INTRODUCTION

My name is Gerry Costello. I am the Deputy Project Director for the Corrib Project for Shell E&P Ireland Limited. Shell E&P Ireland Limited is the operator of the Corrib Gas Field on behalf of Shell, Statoil and Vermilion. I have a BE and an M Eng Sc in Mechanical Engineering from UCD. I have worked in the Upstream Oil and Gas industry for Shell for the past 40 years. I have extensive experience in developing onshore and offshore gas fields in Western Europe, the Middle East and South East Asia. My experience encompasses wet gas and transmission quality gas pipelines and sub-sea developments. I have been the project manager on the Malaysian LNG Dua Upstream Gas Development project in the early 1990s and subsequently was the project manager on the Oman LNG Upstream Gas Development project in the late 1990s. Both projects were successfully brought on stream. I have worked on the Corrib development since 2002.

1. In this Statement I will introduce Appendix Q of the Corrib Onshore Pipeline Environmental Impact Statement (EIS) by explaining its purpose and structure, and highlighting its key aspects.
2. I will also take the opportunity to introduce each expert witness.

PURPOSE OF, AND BACKGROUND TO, APPENDIX Q

3. The purpose of Appendix Q is to 'present a complete, transparent and adequate demonstration that the pipeline 'does not pose an unacceptable risk to the public' and meets all relevant Irish and international safety and design criteria.
4. Appendix Q also provides detailed information on the technical and safety issues raised by An Bord Pleanála in their letters dated 2nd November 2009 and 29th January 2010.
5. It is SEPIL's view that Appendix Q provides a full demonstration that the modified design of the Onshore Pipeline satisfies the criteria specified by An Bord Pleanála with respect to risk tolerability and with respect to 'appropriate hazard distance'.
6. I would like to state that SEPIL's view continues to be that the designs and routes previously proposed for the Onshore Pipeline were safe and fully in accordance with the Codes and Standards designated by the Regulator, the Minister for Communications, Energy and Natural Resources, DCENR.

APPENDIX Q TEAM

7. The preparation of Appendix Q, which covers the technical and safety aspects of the Corrib Pipeline, has required the collaboration of many experts in order to respond to the wide-ranging questions raised by An Bord Pleanála. The experts present for this hearing include Mr John Gurden from JP Kenny, pipeline design consultants, Dr Jane Haswell and Gary Senior from PIE, Pipeline Integrity Engineers, Ian Malcolm and Steve Hamilton from XODUS, Process safeguarding and multi phase flow specialists, Sheryl Hurst, Risktec, Qualitative Risk Assessment specialist, Dr Phil Crossthwaite, DNV, Quantitative Risk Assessment specialist, Dr Turlough Johnston, AGEC, geotechnical specialist, Dr Steve Paterson, Shell, Corrosion specialist, and others who may be called if the need arises.

SCOPE OF APPENDIX Q

8. The scope of Appendix Q is to provide a detailed overview of how all issues affecting the safety in design and the future integrity of the Onshore Pipeline have been, and will be, managed. Although part of separate regulatory approvals, information is included in respect of the offshore sub-sea well production facilities as this has a direct bearing on the gas pipeline pressure regime, internal corrosion management and prevention of hydrate formation.
9. In response to the two letters received from An Bord Pleanála on 2nd November 2009 and 29th January 2010 modifications to the design and operation of the pipeline are now proposed. The key public safety related modifications are:

    A) The pipeline has been re-routed in a 4.9km tunnel under Sruwaddacon Bay; this optimises the distance to dwellings.

B) The Maximum Allowable Operating Pressures (MAOP) in the Offshore and Onshore Pipeline sections have been determined as 150 barg and 100 barg respectively. The latter is significantly less than the maximum pressure of 144 barg recommended by Advantica in 2006, and now falls within pipeline pressure ranges covered by transmission pipeline codes without the need to extrapolate. In point of fact An Bord Pleanala approved a 30" diameter gas transmission pipeline in SW Ireland with a maximum pressure of 98 barg and a wall thickness of 12.5mm in 2009.

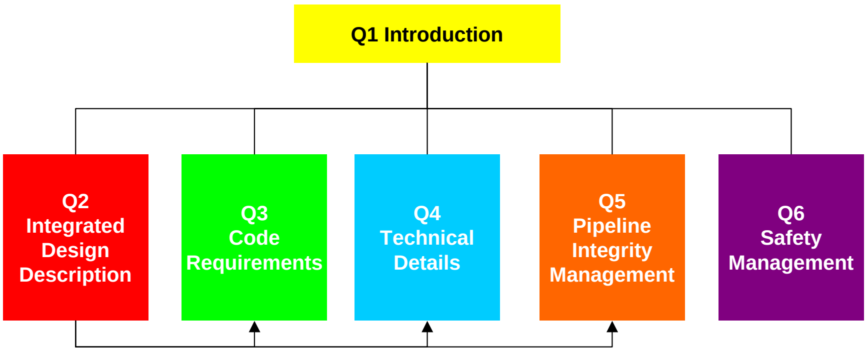
C) The reliability of the offshore process safeguarding system has been significantly enhanced by hardware modifications at the Terminal.

D) Fibre optic based leak detection and intruder detection systems have been newly introduced for the onshore pipeline.

STRUCTURE OF APPENDIX Q

10. An Bord Pleanála in page 2, point (c) of their letter of 2nd November 2009 requested that SEPIL *"provide an integrated set of design documentation in the form of a revised Appendix Q".* To this end Appendix Q draws together and inter-relates the individual documents produced by different specialists and technical experts.

11. A schematic summary of Appendix Q is provided in the Figure below. **[SLIDE 1]**



12. Section Q1, attachment Q1A provides a cross reference between the Bord's questions in their letter of 9th November 2009 and the detailed responses in the EIS.

13. Section Q2 summarises the design approach.

14. Section Q3 describes the Codes and Standards that are applicable.

15. Section Q4 provides an overview of the pipeline design and supplementary services such as fibre optic cable and umbilical. Also included is a review of specific issues such as settlement of the stone road, process safeguarding, and corrosion. (Note that the documents in this Section provide key support to the Qualitative and Quantitative safety assessments in Section Q6).

16. Section Q5 discusses the pipeline integrity management system from design through to operation.

17. Section Q6 provides an assessment of the safety-specific aspects of the Onshore Pipeline and includes a report on public safety aspects of applicable Codes, the Qualitative and Quantitative Risk Assessments, the analysis with respect to hazard distance, and the intended approach to Emergency Response Planning.

CODES AND STANDARDS

18. With reference to An Bord Pleanála's letter of 2nd November 2009, Page 2 Points (a) and (b): The applicable Codes and Standards for the design, construction and operation of the Corrib Onshore Pipeline are clarified in Appendix Q3.2. Appendix Q3.3 contains confirmation that the requirements set down by the Technical Advisory Group to DCENR have been met.

TECHNICAL ISSUES – GAS PRESSURE

19. An Bord Pleanála's letter of 2nd November 2009, page 2, point (c) requested that *"the maximum allowable operating pressure (MAOP) for the pipeline should be stated."* In the context of An Bord Pleanala setting "an appropriate hazard distance" criterion and having regard to public perceptions of pipeline pressure SEPIL has carried out extensive steady state and transient flow process studies for the entire Corrib gas delivery system to minimise the operating pressure envelopes for the offshore and onshore pipelines whilst still retaining supply capacity at 350 mmscfd. By modifying the operating pressure margins and plant operating processes it has been possible to define the following MAOPs. These MAOPs are 150barg for the Land Valve Installation (LVI) and pipeline upstream of the LVI, and 100barg for the pipeline downstream of the LVI.

20. As described in Appendices Q2.1, Q4.5 and Q4.6 there are multiple layers of automatic protection provided for the pipeline system to ensure that the Corrib System is kept below the defined MAOPs. These layers involve the offshore wells, the landfall valve installation and the Gas Terminal. This pipeline pressure protection system will be addressed by Ian Malcolm in his Statement

PIPELINE SAFETY MANAGEMENT

Public Safety: Application of Design Codes and Proximity to Buildings

21. The Onshore Pipeline design codes stipulate requirements for the selection of a factor of safety in relation to the population density called the Design Factor (the lower the design factor the greater the wall thickness hence the safer the pipeline). The Corrib Onshore Pipeline originally had a Design Factor of 0.72, which corresponds to the Design Factor required for a pipeline located in a rural area with low population density. Following a recommendation from Advantica a more conservative Design Factor of 0.3, applicable for suburban areas, was adopted. This more conservative Design Factor is retained although the population density is reduced as a result of routing the pipeline further from occupied dwellings. Furthermore, implicit in the Code based adoption of a Design Factor of 0.3 is that, whilst such a pipeline may leak, it will not rupture.

22. It is noted that the Shannon LNG pipeline, that has recently had its planning application approved by An Bord Pleanála, operates under a similar pressure range as the Corrib pipeline but has a Design Factor well in excess of 0.3.

23. In accordance with graphs in pipeline codes I.S. 328 and BS PD 8010, and based on the MAOP of 100 barg and a Design Factor of 0.3, the pipeline may be located 3 metres from a normally occupied building. For the Corrib pipeline the minimum distance from the pipeline to a normally occupied dwelling is 234 metres, which is substantially in excess of the Code minimum requirements.

24. This aspect will be covered by Dr. Jane Haswell in her Statement.

Qualitative Risk Assessment

25. In response to An Bord Pleanála's letter of 2nd November 2009, page 3, point (e) a comprehensive qualitative risk assessment is presented in Appendix Q6.3. .

26. The principal means for assessing the benefit from additional risk reduction measures has been via the qualitative approach which concludes by demonstrating that the risks associated with the pipeline have been reduced to levels that are As Low As Reasonably Practicable (ALARP).

27. The output from the qualitative assessment, together with output from studies in Section Q4 has provided a key input to the Quantitative Risk Assessment (QRA).

28. The Qualitative risk assessment will be presented by Ms Sheryl Hurst in her Statement.

Quantitative Risk Assessment

29. In response to An Bord Pleanála's letter of 2nd November 2009, points (a), (b), (d), (j) and (k) and clarification provided in their letter of 9th January 2010, a QRA of the Onshore Pipeline is provided in Section Q6.4.

30. A key element of the revised quantitative risk assessment is the transparent approach to failure frequencies as requested by An Bord Pleanala.

31. The overall conclusion from the QRA is that the predicted levels of risk associated with the proposed pipeline and LVI are extremely low. For example, the predicted level of individual risk at the nearest dwelling to the pipeline of receiving a dangerous dose is 1.8 chances in 100,000,000,000 per year, almost 100,000 times below the level of risk described by An Bord Pleanála in their correspondence as being the 'broadly acceptable' threshold.

32. The QRA includes a number of sensitivity studies using more onerous parameters; nevertheless risk levels associated with the pipeline remain well within the 'broadly acceptable' region.

33. The QRA will be presented by Mr. Phil Crossthwaite in his Statement.

Emergency Response Planning & Provisions

34. Appendix Q6.6 provides an initial draft of the emergency response planning and provisions to illustrate SEPIL's intent with respect to managing emergency response and describes the plans for engaging with, and involving the public and the emergency services. I do not propose to go into all the details now but would like to make a number of key points.

35. The Emergency Response Plan must be approved by Mayo County Council prior to the start-up of the pipeline, though the plan cannot be approved until planning permission for the pipeline has been given.

36. Discussions with the relevant authorities and emergency services have commenced and the Emergency Response plan for the Bellanaboy Bridge Gas Terminal has been agreed.

37. SEPIL is one of a number of the responders; the other key responders are the Gardaí, Ambulance and Fire Services and the Coastguard. The lead responder to a given incident will be dependent on the type of incident.

38. The emergency response provisions in place will be practically identical to those in place for BGE transmission lines across the country.

39. Prior to the pipeline becoming operational SEPIL will liaise with the local community. Part of this liaison will be to ensure that residents are briefed on the specific details of what they are advised to do in the case of an emergency and how they would be contacted. Residents will receive an information pack containing briefing material on what to do in an emergency, with all relevant contact details and phone numbers.

40. In the event of an incident, the community will be automatically notified via an automated notification system. Residents will be contacted prior to start-up and invited to submit their priority contact details.

41. All Shell operations across the globe must have emergency response provisions in place. This experience has been used in developing the response plan for the terminal and pipeline.

42. SEPIL staff at the terminal are trained in responding to emergency situations, that training has already commenced.

43. I would like to close this item by reminding you that the Emergency Response plan is mandatory and having a plan in place does not give an indication that it will ever be required.

UNPROCESSED NATURAL GAS

44. Transmission system gas has a certain familiarity for all of us. It is that familiarity which ensures that as a society, we have an appropriate response to the risk associated with it, i.e. because we understand its benefits and safety features, we accept the risk. Although there are some differences, in reality, both transmission system gas and Corrib gas would present the same impact to the community, in the highly unlikely event of a worst-case scenario.

45. I will address here the differences between the gas produced from the Corrib reservoir, which can be termed unprocessed or untreated natural gas, wet gas or raw gas, and treated transmission gas and how those differences can be mitigated to ensure safe and reliable production of the Corrib gas comparable to the well accepted transmission system gas. The key

to ensuring safe production is in understanding all of the risks associated with Corrib gas and managing those risks effectively.

46. The composition of natural gas in reservoirs varies considerably and in 40 years of working in the Upstream oil and gas industry I have been involved in natural gas projects with gas with very high concentrations of Carbon Dioxide, CO_2, with concentrations of Hydrogen Sulphide, H_2S sufficient to be toxic and with very high quantities of liquid hydrocarbons, condensate. Each of these projects posed their special challenges in terms of corrosion management, safety concerns on account of toxicity and management of potential slugging in the pipeline. The Upstream offshore gas industry has developed techniques to safely manage the challenges posed by the varying composition of natural gas as it is discovered in reservoirs.

47. By contrast with developments I have previously worked on, the composition of the Corrib gas contains a very low concentration of CO_2, H_2S has not been detected and there are very limited quantities of hydrocarbon liquids in the Corrib gas. Relative to other natural gases the Corrib gas poses fewer threats and requires less processing before it enters the gas transmission system.

48. The composition of the Corrib gas will not change over time. The mode of production for the Corrib reservoir will not introduce extraneous fluids (imagine the Corrib reservoir as an inflated balloon, the air exiting the balloon has the same composition at the end as it has at the start) and thus H_2S will not start to be produced from the reservoir.

49. **[SLIDE 2]**: As can be seen from the slide the composition of the Corrib gas in the pipeline as it arrives at the Bellanaboy Bridge gas terminal and as it is exported into the Bord Gais Eireann transmission system is virtually unchanged with the exception that water and injected methanol have been removed from the gas and the proportion of heavier hydrocarbons - butane and higher, which represent the liquid part of the reservoir fluid, have been reduced from an already very low proportion. In terms of energy content per cubic meter there is virtually no change between the pipeline gas and the sales gas.

Parameter	**Unit**	**Pipeline Gas**	**Sales gas**
Methane, Ethane and propane	Mole %	95.57	96.93
Butane, Pentane & higher (C5+)	Mole %	0.13	0.12
Carbon Dioxide	Mole %	0.25	0.26
Nitrogen	Mole %	2.61	2.64
Water	Mole %	1.09	0.00
Methanol	Mole %	0.35	0.05
Heating Value of Corrib gas	MJ/m3	37.38	37.76

50. Having established that natural gas in the Corrib pipeline is very similar to the sales gas let us now review the differences and how these affect the design and operation of the pipeline. As can be seen from the slide the main difference is the water and methanol content for the upstream pipeline gas versus the transmission quality gas.

51. The presence of water in the gas has three effects and I will go on to explain how these effects can be mitigated,

    A) In combination with CO_2 it can give rise to corrosion under the conditions prevailing in the pipeline,

    B) It can in combination with methane form crystalline solids, called hydrates, at low temperature and high pressure, which can block production in the pipeline and

    C) In the liquid phase, the water in combination with liquid hydrocarbons that may be present, gives rise to multi-phase flow (i.e. a mixture of hydrocarbon gas, water and hydrocarbon liquid), which if flow conditions are not controlled can create liquid slugs or surges in the pipeline.

52. Firstly let us look first at CO2 corrosion, which is the main threat to the integrity of the Corrib pipeline associated with the untreated nature of the gas. There are three key factors that demonstrate low corrosivity:

a) The CO2 content of the gas is low at 0.25 mole %, which compares favourably with the sales gas specification limit of 4.0 mole %,

b) The temperature of the gas in the onshore pipeline is close to ambient sea bed temperature and this reduces the corrosion rate

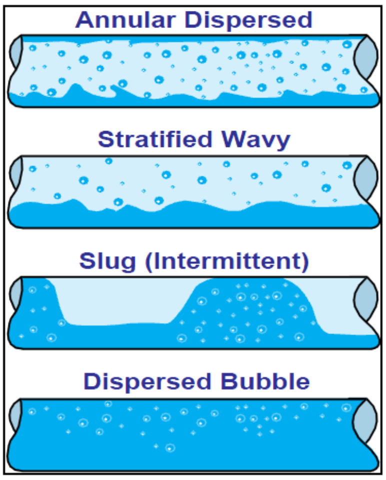
c) Corrosion inhibitor will be continuously injected with the methanol at the wells, which further reduces the rate of corrosion.

The upshot of all these factors is that the expected rate of corrosion in the pipeline is less than 0.02 mm/yr and so the threat to the pipeline (wall thickness 27.1mm) from corrosion can be safely contained and monitoring processes will be in place to confirm the continued integrity of the pipeline. To put this in context 0.02 mm is one sixth the thickness of a sheet of copy paper.

This topic will be addressed further by Dr Steve Paterson in his statement.

53. Secondly the concern with hydrates forming in and blocking the pipeline is primarily the associated loss of production and security of supply. Shell and Statoil have carried out extensive research into the formation and remediation of hydrates and for a development like Corrib the hydrate issues are well understood and the risks can and will be mitigated to ensure safe and reliable operations. To prevent hydrates forming methanol is continuously injected into the pipeline at the wells and sub-sea manifold at a rate well in excess of that required. The methanol injection pumping facilities at the Bellanaboy Bridge gas terminal have 100% back-up on automatic standby to ensure reliability of injection and the operating procedure requires offshore gas production to be stopped immediately if there is an interruption in the injection of methanol at the wells. Hydrate blockages will not cause the pipeline to fail and detailed procedures will be put in place and technical specialists from Shell's technology group in the Netherlands would be mobilized to safely remediate a hydrate blockage in the unlikely event that one occurs. Hydrates are dealt with in App Q 4.5 Section 6 and in the Statement from Dr Steve Paterson

54. Thirdly there is the issue of multi-phase flow in the Corrib pipeline. Again Shell and Statoil have been at the forefront of research into the behaviour of multi-phase hydrocarbon pipelines and software is available that accurately predicts the flow behaviour in the Corrib pipeline under both steady state conditions and transient conditions (e.g. during start up, shut down or when flow rates change). Because the liquid fraction in the pipeline is low it is easier to maintain stable flow in the pipeline. **[SLIDE 3]**



55. Extensive analyses have been carried out for the varying conditions over the life of the Corrib field and these analyses show the pipeline flow regime to be in the stable annular dispersed mode. The slug catcher is also sized to have sufficient capacity to cater for the predicted liquid surges that occur when flow rates increase due to varying demand. The Corrib pipeline will not, therefore, operate in a slugging regime with associated flow instabilities and consequent vibrations. This topic is dealt with in Appendix Q 4.5 Section 5 and can be further elaborated on

by Mr Steve Hamilton, from XODUS, one of the leading specialist consultancies in Flow Assurance.

56. In summary the concerns related to internal corrosion, hydrate formation and multi-phase flow as a result of producing untreated or wet gas are well understood and have been properly mitigated by the design and planned operation of the Corrib onshore pipeline. The nature and the composition of Corrib natural gas is close to that of treated gas and thus does not introduce the hazards of other wet gases.. Furthermore, the conservative design factor of 0.3 resulting in a wall thickness of 27.1 mm, the distance of the pipeline from occupied dwellings and the leak detection and intruder detection systems further emphasize that Corrib onshore pipeline is a low risk pipeline notwithstanding the presence of untreated gas.

CONCLUSION

57. In this Statement I have outlined the structure and content of Appendix Q, outlined some of the key aspects, and introduced the specialists who will be presenting further detailed Statements and answering any questions you may have.

58. I have summarised the conservatism built into the selected pipeline Design Factor and the fact that the building proximity distance according to applicable Codes is 3m from the centreline of the pipeline.

59. I have described how the qualitative risk assessment and specialist studies have provided transparent input to the Quantitative Risk Assessment, and how the quantitative risk predictions for the pipeline are well within the ‘broadly acceptable region’.

60. In particular I have described aspects associated with unprocessed gas, the fact that the nature and the composition of Corrib natural gas is close to that of the downstream processed gas, and the fact that the associated risks of wet gas are well understood and managed.

61. In summary the Corrib onshore pipeline by virtue of being routed well away from occupied dwellings, the conservative design factor used, the wall thickness of 27.1 mm and mitigation of wet gas issues, can be considered among the safest gas pipelines in Ireland.

This concludes my brief of evidence

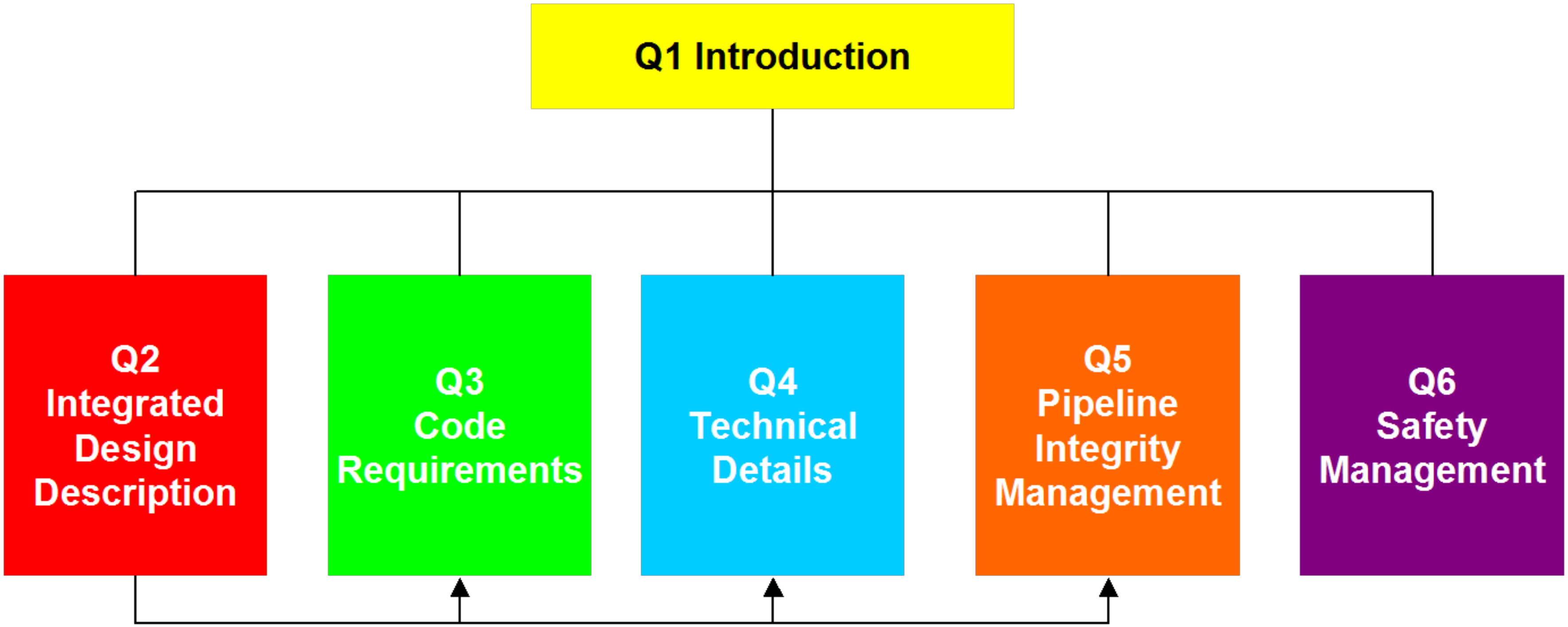
Corrib Onshore Pipeline

Introduction to Appendix Q

By Gerry Costello

(An Bord Pleanála Application Reference No.: 16.GA0004)

Corrib natural gas


Q1 Introduction
Q2 Integrated Design Description
Q3 Code Requirements
Q4 Technical Details
Q5 Pipeline Integrity Management
Q6 Safety Management

Corrib Gas Composition

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Corrib natural gas

Multi-phase flow patterns in horizontal pipelines