Cold Venting and Ignition

Witness Statement of Robert Burns to the Corrib IPPC Lice

Witness Background

My name is Robert Burns and I am a chartered engineer with a B.Sc. and Ph.D. in Mechanical Engineering. I have worked for Shell for 15 years, the last 7 years as a risk consultant in Shell Global Solutions. My work involves hazard identification, determining the physical effects of these hazards and quantification of the risks associated with them. Many of the hazards are related to hydrocarbon gas releases and a large part of my work is in modelling gas releases, cloud dispersion and hydrocarbon fires/explosions.

I have performed an assessment of the potential hazards arising due to the cold venting operations and potential ignition of these vents. As part of this assessment I have familiarised myself with the specific venting processes and gas compositions of the Bellanaboy Gas Terminal. From the perspective of the cold vents and flares the Corrib plant is similar to many other gas plants and presents no unusual technical issues.

1. Introduction

This statement has been prepared to answer a number of objections raised against the Proposed Determination of the IPPC licence for the Bellanaboy Gas Terminal.

Objections have been raised concerning the following issues:

- the movement of the vented gases after release into the atmosphere and whether these could present any hazard downwind of the plant
  "The cold venting ... in such close proximity to local dwelling houses and outlying towns and villages will surely pose a serious health risk in the future."

- the potential separation of heavier components of the released gas leading to locally concentrated levels of the heavier components released
  "Cold Venting - the release of gas that hasn't been burned, into the atmosphere will cause air pollution. Standard pipeline gas is usually over 80% methane. The methane is lighter than air and thus floats up into the atmosphere. However the problem arises when heavier than air compounds and chemicals are dispersed into the air along with methane. The fact that these toxic heavier than air compounds and chemicals come to ground within the proximity of the site, poses an unacceptable health and safety risk to the local community"

- the effect of igniting the vented gases and any potential thermal or over-pressure (explosion) effects
  "Into an environment already charged with c.eight million cu.mt per day of emissions, the applicant additionally proposes to release large quantities of raw natural gas. .. the release of highly flammable and combustible gas in this context constitutes a serious fire hazard"

This statement addresses the above topics and objections.

2. Venting And Dispersion

2.1 Corrib Plant Vent Stacks

Flaring and venting scenarios are discussed fully in Ian McRae's Witness Statement. The releases discussed in this section are unignited cold vents released from either the HP (high pressure) or LP (low pressure) vent/flare stacks. These are dual purpose open ended stacks 40m high which run alongside one another to the top of the flare/vent tower. The HP flare is 407mm in diameter and the LP flare is 305mm in diameter. They are designed for operation in the unignited state as vents, or if the gas is ignited as flares. There is an ignition system consisting of pilot light burners that can be used when flaring is required but outside of plant maintenance or other depressurisation situations these will not be lit.

2.2 The Form of the Vent and Dispersion

The vented gas is normally odourless and has a composition similar to that of natural gas found in the gas mains. It is emitted vertically from the top of the vent stack as a jet and will form an invisible plume. Initially it is carried upwards into the surrounding atmosphere by the momentum associated with its release velocity. The jet will interact with the surrounding atmosphere forming a series of eddies that will mix air into the plume. Through this process the plume will become more dilute, will expand and will slow down. This process is known as jet dispersion.

The density of the plume at the point of release is approximately 60% that of the surrounding air and is positively buoyant. In addition to the upwards velocity of the plume it will thus have an additional tendency to rise. As it mixes with the air the concentration of natural gas in the plume decreases.

After a certain distance the plume's velocity will have reduced to a level where its behaviour will become dominated by the effects of buoyancy, air stability (or turbulence) and the prevailing wind. This process is known as passive dispersion.

The wind, buoyancy and momentum remaining in the plume will cause it to continue moving away from the stack and the mixing effects present in this passive dispersion region will continue to cause it to become more dilute with distance from the release point. As it does so it continues to grow in size and at some point will contact the ground. The exact point and distance from the stack will vary depending on the release rate, wind speed, and atmospheric conditions. However by the time it does so the plume will be very dilute – between 1000 and 100,000 times less than the concentration at the point of release and it will not be flammable.

2.3 Composition of The Released Gas

The released gas will be similar to that of natural gas in the transmission lines in Ireland. The major sources of venting are compressor purging and compressor seal gas venting.

The primary components of the gas as determined by analyses of gas samples taken from the Corrib field are methane, ethane, nitrogen and carbon dioxide which together account for more than 99% by volume of the released gas. Although at very high concentrations these components can present a danger of asphyxia, they are not toxic and at the levels that can be reached on the ground they will have no effect. However, the gas also contains trace quantities of other components and it is thus necessary to assess the potential exposure levels. This is determined by dispersion modelling and is covered in James Garvie's Witness Statement.

2.4 Release Modelling of Vent Flammability

Modelling tools are commonly used to assess the behaviour of intentional and unintentional releases under different conditions. The tool that has been used to produce the results presented here is FRED (Fire, Release, Explosion, Dispersion). The code within FRED is based on physical models of a number of phenomena including dispersion, combustion and explosion. It has been validated against a series of full-scale experimental tests and it is accepted by many regulatory bodies Worldwide. The composition and conditions of the Corrib vents/flares are well within it's area of applicability.

2.4 Variations in Gas Cloud Composition

The plume of gas has a uniform composition at the point of release. As it disperses it will have higher concentration of gas towards its centre and higher concentrations of air towards the edges where it is mixing directly with the atmosphere. Although the concentration thus varies at different locations in the cloud the relative composition does not. The relative concentration of methane, ethane, carbon dioxide, etc. remain constant and there is no tendency for heavier components to move towards the bottom of the cloud nor for lighter ones to move towards the top.

Buoyancy effects only operate at the macroscopic scale and thus affect the cloud as a whole rather than the individual components. For the same reason the atmosphere itself shows no differences in the proportion of the heavier oxygen or lighter nitrogen components with changes in altitude; they stay in the same ratio of approximately 21% oxygen and 78% nitrogen.

3. Ignition of The Vent

3.1 Necessary Criteria For Vent Ignition

It is only possible for the vent to ignite if it forms a flammable cloud and an ignition source is present within this flammable cloud.

For a natural gas in air cloud to be flammable it must lie between two limits known as the upper Flammable Limit (UFL) and the Lower Flammable Limit (LFL).

At the point of release the concentration of natural gas in air will be too high to support combustion i.e. the mixture is too rich. As it disperses it becomes more dilute and the concentration will fall until it falls below the Upper Flammable Limit. This is equivalent to approximately 15% by volume of natural gas in air.

The now flammable cloud continues to disperse becoming more dilute until a point is reached where the cloud becomes too dilute to support combustion. This is known as the Lower Flammable Limit and beyond it the mixture of natural gas and air is too lean and cannot burn. It is equivalent to approximately 5% by volume of natural gas in air.

Between the Upper and Lower Flammable limits the cloud can burn if deliberately ignited by for example a pilot light or flare gun or by a natural ignition source such as an electrical discharge.

The highest cold venting rate comes from the compressor purge during start-up (for a maximum of 45 minutes up to 12 times per year). For this rate of venting the concentrations at the outlet of the vent are shown in Figure 1 which forms Appendix D to SEPIL's "Submission on Objections to Proposed Determination" of 10th April 2007. The UFL and LFL limits are shown on the figure for the case of a wind speed of 2m/s and the maximum size of the cloud is approximately 5m in diameter and 15m in length. At higher wind speeds the cloud becomes slightly longer and a little narrower.

3.2 Immediate Ignition of the Release

If the gas is ignited immediately at the start of the release it will form a stable flame. The appearance of this flame will be bright yellow and will tend to be vertical but bent over in the direction of the prevailing wind. Because of the high methane content the combustion is quite efficient exceeding 98% and it will burn with almost no visible soot or smoke. This is in contrast for example to a liquid hydrocarbon fire such as kerosene which typically produces large quantities of smoke.

3.3 Delayed Ignition of the Release

If there is any delay between the release starting and ignition the plume will have time to form a flammable cloud of a size similar to that shown in Figure 1. If the release is then subsequently ignited this cloud will burn away and be replaced by the stable flare as before. The burning process is uneventful and often difficult to distinguish from the stable flare which immediately follows it as the cloud is only slightly larger than the stable flare. There would be no overpressure, or explosion, associated with this event and indeed there may not be any noticeable sound produced by the ignition itself. The gas cloud beyond the Lower Flammable Limit cannot ignite and all burning is limited to the flammable cloud between the UFL and LFL limits.

3.4 Natural Gas Explosions

It is not possible for an unconfined cloud of natural gas and air to cause any significant overpressure i.e. it cannot explode and this has been investigated very thoroughly in numerous experimental tests. Ignition of such clouds around vent/flare stacks is a standard operating procedure on gas plants and production platforms throughout the World. The ignition is often performed using a hand held flare gun fired from a point close to the base of the flare stack and presents minimal risk to the plant, operator or surrounding area.

Although natural gas explosions do occur they are caused when the flammable cloud is contained within an enclosure such as a building or a congested area. Neither of these conditions is present at the top of the vent stacks and purging rates are more than adequate to prevent the mixture within the stacks from igniting.

4. Summary

In this statement I have hoped to address the objections raised to the Proposed Determination in connection with the impact of unignited vented gas and the perceived hazard of this subsequently being ignited. To summarise:

4.1 Cold Venting

This assessment has considered the highest credible release rates and conservative weather conditions to determine the maximum concentrations that might be experienced during venting. These present no hazard to the plant or the surrounding area.

There is no tendency for the heavier components in the vent to separate out preferentially towards the bottom of the release plume.

The quantities of gas making up these cold vents is very low and this method of disposal is justified because the alternatives would require the burning of fuel gas to maintain flare pilot lights. This would be accompanied by light pollution and would increase the visible profile of the plant. Moreover several of the vented streams, including the gas vented from the compressor dry gas seals are diluted with nitrogen and not flammable in air.

4.2 Vent Ignition

The LP/HP stacks are designed as dual purpose vents/flares and ignition is a standard operational event. It presents no hazard to the plant or surrounding area and it is not possible for this ignition to cause an explosion.

Figure 1. Position of the Upper and Lower Flammable Limits for the cold venting associated with compressor purging. Wind speed 2m/s.