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IGEM/TD/2
Edition 2

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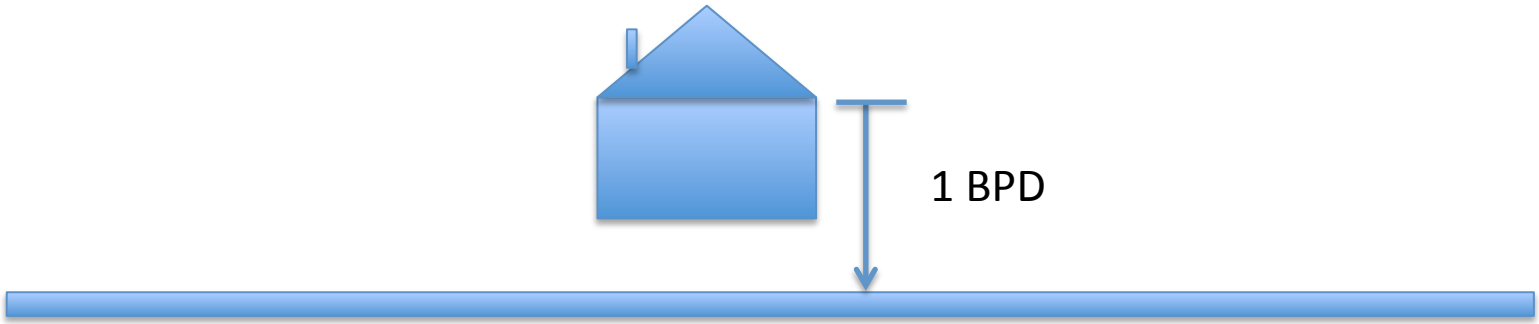
Overview

- Risk management issues
- ALARP and LUP
- Key changes
- HSE comments

It is not always sensible to blindly follow the code



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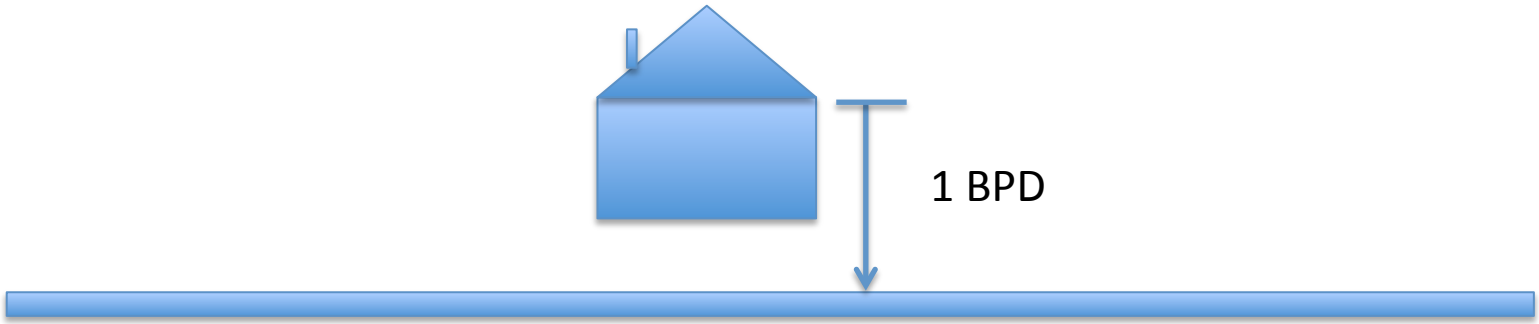
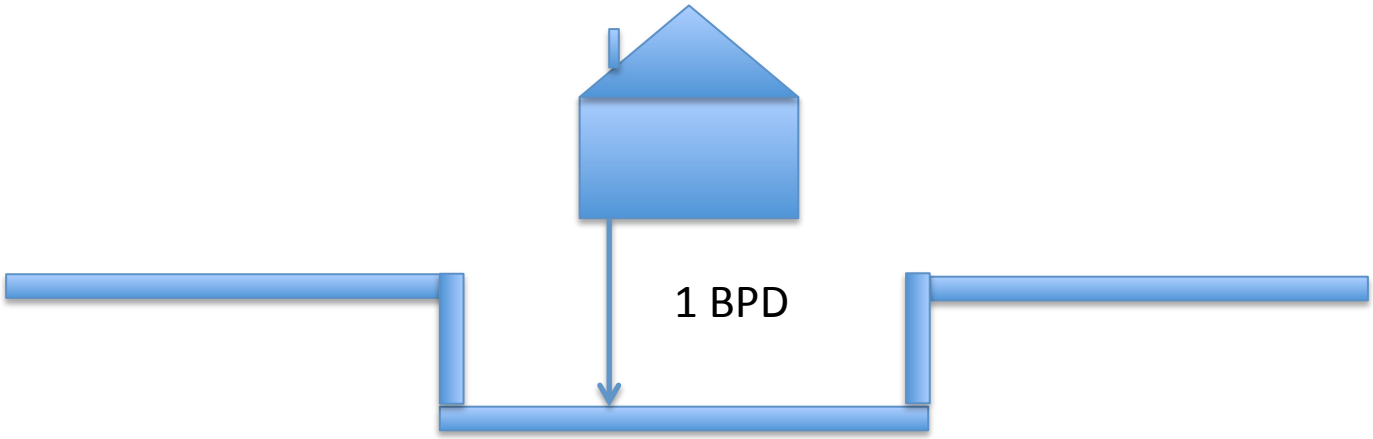
It is not always sensible to blindly follow the code





Risk Management Issues

- ## Health and Safety at Work Act

- Based on the principle that the primary responsibility for controlling hazards lies with those who create risks and those who work with them

  It shall be the duty of every employer to conduct his undertaking in such a way as to ensure, so far as is reasonably practicable, that persons not in his employment who may be affected thereby are not thereby exposed to risks to their health or safety.

Self regulation

–those who create risks should control them

Reasonable practicability

–Controls should be appropriate to the risk

–Cost must be considered

–Absolute safety cannot be guaranteed

–Unless the expense undertaken is in gross disproportion to the risk, the employer must undertake the expense.

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Controlling Pipeline Risks

- The best way of protecting people from the risks associated with pipeline failures is to keep people outside the hazard range
- Because of the high hazard ranges this is not always possible

Pipelines cannot always be routed away from people

Eagle to Lincoln
300 mm 15.2 bar

UKOPA/13/039

Pipelines cannot always be routed away from people

Findern Tee to Findern
100 mm 19 bar

Anslow – Burton
300 mm 19 bar

Goal Setting Legislation

- Many of the HSE's Regulations are Goal Setting and therefore support the use of QRA
- PSR Regulation 9 Construction and installation:

  The operator shall ensure that no fluid is conveyed in a pipeline (save for the purpose of testing it) unless it has been so constructed and installed that, so far as is reasonably practicable, it is sound and fit for the purpose for which it has been designed.

- If the extra cost can be shown to be grossly disproportionate to the reduction in risk then the risks can be demonstrated to be As Low As Reasonably Practicable i.e. 'ALARP'

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The ALARP Calculation

$$\text{Cost per Casualty Avoided} = \frac{\text{Mitigation Expenditure}}{\text{Reduction in Predicted Loss (Casualties)}}$$

$$\text{Cpca (cpls)} = \frac{\text{Unit cost x Extent of measure}}{(\text{EV } y^{-1} \text{ before} - \text{EV } y^{-1} \text{ after}) \times \text{Asset life}}$$

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Applications

- Design and Operation (ALARP) – Population there first
- Land Use Planning (LUP) – Pipeline there first

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PADHI

Sensitivity	Inner Zone($>10^{-5}$)* or 1BPD	Middle Zone(10^{-5} – 10^{-6})* or 1BPD	Outer Zone(10^{-6} – 3.10^{-7})*
1 (Workplace)	DAA	DAA	DAA
2 (Residential/ commercial)	AA	DAA	DAA
3 Vulnerable	AA	AA	DAA
4 Large 3 and large outdoor 2	AA	AA	AA

* Individual Risk of Dangerous Dose

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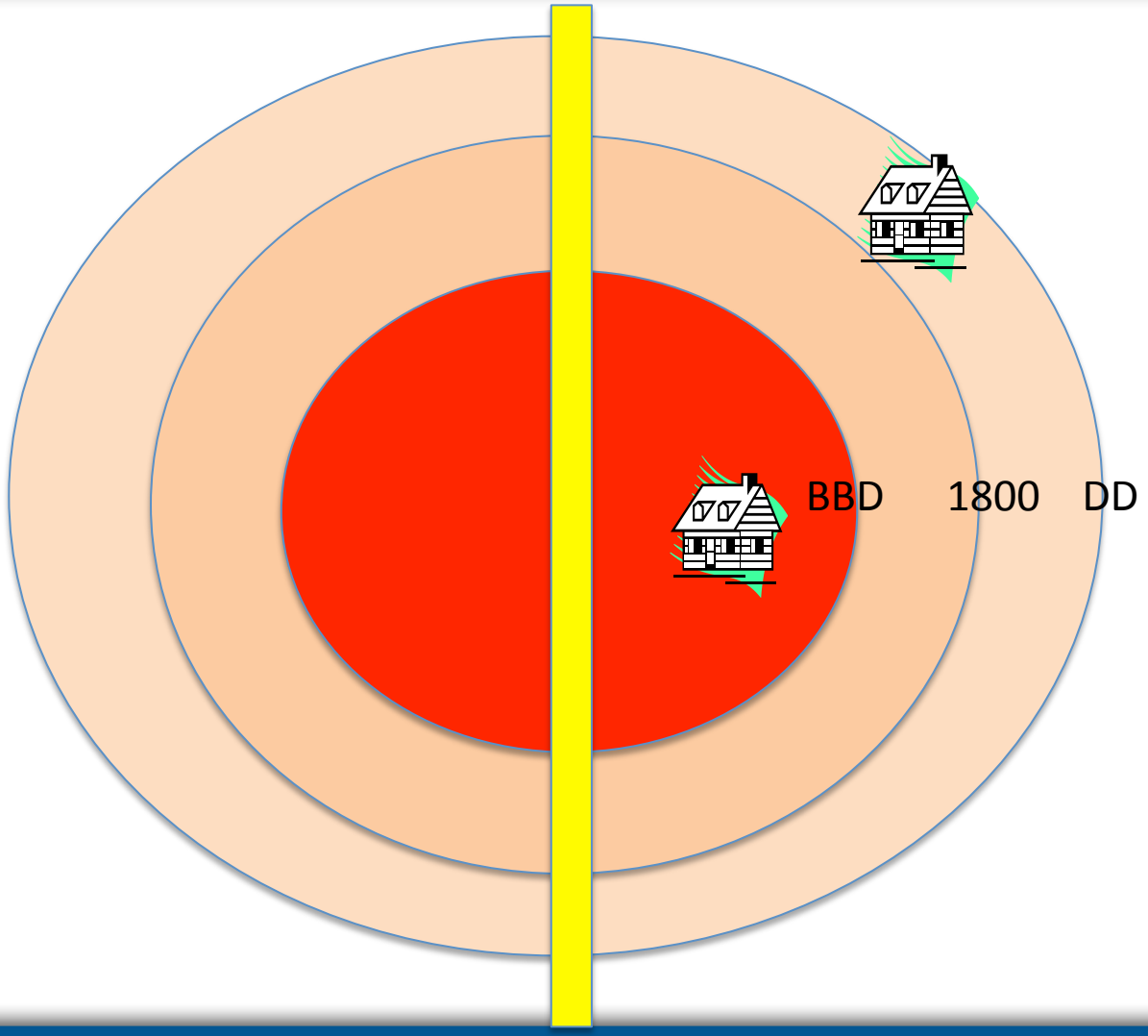
Hazard Ranges



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Why there was a need for TD/2 and PD8010

- Ensure consistency across the pipeline industry when pipeline QRAs were undertaken
- Document what is considered current good practice in terms of methodology
- Provide benchmark cases against which different pipeline risk assessment models could be assessed
- It provides criteria against which risk acceptability can be judged
- Provide credibility for pipeline operators' QRAs when they are discussed in public forums, e.g. Planning Enquiries
- Outline for pipeline operators the options in terms of potential risk reduction measures and risk reduction factors for these measures.

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LUP

- Can repeat assessment with Dangerous Dose
- Provides robust assessment of risk
- Demonstrate relationship with TD/1
  - can use to discuss with LPA if refusal within Code
  - Can discuss with developer if refusal outside Code
- Outcome still may not line up with Code- not just safety

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Overview of Key Changes

- Clarifications on application
- Update of risk mitigation measures (Section 8.2)
  - Slabbing
  - Depth of Cover
- Update of HSE Approach to LUP (Appendix 3)
- Update of failure frequency data (Appendix 4)
  - Prediction of failure frequency due to external interference
    - Damage distributions
    - Generic failure frequency curve
  - Prediction of failure frequency due to landsliding

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Clarifications on Application

- Presents the methodology for the risk assessment of high pressure gas pipelines
- Explains application to risk management (ALARP assessments) and implications of land use planning applications
- Explains different criteria for used for ALARP assessments and calculation of land use planning zones
- Confirms that risk reduction measures presented in Section 8.2 apply to external interference only

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ALARP vs LUP Criteria

- Operator ALARP assessments are carried out using the 1800 tdu (50% fatality) criterion
- HSE sets land use planning zones for major hazard sites and high pressure pipelines using the 1000 tdu (1% fatality) criterion
- For direct comparison with LUP assessments carried out by HSE, the 1000 tdu criterion should be applied

Changes to Risk Mitigation Measures

- Risk reduction due to slabbing – Table 2
- Risk Reduction due to depth of cover – Figure 10

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Risk Reduction due to Slabbing

- Table 2 - Edition 1 reduction factors of 0.16 and 0.05 replaced by single reduction factor of 0.1, in accordance with slabbing analysis carried out by GLND for UKOPA.
- Table 3 – Reduction factors of 0.15 and 0.125 applied by HSE

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Table 2 – Recommended Risk Reduction - Slabbing

Measure	External Interference Failure Rate Reduction Factor, R_p
Installation of concrete (or equivalent) slab protection	0.1

Note 1: The installation of visible warning tapes identifying that the slab is protecting a high pressure gas pipeline is considered to be good practice. Alternatively, the visible indication of the presence of a high pressure gas pipeline can be incorporated into the design of the slab.

Note 2: The physical barrier mitigation measures should apply to the whole pipeline interaction length to justify the values.

Note 3: The above risk reduction factor is recommended for pipeline operators to apply when assessing whether the risks have been made 'as low as reasonably practicable' (ALARP). The equivalent factors that are applied by the HSE when assessing the acceptability of proposed new developments in the vicinity of high pressure gas pipelines are summarised in Appendix 3.

TABLE 2 - EXTERNAL INTERFERENCE FAILURE RATE REDUCTION FACTORS FOR ADDITIONAL PROTECTION MEASURES

Table 3 – Risk Reduction due to Slabbing applied by HSE

Barrier Type	External Interference Failure Rate Reduction Factor
Concrete Slab Only	0.15
Slab and Marker Tapes	0.125

TABLE 3 - EXTERNAL INTERFERENCE FAILURE RATE REDUCTION FACTORS FOR SLABBING APPLIED BY HSE

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Risk Reduction Due to Depth of Cover

- Revision of risk reduction curve for depth of cover based on analysis carried out by GLND for UKOPA
  - Assessment of average depth of cover of pipelines in the UKOPA database
  - Analysis of effect of depth of cover on external interference hits
  - Normalisation of risk reduction curve and hit rate to standard depth of cover (1.1m)

Figure 10 – Risk Reduction due to Depth of Cover

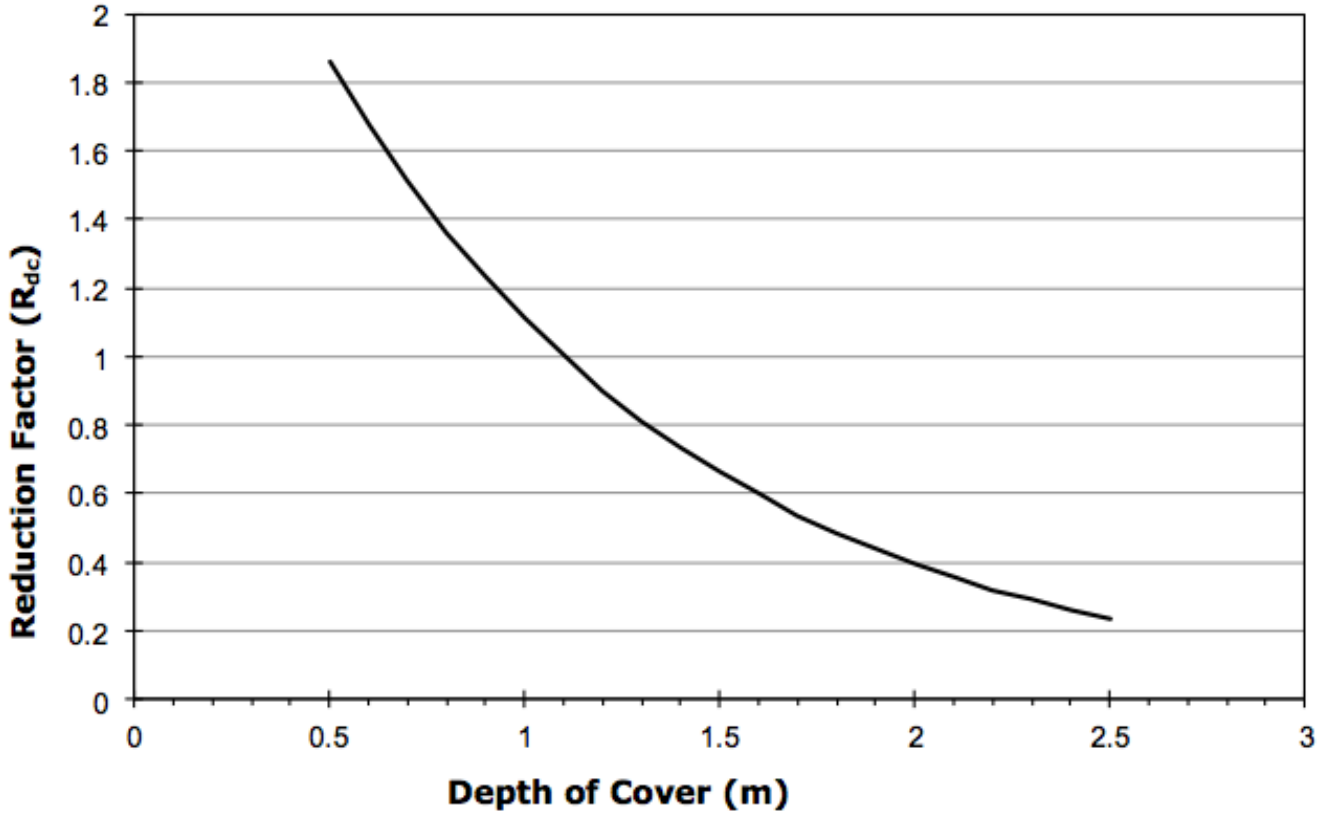

FIGURE 10 - REDUCTION IN EXTERNAL INTERFERENCE TOTAL FAILURE FREQUENCY DUE TO DEPTH OF COVER

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Failure Frequency due to External Interference

- Predictive modelling is recommended
- Damage probability distributions and hit rate have been updated for UKOPA by Penspen Integrity
- Probability distributions are published by UKOPA
- Penspen Integrity have developed a failure frequency prediction model (PI-Fail) using UKOPA recommendations and incorporating updated distributions and hit rate
- Following detailed comparisons with other failure frequency prediction models, this model has been used to update the generic failure frequency curve in TD/2 Edition 2

Recommended Failure Frequency Prediction Method

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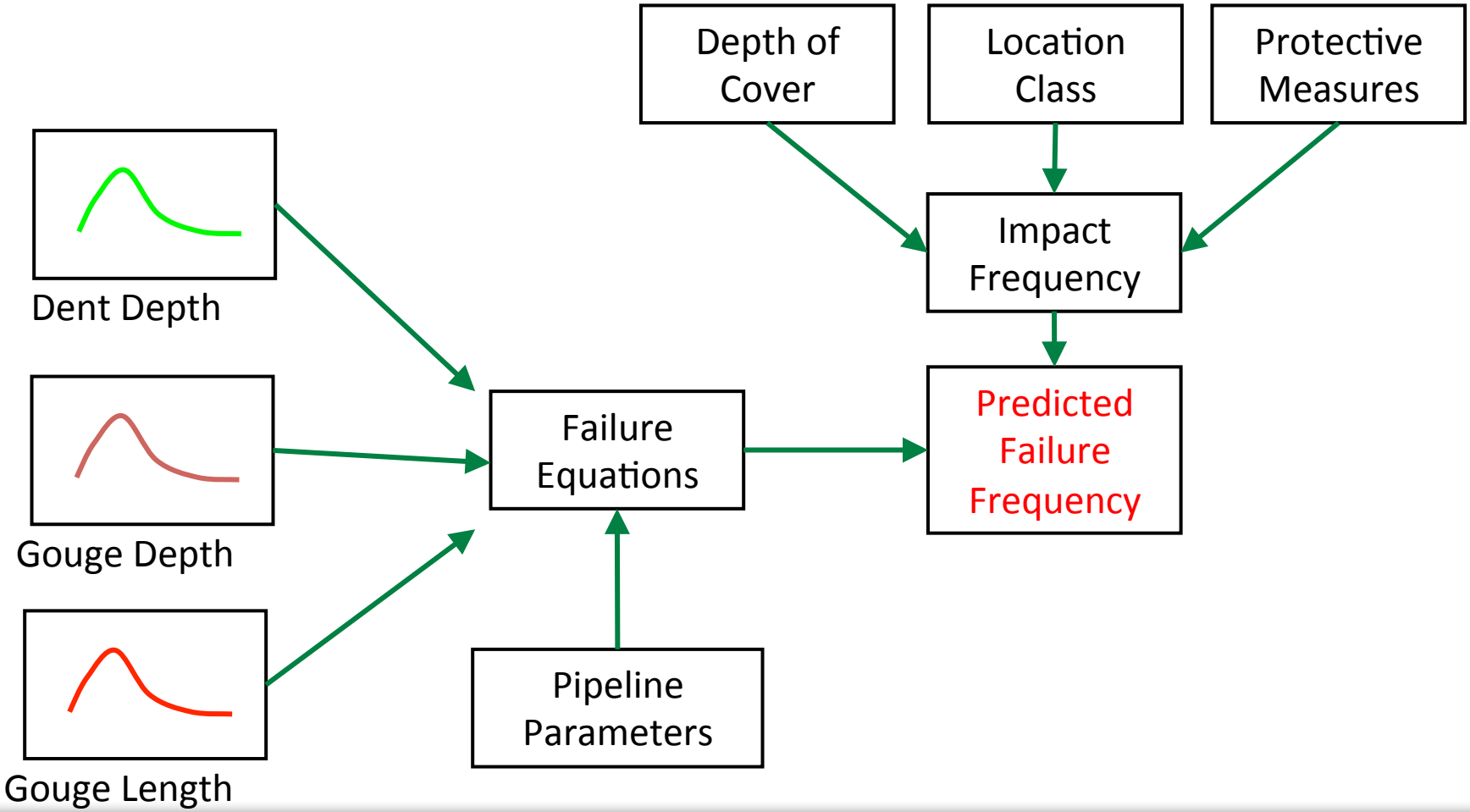
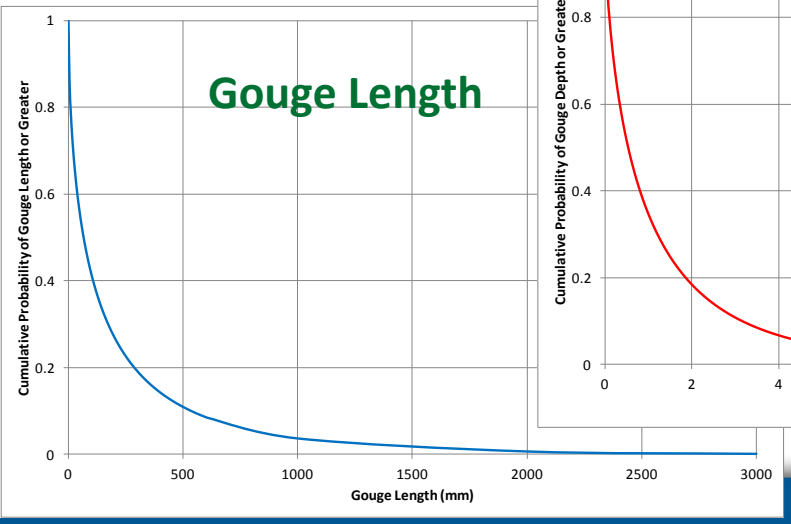
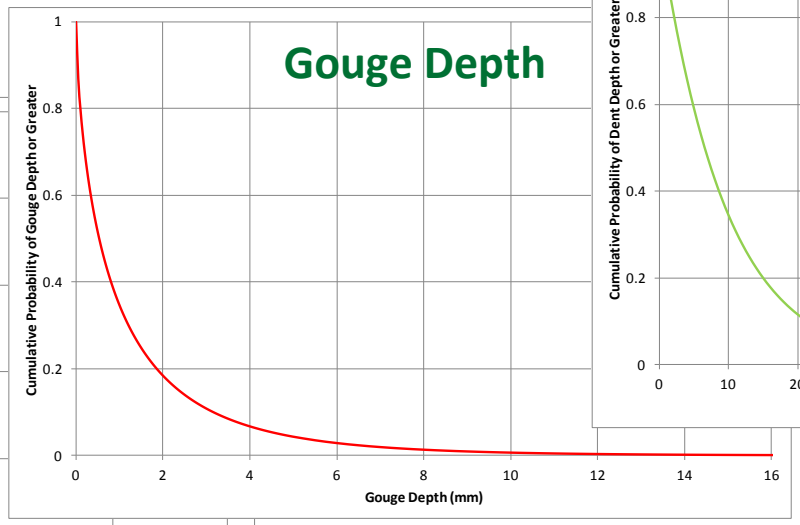
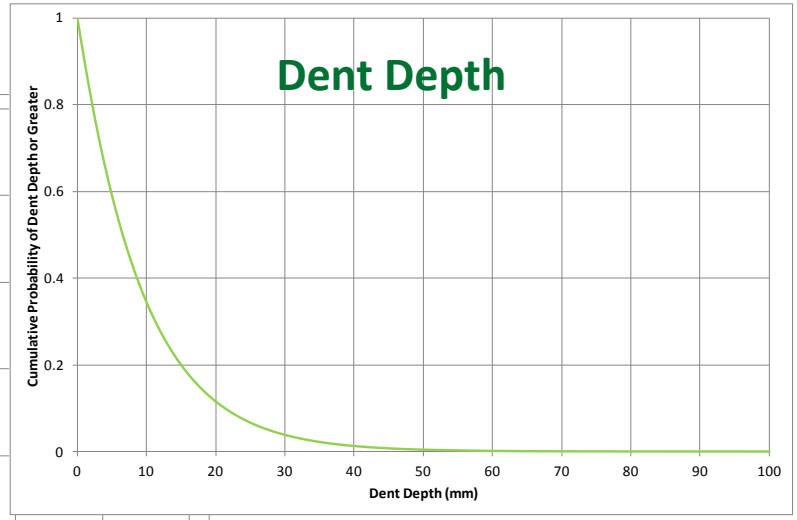


UKOPA Weibull Parameters Produced by Penspen

Distribution Parameters	Gouge Length	Gouge Depth	Dent Depth
Shape (α)	0.573	0.674	1.018
Scale (β) mm	125.4	0.916	9.382







Generic Failure Frequency Curve

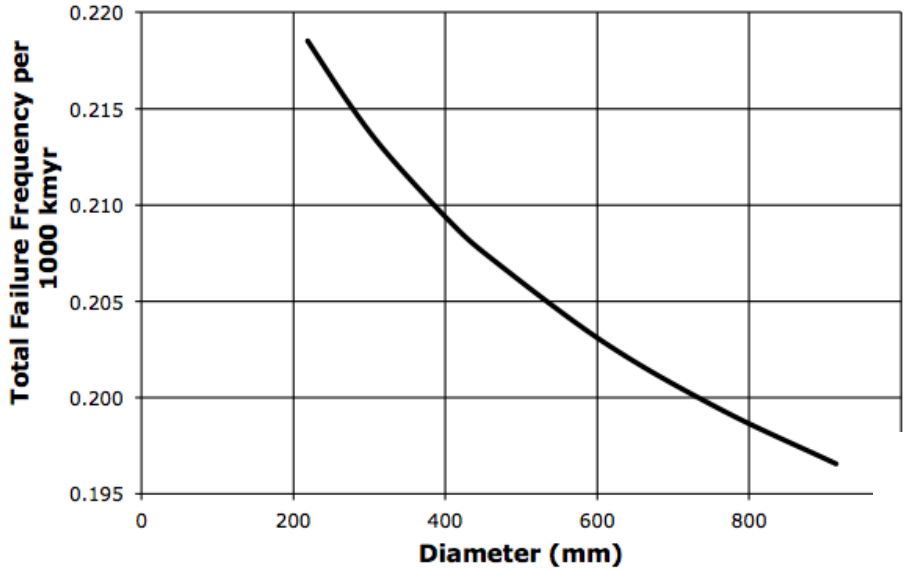


FIGURE 13 - GENERIC FAILURE FREQUENCY CURVE FOR ESTIMATI
FAILURE FREQUENCY DUE TO EXTERNAL INTERFEREN

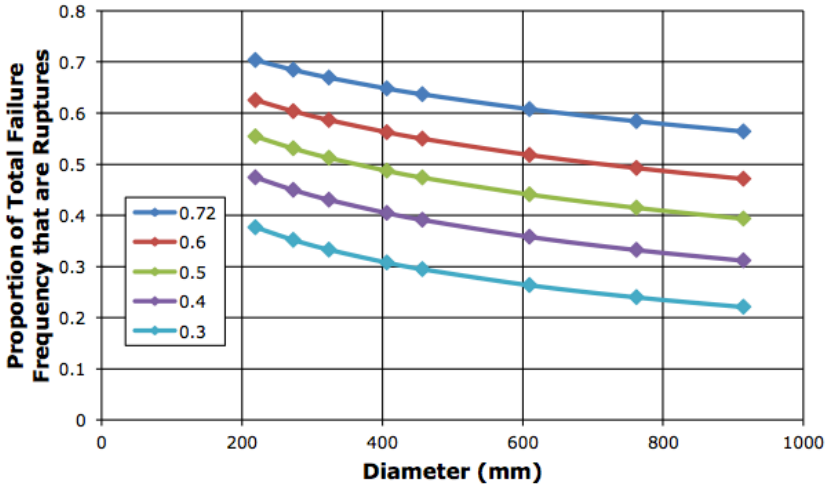


FIGURE 14 - PROPORTION OF RUPTURES AT DIFFERENT DESIGN FACTORS TO BE APPLIED TO TOTAL FAILURE RATE DERIVED FROM FIGURE 13

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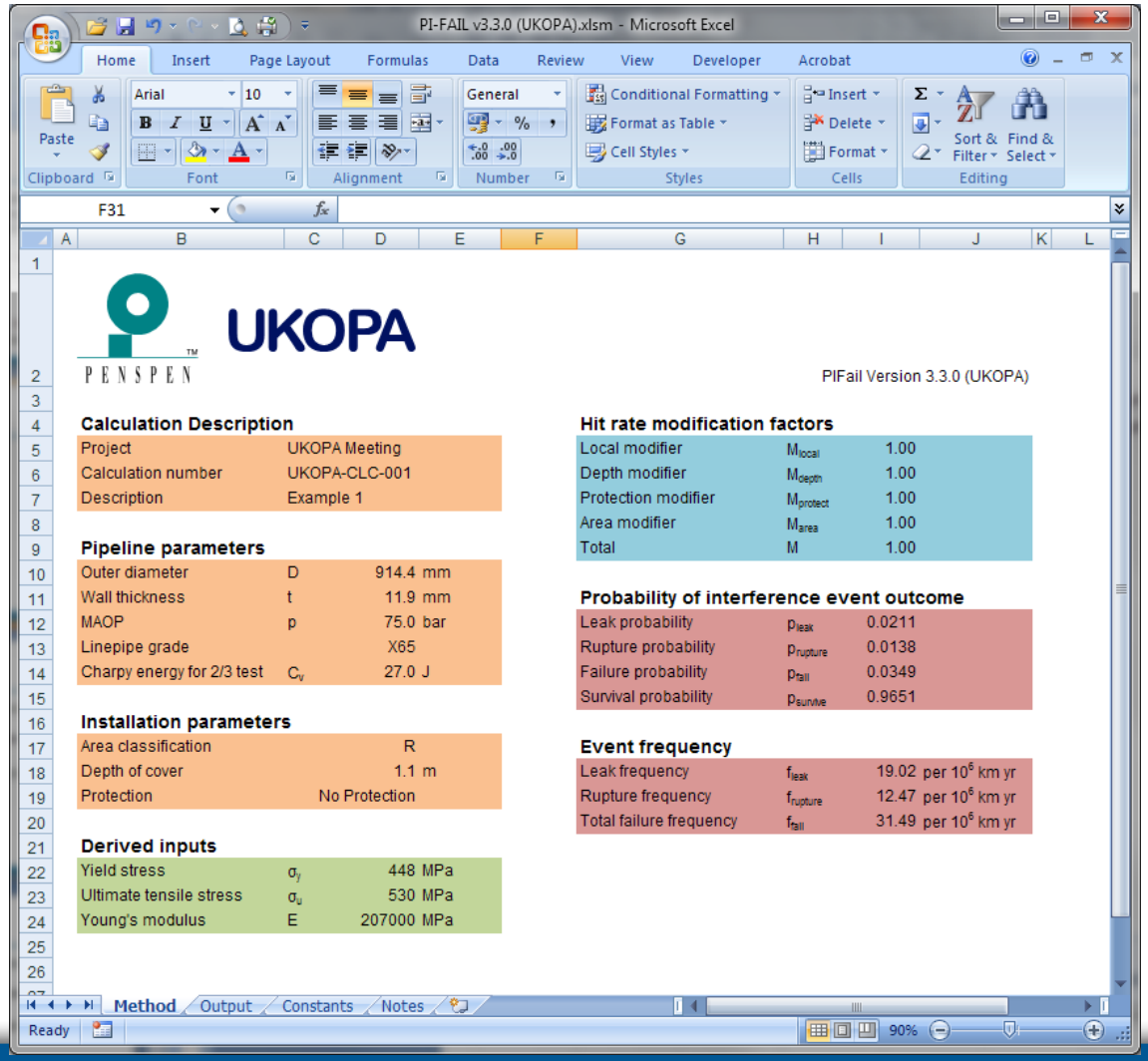
PI-Fail Screenshot



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Failure Frequency Due to Landsliding

- The recommendations for failure frequency due to ground movement have been updated for UKOPA by Geoff Leach to take account of:
  - BGS updates to landslide susceptibility
  - UK landslide incident rates
  - pipe wall thickness
  - girth weld quality
  - leaks and ruptures

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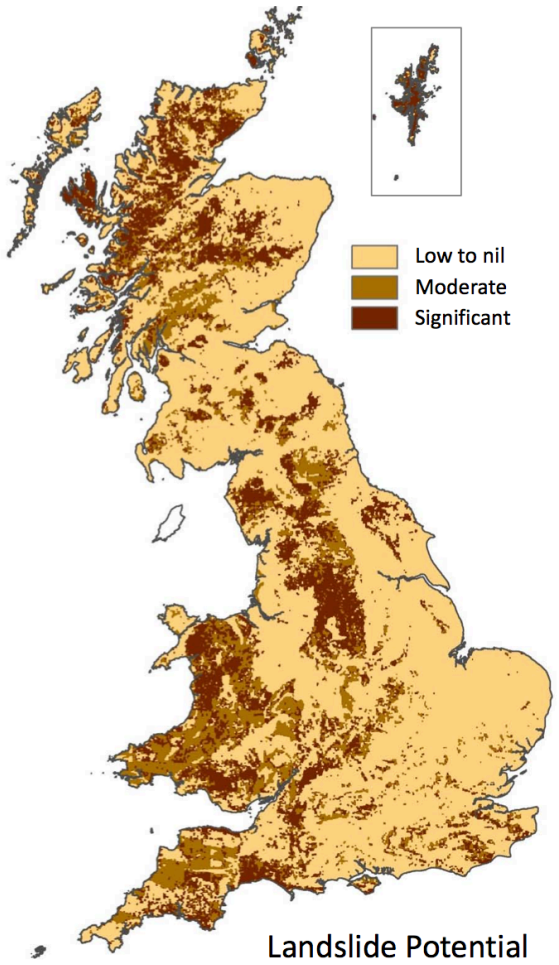
UK Landslide Incident Rates



Landslide Potential

Landslide Potential	Description	UK Landslide Incident Rate (number per 1000 km yr)
Significant	Landslide prone geological formations are present in areas of slopes with adequate relative relief for instability. Active and dormant landslide deposits are probably present.	0.50
Moderate	Landslide prone geological formations are present but slope angles, relative relief or groundwater conditions are not currently conducive to instability. Slope instability may be triggered by significant changes in conditions. Dormant landslide deposits may be present	0.05
Low to nil	Landslide prone geological formations are generally absent or slopes angles and relative relief are typically too modest for instability. Groundwater changes are unlikely to influence stability. Instability is likely to be associated with extreme changes in conditions.	0.005
Weighted Average	Background rate due to all landslide exposure.	0.02

TABLE 8 - INDICATIVE UK LANDSLIDE INCIDENT RATES

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Survival Trends for Natural Landsliding

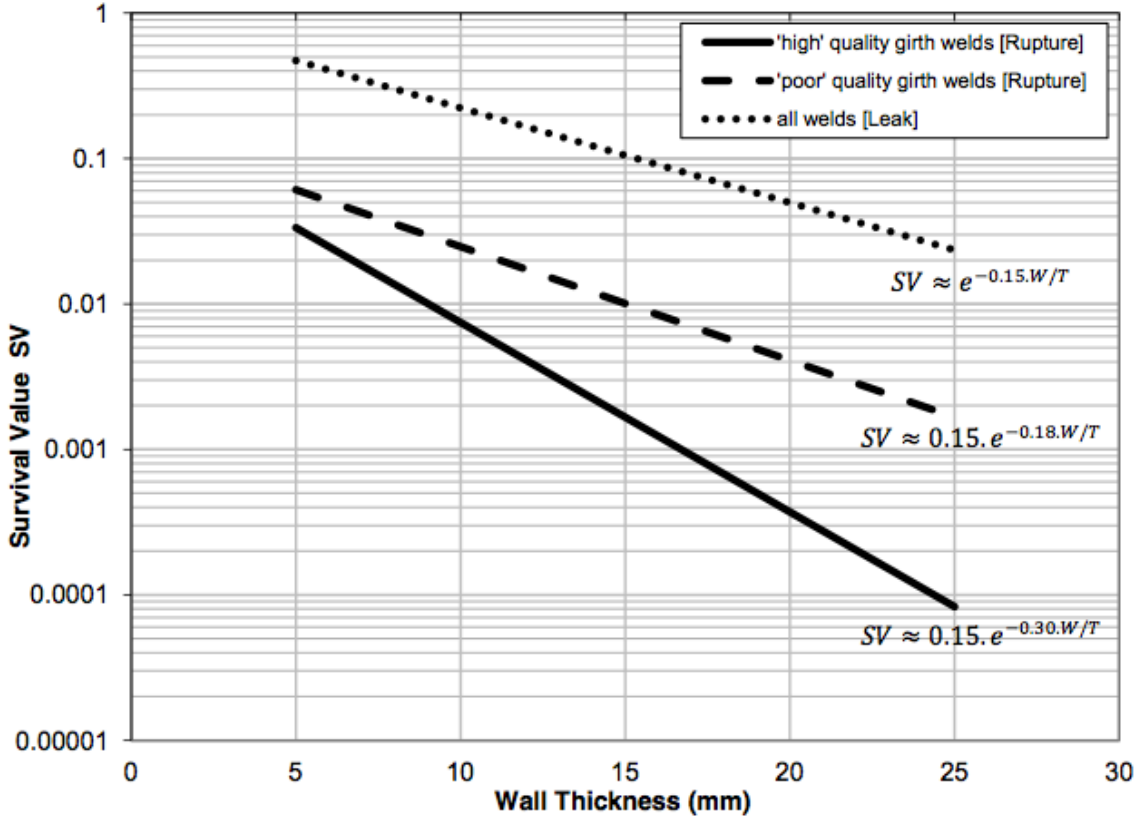

FIGURE 15 - SURVIVAL VALUE TREND LINES FOR RUPTURE DUE TO NATURAL LAND SLIDING

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Summary

- Application – Pipeline Risk Analysis – Risk Management and assessment of LUP decisions
- Improved explanations
- Updates to failure frequencies and reduction factors

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HSE Comments

- PADHI Decision Matrix – possibility of "2nd Bite Cases" for pipelines
- HSE now takes the following mitigation measures into account:
  - Wall thickness
  - Depth of Cover (same curve as TD/2)
  - Slabbing (similar FR reduction to TD/2)
  - Pipeline route

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HSE Comments – Use of TD/2

- Should promote consistency in risk assessments
- Provides a framework for discussion on risk issues
- Transparency
- Used by Operators for ALARP and mitigation decisions

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HSE Comments – Use of TD/2

- Starting point for those without a fully developed pipelines risk assessment tool
- Requires knowledge of principles of pipeline risk assessment
- Requires consequence models
- Not to challenge directly HSE's methodologies