mm). This line conveys rich gas, i.e. a mixture of natural gas and heavier hydrocarbons and has to be kept at high pressure to ensure that there is no phase separation. It copes with shut down and start-up conditions. It had a precautionary shut down after a supertanker dropped and dragged its anchor across it, moving it by several metres, the pipeline coating was damaged but there was no loss of containment. This pipeline was also built to the requirements of CP2010.

The Corrib gas has a specification very close to that of Sales Gas (i.e. the gas conveyed by Bord Gáis Éireann pipelines). It only differs in a tiny additional quantity of propane / butane fractions and the presence of a small quantity of water. In order to ensure that there is no free water in the pipe excess methanol will be added. The carbon dioxide content of the gas is very low (much lower than most North Sea gas) and therefore the potential for acidic corrosion (due to mixture of acid gases and water) is very low.

Most offshore reservoirs, particularly in the northern North Sea, contain mixtures of oil, gas and water. The processing offshore is very basic and separates the hydrocarbons from most of the water, then the hydrocarbons are separated into two or three streams, such as crude oil (containing pentane and heavier hydrocarbons), “natural gas liquids” (mainly propane and butane) and natural gas (mainly methane, but may contain significant fractions of other gases including nitrogen, carbon dioxide and hydrogen sulphide). All these streams may contain water and other contaminants. Even if three streams are separated they will be combined into two before being exported by pipeline or tanker. Therefore pipeline gas arriving at the beach often contains natural gas liquids, water, carbon dioxide and hydrogen sulphide and possibly other contaminants which need to be removed before being fed into “sales gas” distribution systems. Offshore processing to sales gas specification is rare.

Therefore it is believed that the assessment of safety can be carried out on the basis of criteria applied to the safety of other pipelines within the experience of the assessment team, applying the requirements of the most stringent codes and standards, to ascertain whether SEPIL’s assurance of the high standard of safety claimed is demonstrated in their submissions and the proposed methods of construction and operation.

## Safety Distances

ABP has requested that the distance between dwellings and the pipeline should be maximised and in any case should be great enough so that even in the event of an unprecedented total rupture of the pipeline, inhabitants of the nearest dwellings would not receive a dangerous dose of “thermal radiation”. This has been interpreted by SEPIL, in agreement with ABP that this should involve calculating the harm to someone who is assumed to be initially outdoors rather than already indoors at the time the hypothetical incident occurs. The current route meets this test.

However this is not the normal method of judging whether a pipeline has been routed and designed correctly. The normal approach, both by other regulators and within standards such as PD 8010 or IGEN/TD1 and TD/2 is to use a risk based approach. Indeed without consideration of likelihood there is no reason for increasing the safety of a pipeline such as by increasing the wall thickness.

The SEPIL risk analysis, presented by DNV as an independent third party assessment, shows that the likelihood of any pipeline leaks is very low. As stated by Dr. Haswell this is because the pipeline design is intended to ensure that leaks due to all the identified causes are designed out, nevertheless the DNV analysis allows for the likelihood of leaks based on the past record of high pressure pipelines adjusted for the circumstances of the Corrib pipeline but accepting that eliminating 100% of all pipeline leaks may not be credible. This follows the approach of the latest codes such as PD8010 part3. The analysis shows that even immediately above the pipeline the risk from an ignited leak is less than  $3 \times 10^{-9}$  per year risk of experiencing a Dangerous Dose (as described by the UK HSE for someone in the open, 100% of the time). This is one hundred times (two orders of magnitude) lower than the normal UK HSE outer boundary of the outer consultation zone and would be described by the HSE as a negligible risk. At the road crossing the pipeline is provided with a concrete slab over protection. Therefore, people in the open or in road vehicles at the pipeline road crossing are at such low levels of risk that would normally be described as “safe”.

## Risk Assessments

The Qualitative and Quantitative Risk Assessments have been carried out in accordance with best international practice. In particular the Quantitative Risk Assessment (QRA) has been carried out using widely accepted consequence models and appropriate frequencies derived from industry databases. The modification of frequencies for Corrib has been carried out in more detail than normal. Whereas some failure modes have been discounted due to the inherent safety provided by the design, the frequency of others has been estimated very cautiously, for example the use of CONCAWE data (from thinner walled pipelines transporting fluids with more corrosive potential) for corrosion is very conservative.

## Failures in Pipes with Wall Thickness > 15 mm

Some pipeline failures in “thick walled” pipelines have been identified:

- 1993 Moffatt pipeline rupture with wall thickness of 19mm – a concrete raft had been laid to protect the pipeline during construction but it was close to an existing road crossing. The pipeline crossing under the road had been laid on consolidated material but the raft had been laid over the pipe where the soil was not consolidated. Differential movement of the pipeline by 100 – 300 mm caused a high longitudinal stress which exceeded the specified minimum yield stress of the pipeline. This illustrates the need to ensure that concrete slab protection is properly designed and is laid on consolidated foundations.
- 1994 Edison, New Jersey 17.1 mm - the rupture was caused by a crack which formed in a gouge to the pipe made earlier (but not detected), growth ascribed to metal fatigue, although the cause of the fatigue (movement or expansion / contraction is not described). (36 inch diameter 69.2 barg operating pressure).

Therefore it would be more correct to state that there are no records of ruptures in pipelines with wall thickness greater than 19mm. There is no record of third party interference leading to a rupture for wall thickness greater than 17 mm.

Moffat does not affect the European records of failure due to third party interference as this was not the cause.

## Control of Modifications

Shell has a corporate safety management system that requires modification of plant to be assessed and approved. The Pipeline Integrity Management System needs to be completed to describe the procedure for this either within the overall Corrib scheme, or as a standalone component. This would normally be part of the detailed work during the detailed engineering and construction phase although all modifications to the approved design would be expected to go through change control for safety, environmental, technical and cost implications.

If there were to be a change to the Plan of Development or a new Plan of Development because SEPIL wished to connect new fields to Corrib then a full assessment and a new permit would be required before the introduction of new fluids would be allowed.

## Response to Defects in the Tunnel

SEPIL has determined criteria for damage to the pipeline that would require intervention. Note that damage has to be greater than a predictable depth and area for it to pose a threat to the integrity of the pipeline. In the event that damage or deterioration of the pipeline exceeded this threshold (itself highly unlikely) then SEPIL have a contingency plan to insert a smaller diameter pipe inside the main pipeline. This would not involve disturbance to the bay as access would be gained from an on-land section of the pipeline. It is not considered necessary to assess the impacts of this contingency plan as it is of such low probability.

## Vibration and Ground Instability

A search of world wide standards for thresholds of vibrations to cause damage has been undertaken. Continuous vibrations will be noticed from as low as 0.14 mm/s ppv, but the threshold of damage to buildings such as dwellings is usually quoted as 8 mm/s ppv (peak particle velocity) or more. The lowest thresholds for inducing slope instability are of the order of 25 mm/s. (Obviously precariously balanced stones may move prior to this but that is not the type of structure of concern here, if it were then the lowest possible threshold would be that for sensitive, delicate historic buildings which is 2 mm/s ppv in California. - Note an error in a secondary source conversion of units resulted in an inaccurate figure during Peter Waite's response to questions).

Given that the SEPIL predictions for vibrations from piling are up to 0.1 mm/s ppv (which is higher than from tunnelling) at the nearest house, monitoring with an action level below the threshold of damage to houses and an absolute limit below the minor damage level would give further assurance. This would give a considerable margin above the predicted levels. In addition it is much lower than the trigger of landslide risk even though further attenuation takes place before the slopes of Dooncarton.

Therefore the proposed monitoring with a reasonable ppv threshold would give protection against building damage and the landslide risk. It is suggested that SEPIL set a low action threshold so that mitigation would be introduced well before any annoyance or damage thresholds are reached. Both effects depend to some extent upon frequency and so conservative levels should allow for any frequency being present whether the vibration arises from tunnelling, piling, traffic or other sources.

Continuous vibration at 0.5 mm/s ppv at the proposed monitoring points representing dwellings closest to the route, might be regarded as a suitable warning level (this would be well above any modelling predictions so not likely to occur). Levels above 2.5mm/s ppv (the high end of tolerability) should result in immediate mitigation measures and an absolute upper limit to avoid any significant damage could be the 12.5 mm/s ppv proposed by SEPIL. These levels at the road would also indicate that the levels at the steep slopes on Dooncarton Mountain would be much lower due to further attenuation (less than 0.2 mm/s expected from the attenuation results presented) and so three orders of magnitude (or one thousandth) of levels that are quoted as the threshold for instigating land slides.

## Verification of Pressure Limits

The systems for limiting the pressure in the pipeline are automatic and have fixed set pressures which can be verified by inspection. In addition modern process instruments are linked to central computers which monitor all instrument readings (via a "SCADA" system). These records may be interrogated to verify that pressures have remained within the permitted limits. Although the codes allow short excursions above MAOP this cannot happen in the Corrib pipeline as the systems are set to close the shut down valves before the MAOP is reached.

## Independent Verification

SEPIL has its own system of verification which is tracking the pipeline from metal sheet production at the mill through to installation and commissioning. Mr Gerard Keane described the DCENR process for reviewing the verification process and making independent checks and observations of the work as well as of the formal reports.

## Tunnel Feasibility

The increasing level of detail available from the geotechnical investigations gives more confidence that the TBM and construction of the tunnel will not encounter unforeseen conditions. This relates not only to hardness of the rock and presence of obstacles or obstructions, but also the stability of the tunnel in the layers encountered. Calculations have been carried out but will need to be confirmed upon completion of the survey and final selection of the TBM and contractor. The tunnel as designed allows for the peat layers and sediments identified.

## MAOP and Other Constraints as Conditions or Legal Limits

The MAOP, flow rate and the wells feeding the Corrib pipeline are described in the Plan of Development and will be part of the conditions of operation of the pipeline. If these are not adhered to then SEPIL would be in breach of the consents and permits issued.

## Outstanding Matters

SEPIL has provided more detail of the following matters referred to in the opening statement by Peter Waite on behalf of DCENR:

- third party verification of reliability of pressure control systems;
- verification of concrete slab design and construction at water channel and road crossings;
- response to defects or damage in the pipeline within the tunnel;
- selection of TBM and tunnelling contractors with experience of similar projects;
- ground conditions beneath Sruwaddacon Bay and how the material properties have been taken into account in the specification of the tunnelling works;
- attenuation of vibration away from the road to the south and proposed monitoring north and south of the Bay to check that vibrations are below the thresholds of damage or instability, in line with the modelling predictions.

The responses indicate that there are no major concerns sufficient to withhold a permit to construct, subject to technical expert review and further confirmation of details of TBM design. There would also be conditions attached to ensure commitments were followed.

Three matters that are properly for completion prior to an operating consent being granted but which need to be considered during the final Engineering and Construction are:

- Project and Plant specific safety management system procedures for the control of modifications, (note that modifications cannot result in operating outside the parameters defined in the Plan of Development, or further constraints within the Consent Conditions). This and other key procedures required is shown in the EIS Appendix Q 6.3 Table 2.1;
- Details of the testing procedures for the emergency shut down valves and their controls and instrumentation. Although these are described in terms of frequency the procedures need to be reviewed to ensure completeness; and,
- Completion of Emergency Response Plan incorporating the necessary measures for the pipeline and LVI into the terminal's plan.

Minor matters which are not seen as fundamental to granting of consent but which need to be confirmed as satisfactory and in place include:

- Monitoring and control systems on TBM fluids, principally bentonite slurry and grout;
- Confirmation of pipeline stress analysis, for example, when the tunnel contractor details method statement, including allowance for any differential settlement at tunnel / trench, or stone road interface.

## Conclusions

The assessment carried out on the proposed design, as described in the submissions leads Entec to conclude that there are no significant reasons on grounds of public safety reasons for refusing to grant a consent to construct the Corrib pipeline on the basis of both absolute separation from dwellings and the extremely low level of risk presented by the pipeline. DNV's QRA and the verification of the high reliability of the pressure limitation system provide assurance that the pipeline will be operated within the design specified.

Conditions will be recommended to ensure that the analysis and assumptions used in the assessment remain valid and in compliance with the codes quoted by SEPIL and specified by TAG. The conditions should refer to ongoing verification and inspection.

Some further details are required before issuing a permit to operate can be recommended but these are matters which would be expected to be developed during engineering and construction but prior to commissioning.