

Application of Pipeline Risk Assessment for the purpose of providing Land Use Planning Advice to Local Planning Authorities

Scope of Application

- 1 Guidance is given on the methods for calculating the risk levels for pipelines defined as Major Accident Hazard Pipelines (MAHP) in accordance with the Pipelines Safety Regulations (PSR) 1996, in order to assess the acceptability of developments within the Land Use Planning (LUP) zones.
- 2 Guidance is specifically provided for existing cross country hazardous pipelines, and general principles to be applied to all hazardous pipelines.
- 3 The Guidance below is based on the standard methodology for deriving the risk levels used to define the generalised Land Use Planning zones for MAHPs as defined above. In many cases, specific local conditions will change some of the parameters used in the methodology resulting in different risk contours.
- 4 The general approach to the risk assessment process follows the stages outlined in [IGE/TD/1 EDITION 4 Appendix 3](#).
- 5 This guidance presents the consultation zones for [natural gas](#) pipelines based on recommended building proximity distances ((BPDs) [given in IGE/TD/1 Figures 4 and 5 of Section 6.7](#)) for the inner zone, and risk levels of 10^{-6} and $0.3 \cdot 10^{-6}$ calculated in accordance with the methodology given in [IGE/TD/1 EDITION 4 Appendix 3](#).
- 6 Recommendations for conducting site specific risk assessments and relevant risk reduction factors are given.
- 7 Recommendations for the installation of pipeline protections measures in line with those for new pipelines are included.

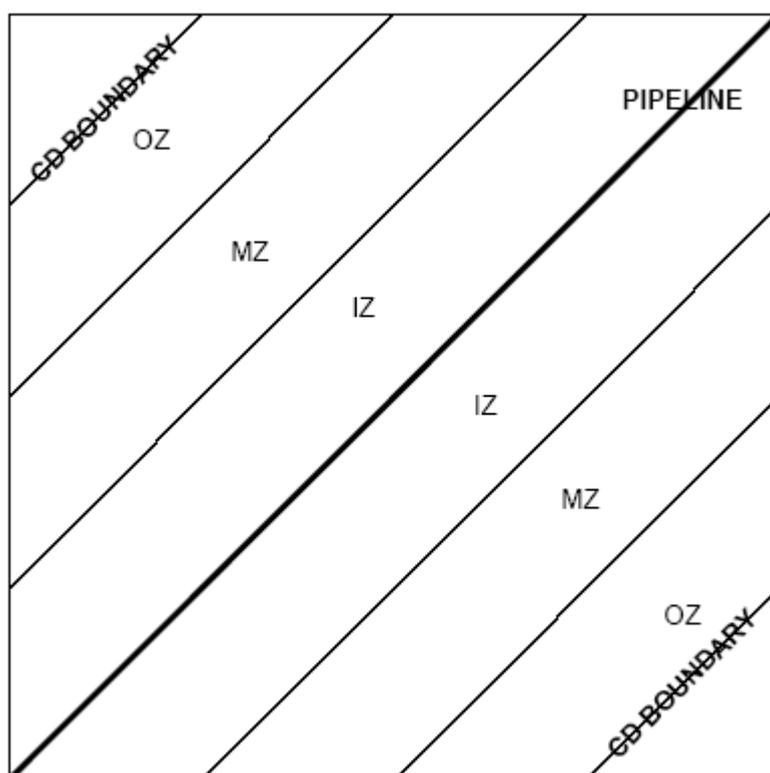
Land Use Planning

- 8 Land Use Planning describes the process of applying zones to Major Hazard Installations, including major hazard pipelines, inside which there are restrictions on the type and location of planning developments.
- 9 The purpose of the zones is to mitigate the risk to the surrounding population by limiting (or reducing) the number of people who might be affected by a major accident involving the pipeline, and to minimise the possibility of third party excavations causing damage to the pipeline.
- 10 Land Use Planning zones in the UK are only applied to major hazard pipelines as defined by the 1996 Pipeline Safety Regulations.
- 11 Local Planning Authorities are responsible for land use planning decisions under the Town and Country Planning Act (*insert Scottish legislation*) and the Health and Safety Executive (HSE) are a statutory consultee with responsibility to advise on acceptability of any developments planned in the vicinity of hazardous installations and pipelines with respect to public safety (*extend section with ref to PADHI*). Local Authorities notify HSE of any developments within a risk based consultation zone defined by HSE for this purpose.
- 12 Land Use Planning zones define 4 areas:-
 - i) Inner zone which is immediately adjacent to the pipeline, and inside which the most restrictions to development are applied.
 - ii) Middle zone which limits significant development.

- iii) Outer zone which limits vulnerable or very large population.
 - iv) Area outside the Outer zone, where no restrictions apply.
- 13 Details of permitted developments and limitations are contained in a document produced by HSE called Planning Advice for Developments near Hazardous Installations (PADHI). This methodology defines the HSE approach for the provision of LUP advice for proposed developments in the vicinity of pipelines.
- 14 HSE have adopted a risk-based approach for calculating the distances to the zone boundaries from the pipeline, defining the levels of risk as each boundary as follows:-
- i) Boundary between inner and middle zone – based on an Individual Risk of 1×10^{-5} per year of “Dangerous Dose” or worse, or the pipeline BPD, whichever is the greater.
 - ii) Boundary between middle zone and outer zone – an Individual Risk of 10^{-6} per year of “Dangerous Dose” or worse.
 - iii) Boundary between outer zone and no restrictions – an Individual Risk of 0.3×10^{-6} per year of “Dangerous Dose” or worse.
- (Dangerous dose is a level of harm defined by HSE methodology and approximates to lethal effects to 1% of the exposed population).

This is shown in Figure 1 below:

Figure 1: Consultation Distance Inner, Middle and Outer Zones



- 15 The inner zone for a high pressure gas pipeline is equivalent to the pipeline BPD, and is obtained directly from IGE/TD/1 EDITION 4 Section 6.7 Figures 4 or 5.
- 16 The middle zone for a high pressure gas pipeline is obtained from the location of the 1×10^{-6} risk contour on the individual risk transect for the pipeline. Typical middle zone distances for gas pipelines are given in Figure 2.

- 17 The outer zone for a high pressure gas pipeline is obtained from the location of the 0.3×10^{-6} risk contour on the individual risk transect for the pipeline. Typical outer zone distances for gas pipelines are given in Figure 3.

Figure 2: 10^{-6} Risk Contour for Natural Gas Pipelines

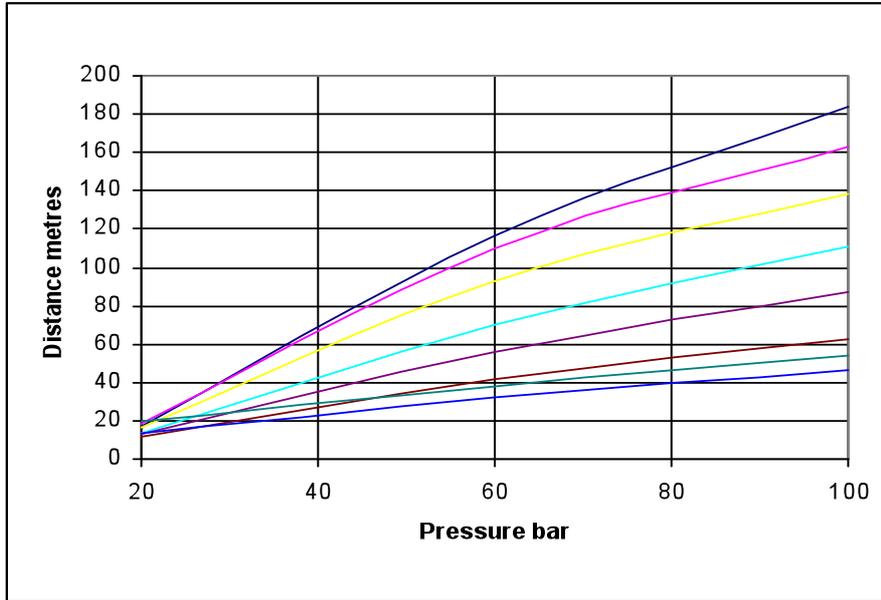
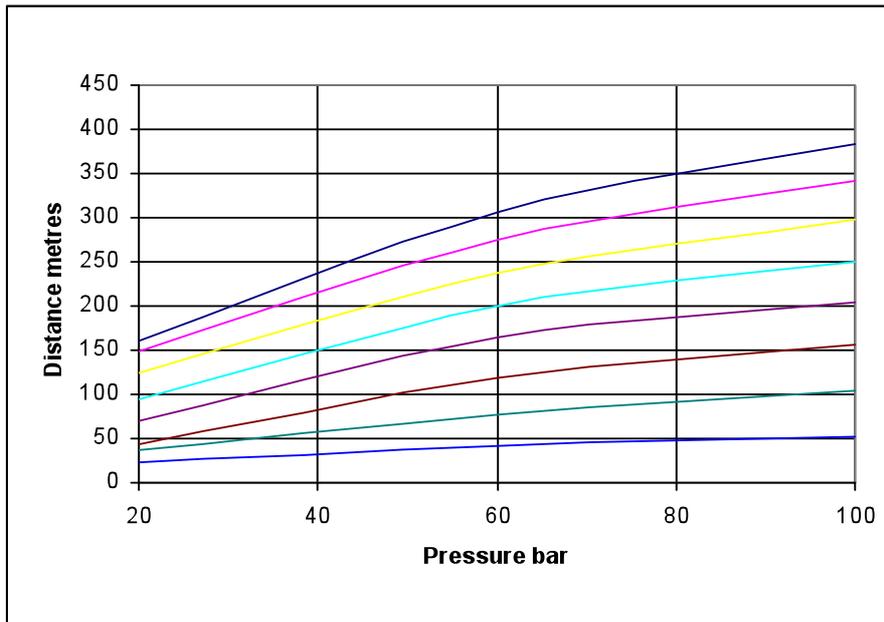


Figure 3: 0.3×10^{-6} Risk Contour for Natural Gas Pipelines



- 18 PADHI uses two inputs to a decision matrix to generate the response:
- the zone the development is located in of the 3 zones (that make up the Consultation Distance) that HSE defines around the major hazard pipeline.
 - the 'Sensitivity Level' of the proposed development which is derived from an HSE categorisation system of "Development Types".
- 19 The matrix generates either an 'Advise Against' or 'Don't Advise Against' response.
- 20 There are a number of aspects of the HSE land use planning and major hazards work that PADHI does not deal with, including: **Developments near pipelines, where the pipelines have sections with additional protection measures** - PADHI uses the 3-zones set by HSE that are based on the details given in the pipeline notification. This covers the whole length of the pipeline and is unable to accommodate isolated local variation. If subsequently advice for a planning application is 'advise against', then the option is given to check with the pipeline operator if the pipeline has additional protection (e.g. thicker walled pipe) near the proposed development. If so, then HSE risk assessors are willing to reconsider the case using the details of the pipeline specification relevant to the pipeline near the development.
- 21 The type of development is obtained from the PADHI Development Type tables.
- 22 Development Types are used as a direct indicator of the Sensitivity level of the population at the proposed development. Exceptions are made for some very large or very small developments by assigning them a higher or lower Sensitivity Level than normal for their Development Type.
- 23 The PADHI Development Type Tables provide details on the four basic development types:
- People at work, parking
 - Developments for use by the general public
 - Developments for use by vulnerable people
 - Very large and sensitive developments
- 24 The Sensitivity Levels are based on a clear rationale in order to allow progressively more severe restrictions to be imposed as the sensitivity of the proposed development increases and the ease of evacuation reduced. There are 4 sensitivity levels:
- Level 1 – based on a normal working population
 - Level 2 – based on the general public – at home and involved in normal activities
 - Level 3 – based on vulnerable members of the public (children, those with mobility difficulties, or those unable to recognize physical danger)
 - Level 4 – large examples of level 3 and large outdoor examples of level 2
- 25 The PADHI decision matrix is:

Sensitivity Level	Allowed Developments		
	Inner Zone	Middle Zone	Outer Zone
1	√	√	√
2	X	√	√
3	X	X	√
4	X	X	X

- 26 HSE have published the risk levels which define the boundaries between the above zones. This supplement to [IGE/IGE/TD/1 EDITION 4](#) provides detailed advice for calculating the distances to these risk levels, and gives examples and results obtained for various natural gas pipeline design cases.

27 This Guidance should be read in conjunction with [IGE/TD/1 EDITION 4 Appendix 3:Risk Assessment](#).

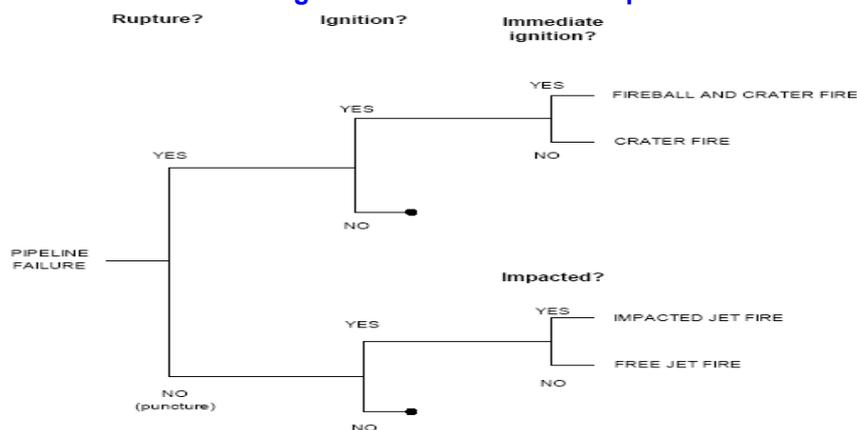
Requirements for the Risk Assessment of Pipelines

- 28 Quantified Risk Assessment (QRA) applied to a pipeline involves the calculation of risk resulting from the frequency and consequences of various credible accident scenarios.
- 29 Pipeline failure frequency is usually measured in failures per 1000 kilometre years. Failure frequency should predicted using recognised predictive models, or otherwise derived from historical incidents which have occurred in large populations of existing pipelines. Various factors are then taken into account for the specific pipeline design and operating conditions to obtain the failure rate to be applied.
- 30 The consequences of pipeline failures are predicted using verified mathematical models, the results validated using experimental data at various scales up to full or comparison with recognised solutions, as well as comparison of model predictions with the recorded consequences of real incidents. The results of a consequence analysis must be derived for the worst case event, in terms of effect distance (radius) over which people are likely to become casualties. This should take into account people both outdoors and indoors.
- 31 Pipelines present a linear risk, so where a length of pipeline over which a location-specific accident scenario can affect the population associated with a specific development, the “interaction distance” of the pipeline must be taken into consideration.
- 32 [The minimum requirements for expert risk analysis applied to a site specific risk analysis are covered in IGE/TD/1 EDITION 4 Appendix 3.](#)

Failure of **Natural Gas** Pipelines

33 Failure of a [high pressure gas](#) pipeline has the potential to cause damage to the surrounding population, property and the environment. Failure may occur due to a range of potential causes, including accidental damage, corrosion, fatigue and ground movement. The consequence of failure is primarily due to the thermal radiation that is produced if the release ignites, therefore presenting a major threat to people and property. This can be caused directly or indirectly, by igniting secondary fires. [The event tree for the failure of a gas pipeline is shown in figure 4.](#)

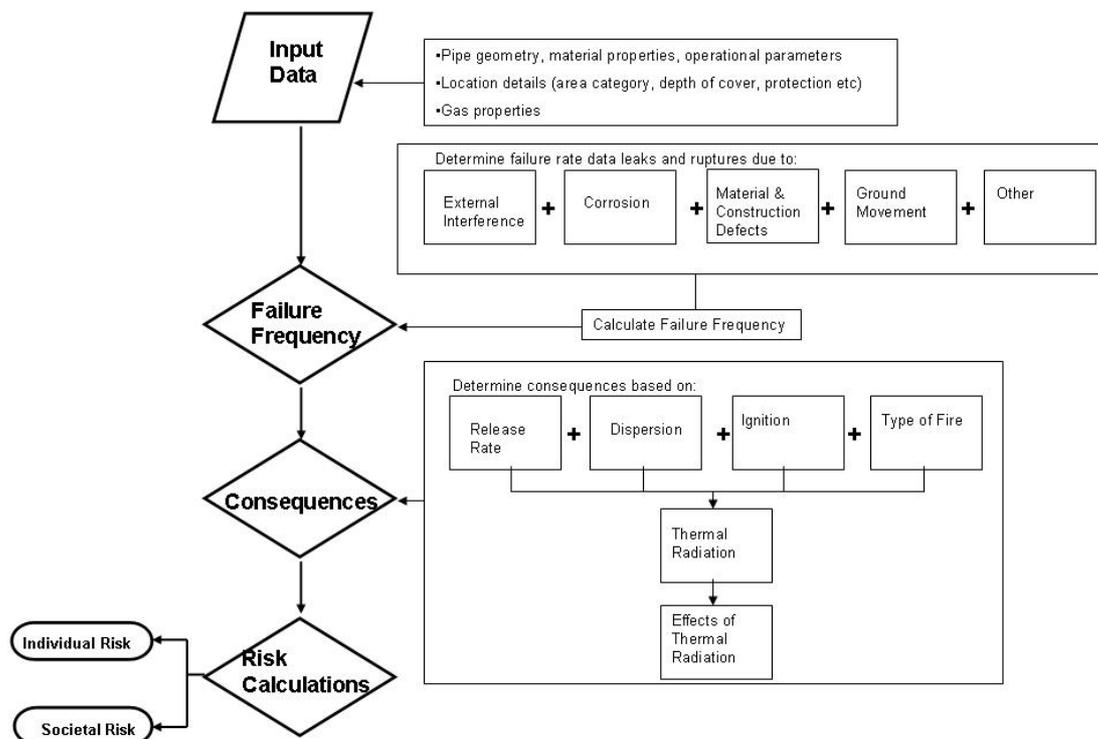
Figure 4: Event Tree for a Pipeline Failure



34 For a rupture release, it should be assumed that the pipe ends of the failed pipe are aligned and the jets of released gas interact. (Note: this is a standard assumption based on investigations of pipeline failure incidents, which confirm that in most cases the ends of the pipeline are aligned resulting in a double ended release into the crater formed). If immediate ignition occurs, a fireball will be produced which lasts for up to 30 s and will be followed by a crater fire. If ignition is delayed by 30 s or more, it is assumed that a jet or crater fire will occur. The possibility of a release of natural gas, from either a puncture or rupture release, leading to a flammable mixture which could drift and be ignited remotely causing a flash fire (sometimes referred to as a cloud fire) is not considered. This is because, for high pressure natural gas pipelines, the release will have a large momentum flux at the source and this will normally have a significant vertical component. The transition to a low momentum (passive) release will only occur when the pipeline has depressurised, at which time the released natural gas will be diluted below the lower flammability limit.

35 The stages of pipeline risk assessment are represented in Figure 5.

Figure 5: Risk Calculation Flowchart



36 In general terms, a quantified risk assessment of a natural gas pipeline consists of 4 stages:

- Input of data (pipeline and its location, meteorological conditions, physical properties of gas)
- Determination of failure frequency
- Prediction of consequences
 - a. Calculation of release flow rate
 - b. Determination of ignition probability
 - c. Calculation of thermal radiation emitted by fire in an ignited release
 - d. Quantification of the effects of thermal radiation on the surrounding population
- Calculation of risks

Input Data:

- 37 The primary input data will comprise of:-
- Pipe geometry – inside diameter, wall thickness
 - Material properties - grade (SMYS)
 - Operational parameters – maximum allowable pressure, temperature, pipeline shutdown period
 - Locations details - [area category \(R,S\)](#), depth of cover, additional protection (e.g. concrete slabbing), pipeline marking, development and building categories in the vicinity and their distance from the pipeline, population and occupancy levels, road/rail crossing details, including traffic density, length of pipeline to be assessed.
 - Gas properties - calorific value

Evaluation of Failure Frequency**Failure Cause**

- 38 Failure of a pipeline can occur due to a number of different causes such as:-
- External interference
 - Corrosion (internal and external, including Stress Corrosion Cracking (SCC) and Alternating Current (AC) induced)
 - Material or construction defects
 - Ground movement
 - Other causes, such as fatigue, operational errors etc

Failure Mode

- 39 The failure modes which should be considered include leaks, i.e. punctures, or line breaks, i.e. ruptures. Leak sizes range from pinholes to pipeline diameter equivalent, and ruptures are considered as pipeline equivalent diameter, and 2 open ends (guillotine)
Note: In most cases the risk will be dominated by the rupture scenario only.

- 40 Punctures should be considered in terms of specific hole sizes. Failure rate data is usually quoted for the sum of all hole sizes, and should be classified into specific hole sizes to enable the risk assessment to be carried out. The following holes size classifications are typically considered:-
- Small (pinhole) < 25 mm
 - Medium 25 to 75 mm
 - Large 75 to 110 mm

Rupture failure rate is derived from failure rate data and divided into 2 categories:-

- Rupture 110 mm to pipeline diameter
 - Guillotine failure failure with hole equivalent > pipeline diameter
- Note: Punctures greater than 150mm are frequently considered as ruptures.

- 41 The failure mode is determined by the length, depth and type of defect, and is primarily dependent on the pipe diameter, wall thickness, material properties and the operating pressure.
- 42 In a risk assessment the likelihood of each failure scenario is evaluated and expressed in terms of failure frequency and pipeline unit length. The usual form is to express the failure rate in terms of failures per metre per million years, which is equivalent to failures per 1000 kilometres per year.

Determination of Consequences

- 43 In the context of pipelines carrying [natural gas](#) it is the ignited releases that are of real concern. A consequence calculation will need to model and predict the [gas](#) release rate,

the characteristics of the resulting fire (ie fireball, jet fire, plume fire), the radiation field produced and the effects of the radiation on people and buildings nearby.

The following aspects must be considered:

- Outflow as a function of time (influenced by failure location and upstream and downstream boundary conditions)
 - Thermal radiation from the initial and reducing flow if the release is ignited immediately
 - Thermal radiation from delayed ignition fires and jets
- 44 The consequence model should also consider:
- wind speed (usually 2 metres/sec at night and 5 metres/sec during the daytime) because this affects the jet fire tilt and radiation effects downwind, and the degree of cloud drift before late ignition of a flash fire. Weather category also affects gas dispersion and the usual assumption is that nighttime weather is Pasquill Category F and daytime is Category D [*Reference required*].
 - Wind direction – only required for a site –specific risk assessment where wind direction will affect the populated area being considered
 - humidity – this affects the proportion of thermal radiation absorbed by the atmosphere
- 45 In the case of jet fires from punctures or ruptures, the consequence model usually considers a vertical jet flame, with wind tilt created by the current wind velocity. More elaborate models are possible with different angles of flame but these have a relatively small effect on risk levels from a pipeline.
- 46 For large failure cases such as full diameter and guillotine ruptures, the release rate should be determined as a function of time. This calculation requires an estimate of the initial and steady state release rates and an estimate of the inventory of the pipeline network which is discharging to the release point. For generic calculations a conservative assumption is that the break occurs half-way between a compressor station (or pressure regulating station) and an isolation valve, with pressure being maintained from the compressor station and no flow (with depressurisation) occurring at the isolation valve.

Probability of Ignition

- 47 The risks from a pipeline containing a flammable fluid depend critically on whether a release is ignited, and whether ignition occurs immediately or is delayed.
- 48 It is usually assumed that immediate ignition occurs within 30 seconds, whereas delayed ignition occurs after 30 seconds. Generic values for ignition probability can be obtained from data from historical incidents and these are product-specific. The various ignition possibilities such as immediate, delayed, and obstructed or unobstructed, are drawn out logically on an Event Tree to obtain overall probabilities.
- 49 There is considerable evidence from actual events and research work that immediate ignition events involving flammable gases are likely to cause a fireball. This is usually modelled by calculating the reducing release rate with time and so obtaining the cumulative amount released. This time is then compared with the burn time of a fireball containing the cumulative amount released. When the two times are equal, the largest fireball is obtained. Typical fireball burn times are 10 to 20 seconds depending on pipeline diameter.
- 50 Probability of occurrence of an immediate ignition fireball is usually considered to be 0.2 to 0.25.
- 51 Jet fires are divided into 2 main types, free or unobstructed jets, and obstructed jets (or plume or crater fires). Free unobstructed jets are released at very high velocity and are

likely to have a “lift-off” distance before the flame appears. Obstructed jets are considered to ignited at ground level (called “grounded jet fires”) and have smaller flame heights. The release rate at 30 seconds is usually used to model the thermal effects of jet fires.

- 52 The probability of occurrence of a jet fire is dependent on assumption made about sources of delayed ignition close to the release point. Typical assumptions result in jet fire probabilities between 0.15 and 0.3.
- 53 Natural gas is lighter than air, so drifting of gas into buildings is not expected to occur.

Thermal Radiation

- 54 Thermal radiation is calculated from the energy of the burning material. There are two main methods of calculation in use, the View Factor method which assumes a surface emissive power from the flame, and the Point Source method which assumes all the energy is emitted from one (or several) point sources on the flame. The energy from the fireball pulse is usually calculated using the View Factor method.
- 55 Thermal radiation effects are calculated using the duration of the fireball to obtain the “thermal dose” obtained at various distances from the fireball surface. A time-weighted method is available to enable the fireball duration to be taken into account. The distance to specific thermal dose levels are obtained, the spontaneous ignition distance within which fatal injuries are assumed to all individuals indoors and outdoors, and 1000 thermal dose units within which all individuals outdoors are assumed to receive “Dangerous Dose” effects.
- 56 Jet fire effects are calculated by assuming all persons indoors try and escape outdoors and those outdoors try and escape from the flame. The potential for individuals sheltering within buildings can be taken into account by calculating the distance that an individual would be able to move away from the fire (away from and parallel to the pipeline) without receiving a probit dose¹ (**definition needed**) of thermal radiation. Modelling of escape distances includes trying to escape within 30 seconds away from the flame, and taking into account the likelihood of finding (evenly spaced) shelter indoors. During the exposed 30 seconds outdoors, running away at 2.5 metres /second, if the cumulative thermal dose of 1000 tdu is exceeded, then fatal injuries are assumed to occur. In some cases (e.g. grounded jet fires) this methodology does not work, and a radiation level of 12.5 kW/m² is taken as the boundary for failing to escape and therefore fatal injury effects.
- 57 For calculating thermal impact effects on the population, It is assumed that the proportion of people indoors during daytime is 90% and during nighttime is 99%. Noting that persons indoors are assumed to try and escape outdoors during a jet fire.

Effects of Thermal Radiation

- 58 The standard methodology applies to the ‘1000 SLOD’ selection option for casualty criteria. The acronym SLOD stands for Significant Likelihood of Death and applies to a casualty criterion of 1000 probit dose units which the Health and Safety Executive consider to be equivalent to a dose of thermal radiation that will lead, in an average population, to 35% of the people being exposed becoming a fatality.
- 59 A mixed casualty criterion assumes 1% lethality and 1000 SLOD.

¹ the probit dose is equal to the sum of $t.I^{4/3}$ where t is the exposure time (s) and I is the incident thermal radiation (kW m⁻²).

Calculation of Risk

- 60 The risks from the various scenarios (ruptures and various holes sizes causing fireballs, jet fires, and flash fires) are collated and the Individual Risk profile (or Risk Transect) at various distances plotted on a graph. From this plot it is possible to identify the risk to an individual at distances from the pipeline.
- 61 The individual risk represents the risk to an individual, located at a specific distance from the pipeline, assumed to be present all the time. It is shown graphically as a cross-section through the pipeline showing the risk on each side of the line at various distances, known as the Risk Transect.
- 62 The risk to people used in land use planning assessments is based on individual risk - defined as the probability of an individual at a specified location being a casualty. Individual Risks are presented in terms of risk of fatality per million years (shortened to chances per million per year or cpm).
- 63 Criteria for individual risk levels are given in paragraph 14.

Definition of the Extent of the Risk Assessment for Land Use Planning (LUP)

- 64 The risk to people used in land use planning assessments is based on individual risk - defined as the probability of an individual at a specified location being a casualty.
- 65 Land Use Planning risk assessments are carried out to define the extent of the zones to be applied to a major hazard pipeline. The assessment calculates the distances to the zone boundaries using the risk analysis methodology described below.
- 66 The risk assessment applies to acute safety hazards only affecting the immediate health of people who may theoretically be present near the pipeline when an accident occurs.
- 67 In the application of risk assessment for land use planning, the physical aspects relating to a pipeline failure specific to the location in question must be assessed in detail, and the justification for the assumptions to be applied must be documented.
- 68 Data and Case Definition - the risk analysis requires the data described in paragraph 38 above. Any site specific variations must be assessed, and any the justification for any additional assumptions to be applied locally must be justified. Note, in the case of depth of cover, site specific measurement should be taken. Where additional pipeline protection such as slabbing is to be taken into account, it should be confirmed that the design and installation of the slabbing is in accordance with [IGE/TD/1 EDITION 4 requirements \(re Section 6.9\)](#).
- 69 Generic assessments of individual risks should be carried out to provide and compare with benchmark cases. Generic assessments of individual risk use single values for population density and shelter density either side of the pipeline and are therefore applicable to situations where the population adjacent to the pipeline is evenly distributed.

Pipeline Failure Mode

- 70 In general, it should be assumed that the failure rate due to all damage mechanisms other than 3rd party interference and ground movement are managed and controlled through testing, inspection and maintenance. The failure rate for 3rd party interference is influenced by the pipeline wall thickness and design factor, as well as the area type, the pipeline depth of cover and the local installation of pipeline protection such as slabbing.

The failure rate for natural ground movement depends upon the susceptibility to landsliding at the specific location. In some cases other causes may need to be considered, such as the quality of girth welds, the potential for stress corrosion cracking (SCC) or alternating current induced (AC) corrosion.

- 71 The failure frequency associated with each damage mechanism should be determined using recognised operational data sources (UKOPA) or predictive models validated using such data (UKOPA Mechanical Damage Model, ground movement failure probability).
- 72 In determining the 3rd party interference failure frequency, account should be taken of the area classification, ie R (rural) or S (suburban). It is recommended that the damage incidence rate for S areas should be assumed to be 3 times that for R areas.

Risk Reduction Factors for Use in Site Specific LUP Assessments

- 73 The site specific risk assessment should take into account relevant details of the pipeline, and should document justification of any assumptions applied following assessment of these details.
- 74 The recommended factors which should be applied to the failure frequency due to 3rd Party Interference are as follows:
 - Depth of cover, given in Figure 6
 - Design factor, given in Figure 7.
 - Wall thickness, given in Figure 8.
 - Surveillance frequency, given in Figure 9.

Figure 6: Reduction in 3rd Party Interference Failure Frequency Due to Depth of Cover

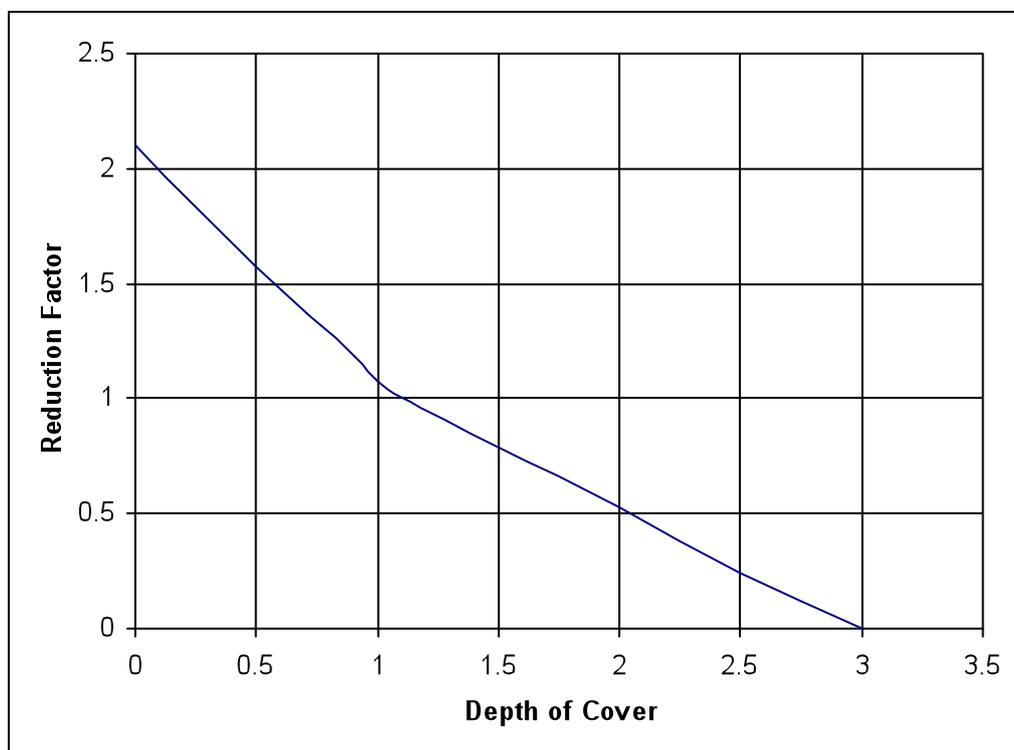


Figure 7: Reduction in 3rd Party Interference Failure Frequency Due to Design Factor

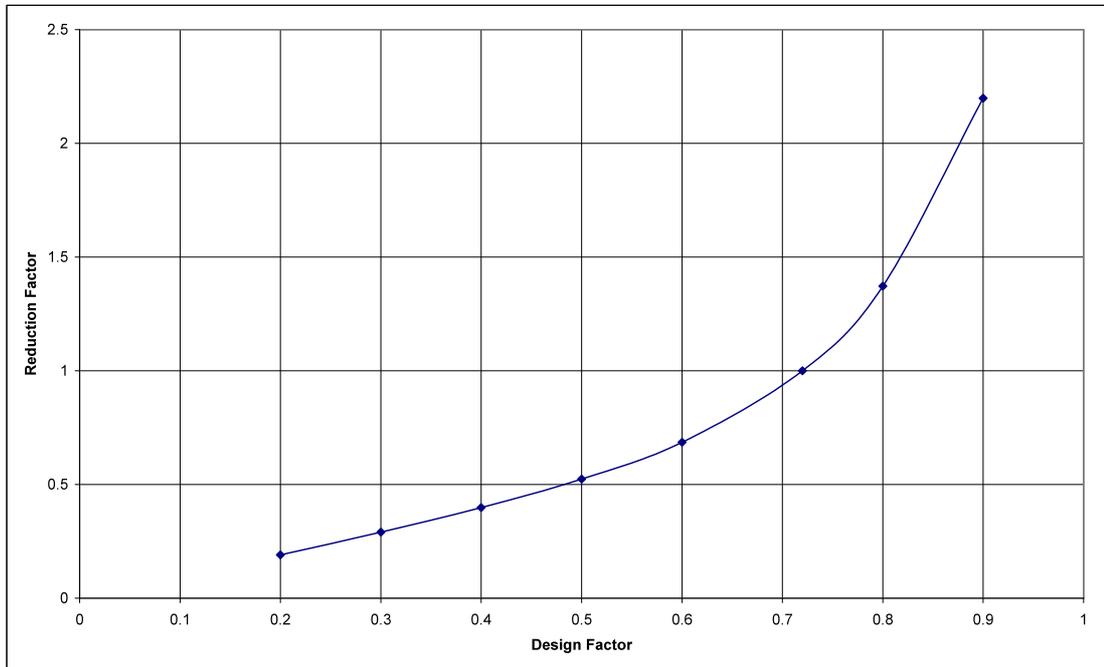


Figure 8: Reduction in 3rd Party Interference Failure Frequency Due to Wall Thickness

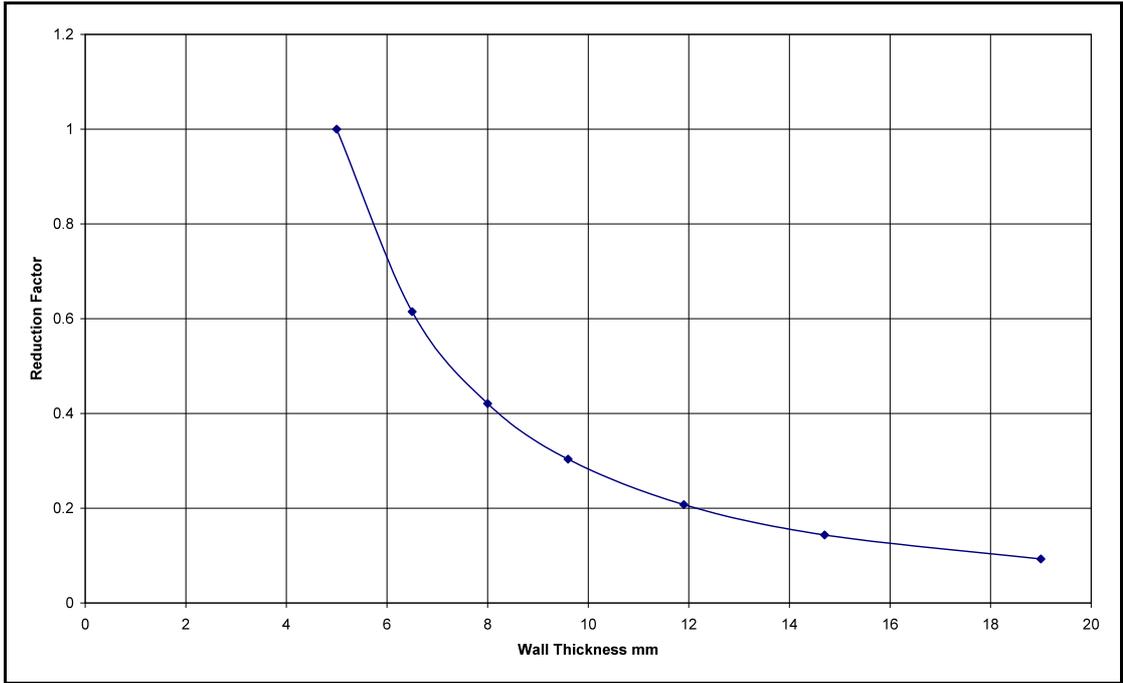
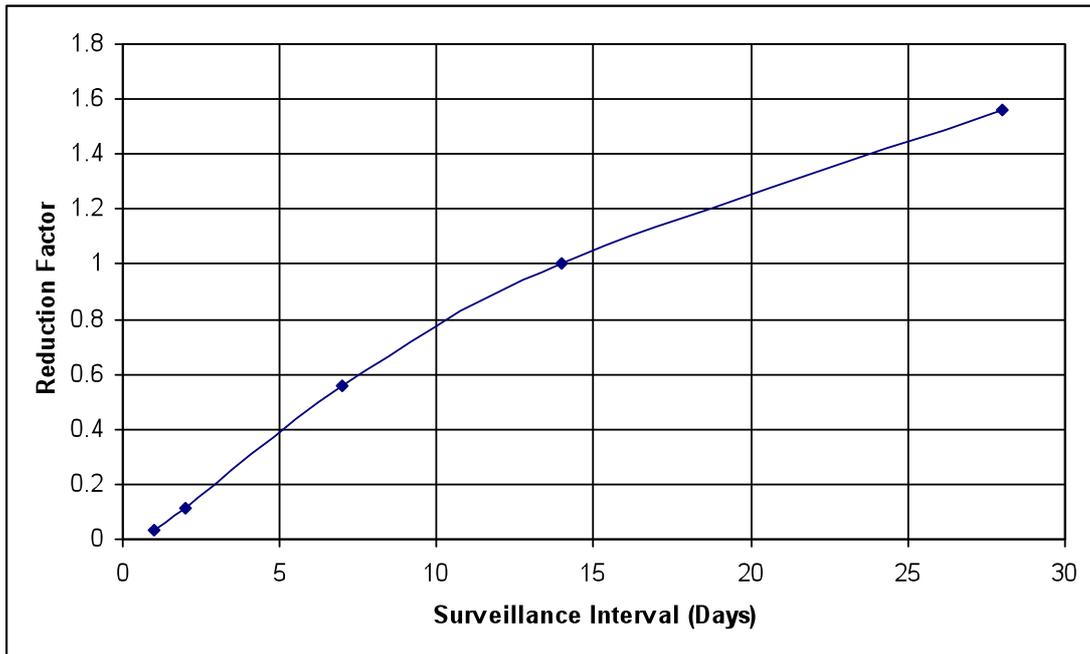


Figure 9: Reduction in 3rd Party Interference Failure Frequency Due to Surveillance Frequency



75 Recommended reduction factors which may apply with documented site specific justification are given in Table 1.

Table 1 – Risk Reduction Factors for Additional measures

Measure	Risk Reduction Factor
High visibility markers	0.85
Additional liaison visits	0.9

Weekly survey	0.58
Installation of concrete slab protection	0.4
Installation of concrete slab protection plus visible warning	0.1

Implementation of Risk Mitigation Measures

- 76 Risk mitigation measures identified as being necessary must be installed prior to the completion and use of any new development within the pipeline consultation zone. Requirements for specific risk mitigation measures are:
- 77 Relaying the pipeline in increased wall thickness:
The pipeline should be designed in accordance with Section 6, constructed in accordance with Section 7 and tested in accordance with Section 8 of IGE/TD/1 EDITION 4. Particular care is required where the consolidation of the pipeline trench bed is disturbed allowing settlement. Settlement at the tie in points with the existing pipeline must be avoided. The function and integrity of pipeline corrosion protection across the new section and at the points of connection with the existing pipeline must be confirmed to be adequate and fit for purpose in accordance with Section 10 of IGE/TD/1 EDITION 4.
- 78 Laying slabbing over the pipeline:
Installation of slabbing to provide impact protection to the pipeline must be carried out in accordance with Section 6.9 of IGE/TD/1 EDITION 4. The installation of concrete slabbing over the pipeline may restrict access to the pipeline in the event of coating deterioration or corrosion damage. It is therefore recommended that a coating survey is carried out prior to the installation of slabbing, the results of previous in-line inspection are assessed to determine whether there are any indications of corrosion in the length of pipeline to be slabbed which may need assessment and/or repair prior to slabbing, and the functionality and integrity of the CP system is confirmed before and after installation of the slabbing.
- 79 Taking account of increased depth of cover:
Increased depth of cover at the location under consideration may be taken into account where this exceeds the code requirements specified in Section 7.15. A full survey of the actual depth of cover over the full interaction distance at the location under consideration must be carried out in order to record the depth of cover. A justification of the permanence of the depth of cover must be prepared, including the reason for the increased depth of cover, the type of soil, the susceptibility to land sliding and the current and future land use. The depth of cover must be rechecked at specified locations during all future pipeline audits carried out in accordance with Section 11.4.2 to affirm the pipeline MOP.
Increasing the depth of cover by lowering the pipeline trench or bunding the pipeline is not recommended.
- 80 Installing additional pipeline markers:
IGE/TD/1 EDITION 4 Section 7.24 recommends that pipeline markers should be installed at field boundaries, at all crossings, and where practicable, at changes in pipeline direction. Installation of high visibility pipeline markers in addition to these requirements, which provide further information on contacts and emergency telephone numbers can be applied as a risk mitigation measure.
- 81 Increasing surveillance frequency:
IGE/TD/1 EDITION 4 Section 11.5.7 recommends that aerial surveillance should be carried out at two weekly intervals. Increasing the surveillance frequency will increase the likelihood of detection of activities which may damage the pipeline. The surveillance interval may therefore be reduced using walking or vantage point surveys at specific locations as a risk mitigation measure.

