Application of Pipeline Risk Assessment for 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 s 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 a 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 PD 8010 Annex E Safety Evaluation of Pipelines, following through steps E2 to E11.

5 This guidance presents the consultation zones for hazardous pipelines based on risk levels of 10^{-6} and 0.3 10^{-6} calculated in accordance with the methodology given in PD 8010 Annex E.

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 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 zones 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 HSE's 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 a proportion of the 10^{-6} risk contour.

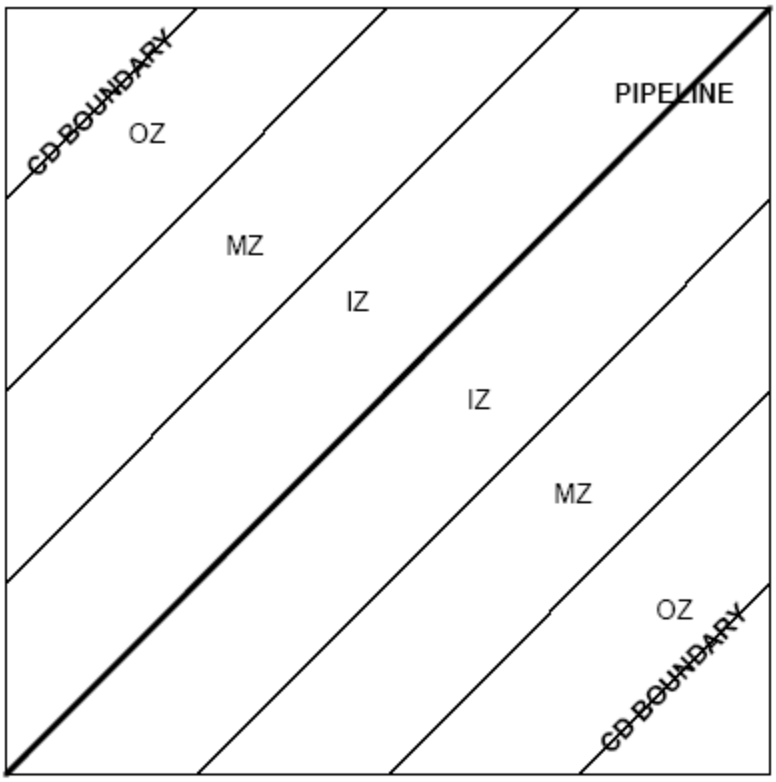
ii) Boundary between middle zone and outer zone – an Individual Risk of 10^{-6} per year of "Dangerous Dose" or worse.

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 hazardous pipeline is equivalent to 0.67 x the 1×10^{-6} risk contour.

16 The middle zone for a hazardous 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 (ethylene, spiked crude and NGL) hazardous pipelines are given in Figure 2.

17 The outer zone for a hazardous 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 (ethylene, spiked crude and NGL) pipelines are given in Figure 3.

Figure 2: 10^{-6} Risk Based Middle Zones for Hazardous Pipelines (To be included)

Figure 3: 0.3×10^{-6} Risk Based Outer Zones for Hazardous Pipelines (To be included)

18 PADHI uses two inputs to a decision matrix to generate the response:

i) the zone the development is located in of the 3 zones (that make up the CD) that HSE sets around the major hazard site.

ii) 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 HSE's 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. 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 PD 8010 provides detailed advice for calculating the distances to the risk levels, and gives examples and results obtained for various major hazard pipeline design cases.

27 This Guidance should be read in conjunction with PD 8010 Annex E: Safety evaluation of pipelines.

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 data is 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 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 PD 8010 Annex E.

Failure of Hazardous Gas or Liquid Pipelines

33 Failure of a hazardous gas or liquid 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 consequences of failure primarily due to the thermal radiation that is produced if the release ignites that presents the 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 hazardous pipeline is shown in figure 4.

Figure 4a: Event Tree for a Gas Pipeline Failure

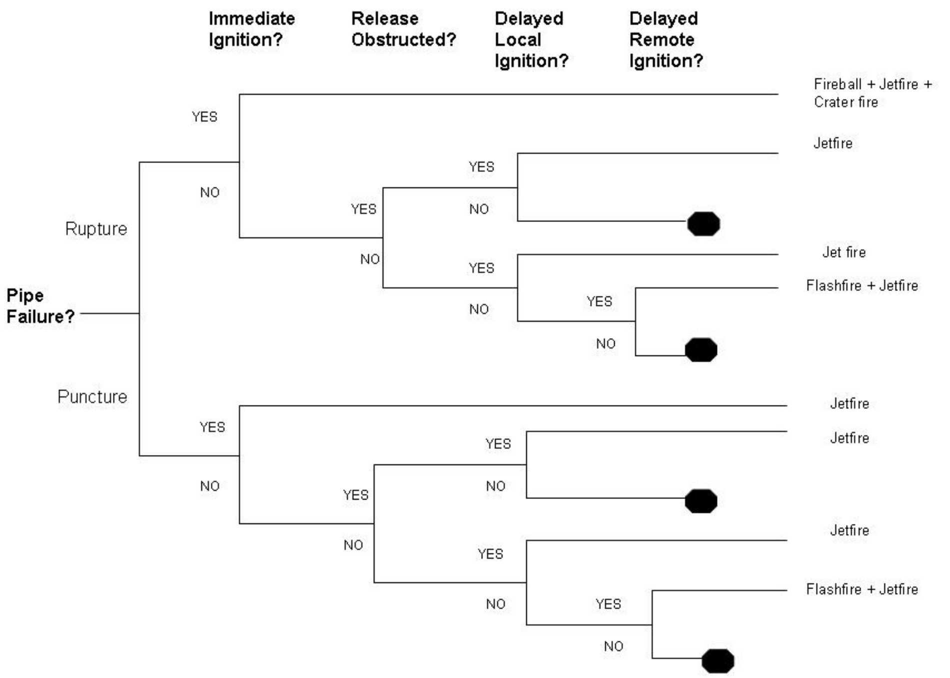
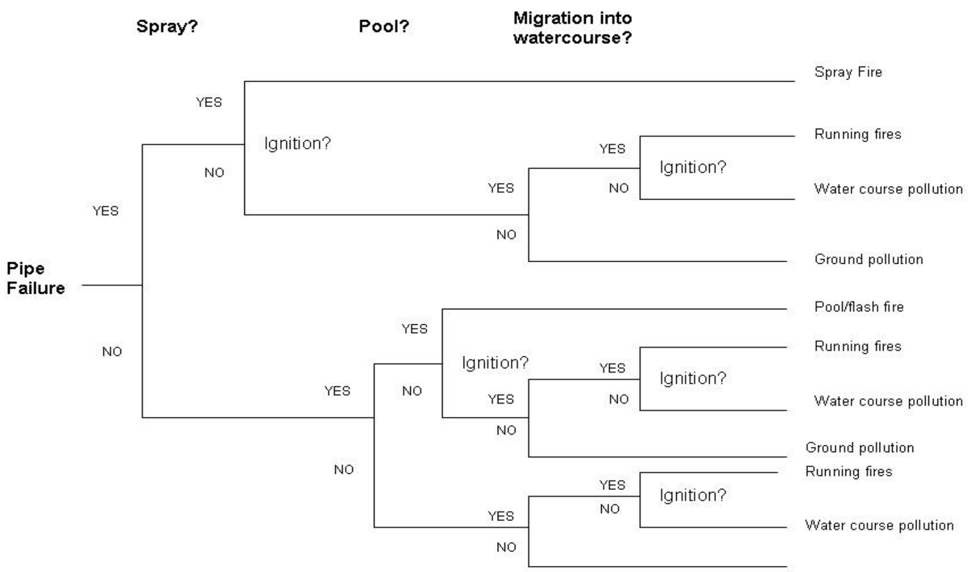


Figure 4b: Event Tree for a Liquid Pipeline Failure

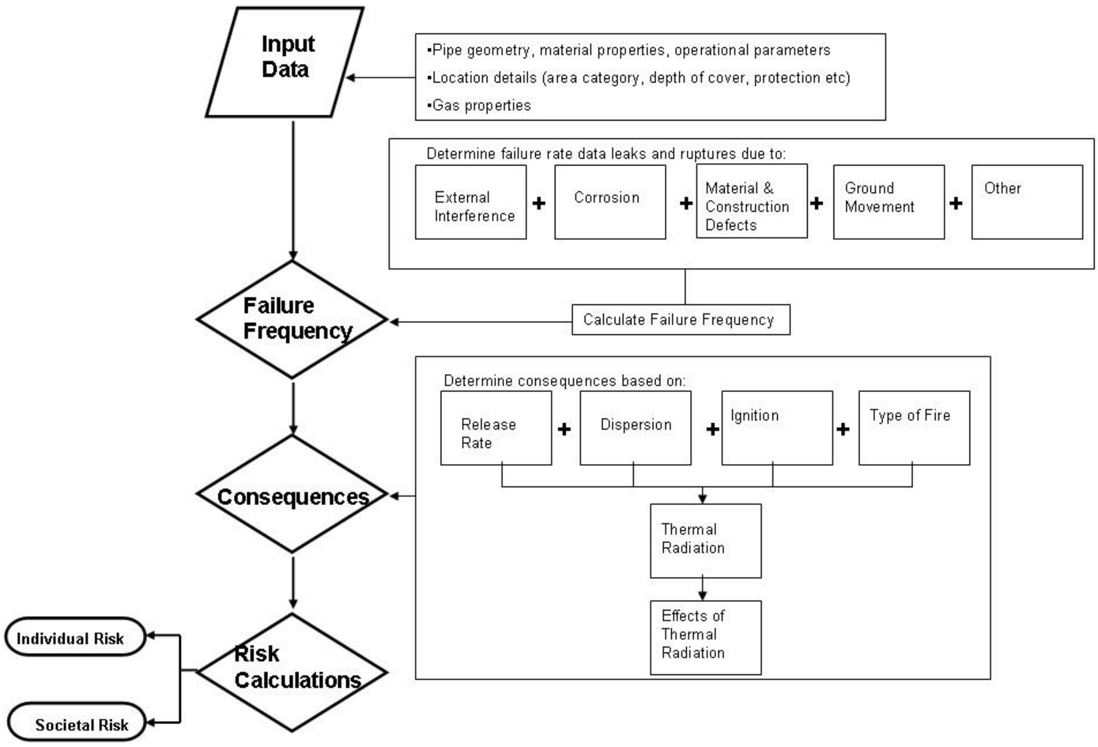


34 For a rupture release of a gas pipeline, it should be assumed that the pipe ends of the failed pipe are aligned and the jets of released gas interact. If immediate ignition occurs, a fireball will be produced which lasts for up to 30 s and will be followed by a crater fire. If ignition is delayed by 30 s or more, it is assumed that a jet or crater fire will occur. The possibility of a release of flammable 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) should be considered. Note, in the case of natural gas, this scenario is not usually considered, as 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 hazardous gas or liquid 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 class (1, 2), depth of cover, additional protection (eg 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 SCC and 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 (punctures) or line breaks (ruptures). Leak sizes range from small holes from pinholes to pipeline diameter equivalent, and ruptures are considered as pipeline equivalent diameter, and 2 open ends (guillotine) failures with equivalent diameter 1.4 times the pipeline diameter.

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 usually 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

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 flammable substances in the UK, it is the releases which ignite ignition of flammable substance releases that cause immediate hazards. A consequence calculation will need to model and predict the gas or liquid release rate, the characteristics of the resulting fire (ie fireball, jet, flash, spray or pool 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 initial and reducing flow if ignition occurs immediately
- Thermal radiation from delayed ignitions fires and jets

Other aspects which may need to be considered in a full risk assessment include:-

- Release of pressure energy from the initial fractured section
- Pressure generated from combustion during the initial phase if the release is ignited immediately
- Missiles generated from overlying soil or from pipe fragments
- Spray fires caused by pressurised liquids
- Pool fires resulting from liquid releases
- Release of flammable liquids into water courses and the potential for running fires
- Pollution of water courses and/or ground due to liquid releases.

44 The consequence model must take into account:

- 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 nightime weather is Pasquill Category F and daytime is Category D.
- 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
- The type of ground environment into which a liquid is released.

45 In the case of jet fires from punctures of 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 the usual assumption is that the break occurs half-way between pumping stations, that is 8 kilometres from the pumping station.

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 and 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 the 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 Flash fires occur when a plume of un-ignited heavier-than-air gas drifts some distance downwind before finding a source of ignition. The ignition causes the fire to flash back to the source of release and then cause a jet fire. Flash fires drift further in nightime conditions (2 metres/second wind Category F) than daytime (5 metres/second Category D). The usual assumption for natural gas is that flash fires do not occur as heavier-than-air plumes are not usually formed following releases of natural gas.

54 The probability of flash fires is considered low, depending on the extent of population in the vicinity of a pipeline. Typical probabilities used are 10% daytime and 5% nightime.

Thermal Radiation

55 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.

56 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.

57 Jet fire effects are calculated by assuming all persons indoors try and escape outdoors and those outdoors try and escape from the flame. Modelling of escape distances includes trying to escape within 30 seconds away from the flame, and then sheltering 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/m^2 is taken as the boundary for failing to escape and therefore fatal injury effects.

58 Flash fire effects are assumed to cause fatal injuries to all persons in the area of the flash fire – this is usually assumed to be within the lower flammable limit zone downwind from the point of release.

59 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%. However, it should be noted that persons indoors are assumed to try and escape outdoors during a jet fire, and that persons indoors and outdoors are assumed to be equally at risk from a flash fire.

Effects of Thermal Radiation

60 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[1] 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.

61 A mixed casualty criterion assumes 1% lethality and 1000 SLOD.

Calculation of Risk

62 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.

63 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.

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. Individual Risks are presented in terms of risk of fatality per millions years (shortened to chances per million per year or cpm).

65 Criteria for individual risk levels are given in paragraph 14.

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

66 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.

67 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.

68 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.

69 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.

70 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 PD 8010 requirements (see Section 6.9.7 and Annex E.9).

71 Generic assessments of individual and societal risk 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.

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[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 ($kW\ m^{-2}$).

Pipeline Failure Mode

72 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.

73 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).

74 In determining the 3rd party interference failure frequency, account should be taken of the area classification, ie Class 1 or 2. It is recommended that the damage incidence rate for Class 2 areas should be assumed to by 3 times that for Class 1 areas.

Risk Reduction Factors for Use in Site Specific LUP Assessments

75 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.

76 The recommended risk reduction factors which should be applied to the 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

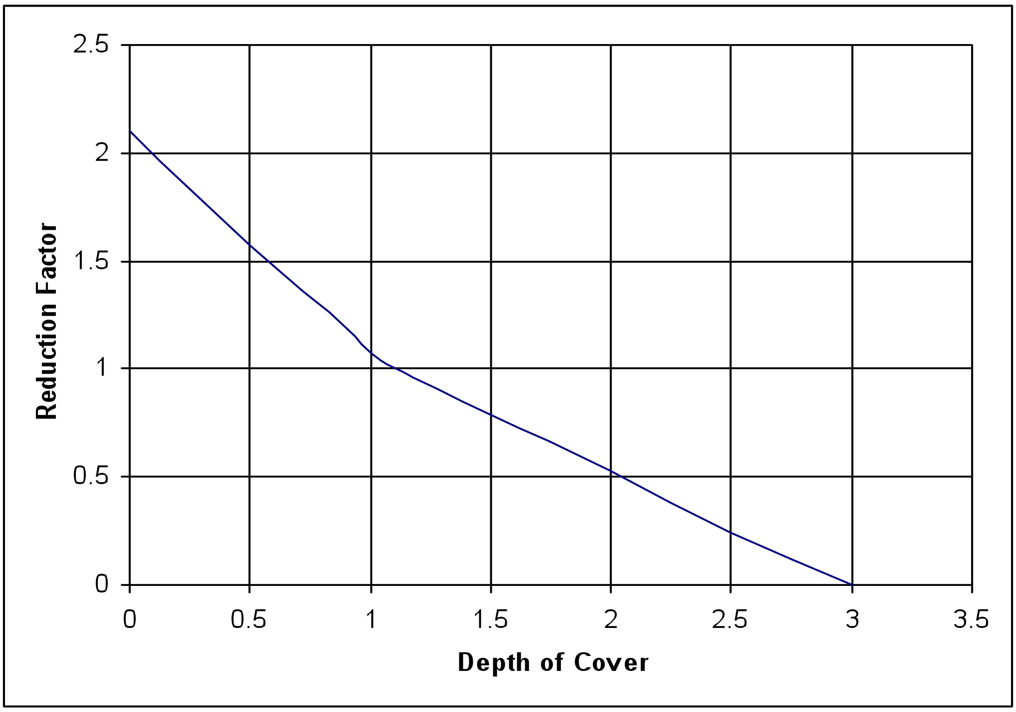


Figure 7: Reduction in 3rd Party Interference Failure Frequency Due to Design Factor

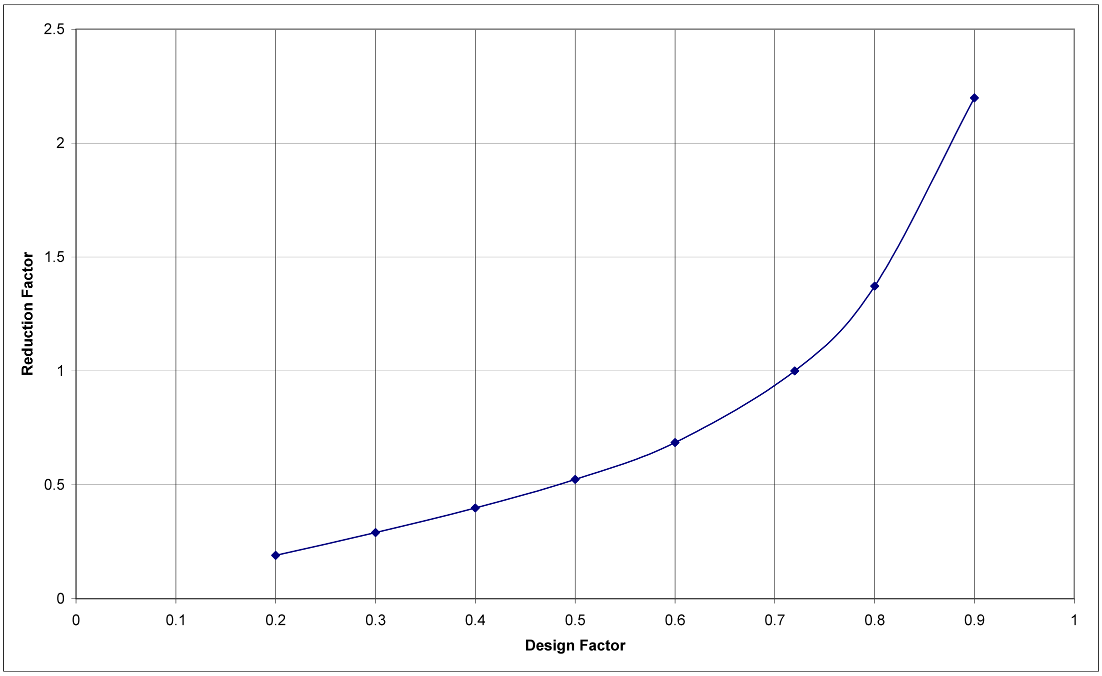


Figure 8: Reduction in 3rd Party Interference Failure Frequency Due to Wall Thickness

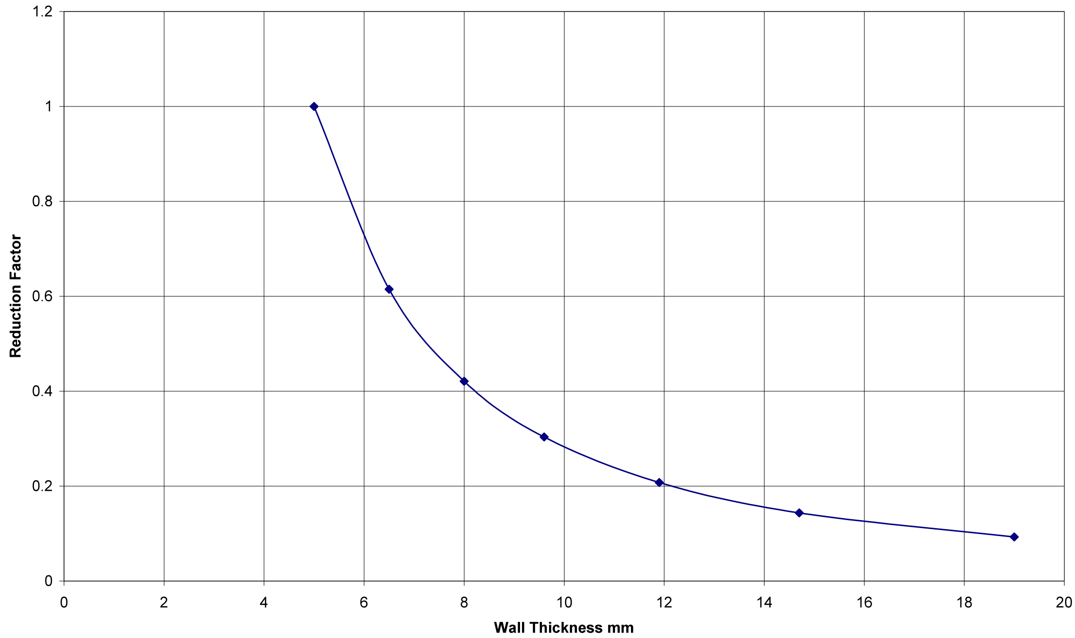
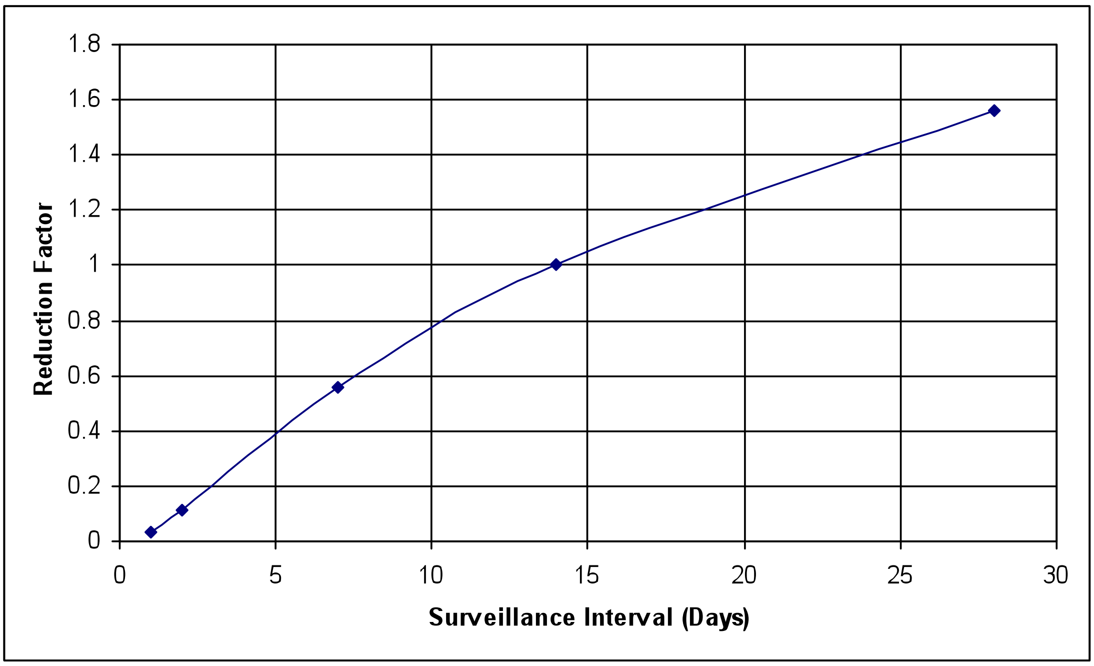


Figure 9: Reduction in 3rd Party Interference Failure Frequency Due to Surveillance Frequency



77 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

78 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:

79 Relaying the pipeline in increased wall thickness:
The pipeline should be designed in accordance with Sections 5, 6 and 8, constructed in accordance with Section 10 and tested in accordance with Section 11 of PD 8010 Part 1. 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 9 of PD 8010 Part 1.

80 Laying slabbing over the pipeline:
Installation of slabbing to provide impact protection to the pipeline must be carried out in accordance with Section 6.9.7 of PD 8010 Part 1. 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.

81 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 6.8.3. 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 pipeline route inspections carried out in accordance with Section 13.3.2 to detect factors that could affect the safety and operation of the pipeline. Such checks should be carried out at intervals not exceeding 4 years.
Increasing the depth of cover by lowering the pipeline trench or bunding the pipeline is not recommended.

82 Installing additional pipeline markers:
PD 8010 Part 1 Section 10.14 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 (see Section 13.3.2 and Annex E.9)

83 Increasing surveillance frequency:
PD 8010 Section 13.3.2 recommends that pipeline route inspections should be carried out. Where route inspections are 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.