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be 2E-07per year. Because of its thickness and its resistance to external impact or operational loadings, and the non propagation of a hole to a rupture, this frequency is adjudged to be an overestimate, and consequently DNV consider that a large failure or rupture in the slugcatcher is of such a low probability that it can be neglected in this analysis. The slugcatcher is provided with two manholes at the southern end for internal inspection. If all controls fail, then there could be a failure of the manhole following an internal inspection. The frequency of this event has been set at once every 100,000 operations, with an internal inspection every 10 years.

- Bund Overtopping. There have been a number of failures of atmospheric storage tanks that have resulted in the contents of the tank being released in such a way that some of the contents have spread over the bund wall (Wilkinson A). Appendix IX contains a frequency and consequence evaluation. Because of the low frequency of failure (less than 2E-07per tank year) and the modern design/construction/inspection of the tanks DNV consider that this mode of failure can be neglected.

- Catastrophic failure of a road tanker. In certain circumstances there could be a major failure of a road tanker whilst on the site. As this type of failure is extremely rare (less than 1E-08per year, see Appendix IX) this scenario has not been included. Consequence information for a major release from a road tanker, e.g. during transfer, is presented in Appendix IX. Another scenario is a fire beneath a road tanker containing methanol or condensate which could result in the failure of the road tanker due to flame impingement. Such a failure would not give a 'traditional' fireball, but a relatively small release of low pressure vapour. This is because the material in the road tanker is liquid (rather than a liquefied flammable gas) and the tankers have a thin wall construction rather than the thicker wall pressure vessel construction.

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## 3.5 External Hazards

As stated above, the OIR 12 data include failures from all types of initiating events. However, as they are based on offshore failures, certain failure modes normally considered for onshore plant may not be included. A consideration of a number of external hazards is contained in Appendix X. One specific external hazard which is relevant for the proposed terminal is considered in more detail in the next section.

## 3.6 Effect of the Trees around the Terminal

The terminal will be surrounded by trees for visual impact reasons; the layout of the tree banks is shown in Appendix I. The presence of trees may affect the hazard potential associated with the terminal in the following ways:

- Fire spread from the trees to the terminal.
- Ignition of the trees from a fire at the terminal.
- Increase in explosion potential because the trees act as a region of congestion.

There are examples of existing hazardous installations within areas of trees in Appendix XI. In all cases the trees are present because the installation is in a rural area and there is a requirement to provide a screen to limit the visual impact of the installation. The distances



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between the control buildings and the trees and between the plant and the trees are indicated, and it can be seen that these distances are as low as 15m for the control building and a similar distance for the plant. This compares with 40m for the proposed control building-tree distance and 85m for the proposed plant – tree distance.

Codes of practice contain guidance on minimum separation distances between process plant (normally storage facilities) and site boundaries etc. A summary of some relevant separation distances is also contained in Appendix XI.

The frequency of tree fires in the west of Ireland is not known. Based on UK data, the frequency of any particular location in a wooded environment being engulfed by fire is 2E-04per year.

### 3.6.1 Impact of Fire Spread from the Trees to the Terminal

This has been considered by calculating the thermal radiation levels at (1) the plant and (2) the control building should the trees adjacent to these areas be on fire. This calculation has used a solid flame method. Assuming that the control building and the tree fire are parallel vertical surfaces, the vertical plane view factor (Yellow Book) can be used. The absorption due to the atmosphere has been calculated using the average value for the formulae given in Bilo and Kinsman and Lees FP. The temperature of the tree fire was derived to be 812°C (1085K), which is equivalent to a surface emissive power of 79kW/m$^2$, based on the received thermal radiation flux levels given in Cohen and Butler, assuming an emissivity of unity. The trees immediately to the south of the control building are some 11-11.5m high, and separated from the building by 40m (this is a distance beyond which ignition of a structure from thermal radiation is unlikely to occur). To derive a flame height, it has been assumed that the ratio of tree height to flame height is 2.5 (Stocks et al). This relationship is for dense 65 year old jack pine 12m high with a black spruce understory, a fuel ideally suited to the generation of high intensity crown fires, so may be conservative for the trees to the south of the control building which are mature conifers (Sitka spruce) planted in 1959 at 2m intervals in rows 3m apart (typical Coillte Teo planting). The duration of a tree fire, and hence the likelihood that the thermal radiation will cause ignition of structures some distance away from the trees is typically one to two minutes (Cohen and Butler). For an exposure of two minutes, the thermal flux required to cause ignition of such structures would be approximately 25kW/m$^2$.

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### 3.6.2 Impact of a Fire at the Terminal on the Ignition of the Trees

The potential impact of the terminal on the trees has been considered using the thermal radiation frequency contours for 25kW/m$^2$ for jet fires (25kW/m$^2$ would be capable of igniting trees if the exposure duration was very long) (Bilo and Kinsman), although a slightly lower level is suggested by Cohen and Butler. For short duration fires, the distance to the spontaneous ignition of wood has been calculated and used (Bilo and Kinsman).

### 3.6.3 Effect on Explosions

There have been several incidents where there has been a release of hydrocarbon from a pipeline in a rural environment and subsequent ignition has caused the generation of overpressure (thought to be assisted by trees in the vicinity of the release). The hydrocarbons



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The application of failure frequencies from offshore experience to onshore plant is not ideal. However, in the view of DNV, the OIR 12 database is the highest quality database available for leak frequency determination, and the high quality of the data more than offsets the potentially inappropriate application to onshore facilities. The leak frequencies derived as described above are, incidentally, higher than those used by DNV from earlier onshore sources, higher than those applied by the UK HSE (Planning Assessment Guidance) and higher than those in the Netherlands (Purple Book).

The OIR 12 data have been applied directly to the high pressure gas system except for the sections below:

- Inlet gas pipeline upstream of the first ESDV. This is the end of the line from the offshore platform as it rises above ground and enters the terminal (approximately 5m in length above ground). Design in accordance with BS 8010 Part 2 results in a pipe wall thickness of 27mm (including 1mm corrosion allowance). Use of underground pipeline failure frequencies for the inlet pipeline within the terminal up to the ESD valve directly would give a rupture frequency of 2E-06per year. A recent analysis of failures in European gas pipelines (Bolt, R) indicates that the major causes of pipe rupture are external interference and ground movement. However, there is a strong relationship between releases caused by third party interference and the pipe wall thickness, and there have been no failures due to third party interference for pipelines with wall thickness exceeding 15mm. Earlier research by British Gas (Jones and Fearnehough) indicated that excavators cannot give a hole of 80mm diameter in pipe which has a thickness of more than 12mm, which led to the conclusion that proximity distances (in IGE/TD/1) should not be defined on the basis of a major puncture (or rupture) and that a 3m separation (for operational reasons) would be adequate because if a failure occurred it would be very small and would not propagate. Further, as the pipeline is totally within the control of the terminal, third party activity will not occur. So far as ground movement is concerned, as the pipe is to be laid on a rock bed within the terminal, this mode of failure has also been dismissed. As an operational pipeline, rapid depressurisation may cause a low temperature which in turn could lead to brittle fracture (this failure mode is not explicitly recorded in pipeline failure data, so a specific frequency cannot been derived). Depressurisation controls embodied in the pipeline blowdown procedure will ensure that low temperature will not occur. On the basis of the resistance to external impact, support of the pipeline by rock, control over the pipeline and its depressurisation and the non propagation of a small hole to a rupture, DNV consider that a large failure or rupture in this section of the pipeline is substantially lower than the generic frequency and is of such a low probability that it can be neglected in this analysis.

- Slugcatcher. The slugcatcher has a wall thickness of 60mm, and has been designed to ANSI B31.3. This code gives a greater wall thickness than other codes considered for the design (vessel and pipeline codes). There are a number of slugcatchers in operation worldwide, but the number of years operation without a failure is insufficient to derive a statistically valid failure frequency. However, on the basis of this thickness and its resistance to external impact or operational loadings, and the non propagation of a hole to a rupture, DNV consider that a large failure or rupture in the slugcatcher is of such a low probability that it can be neglected in this analysis. The slugcatcher is provided with two manholes at the southern end for internal inspection. If all controls fail, then there could

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