IGEM/TSP/10/251
Date: 05/08/2010

IGEM

TECHNICAL SERVICES PAPER

AMENDMENTS TO IGEM/TD/2

COMMITTEE/PANEL		For:	RESPONSES	
GTDC	✓	Approval	**AT MEETING ON:**	24/08/2010
OTHER – PTD/2	✓	Approval		

TO:

Technical

Tel: 0844 375 4436
Fax: 01509 678198
Email: technical@igem.org.uk

COMMENTARY:

Further to an enquiry from Peter Waite and subsequent review by Mike Acton, Jane Haswell and Neil Jackson, amendments have been proposed to IGEM/TD/2.

The correspondence, proposed amendments and suggested improvements for the next review are given below.

SECTION 5 : CALCULATION OF INDIVIDUAL RISK

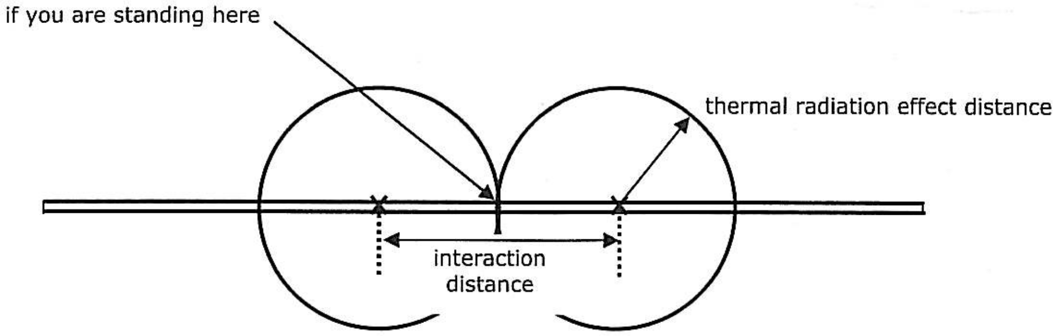
Individual risk is a measure of the frequency at which an individual at a specified distance from a pipeline is expected to sustain a specified level of harm from the realization of specific hazards.

Individual risk contours for pipelines of given geometry, material properties and operating conditions form lines parallel to the pipeline axis. The distance from the pipeline at which a particular level of risk occurs depends upon the pipeline diameter, operating pressure, frequency of failure and failure mode.

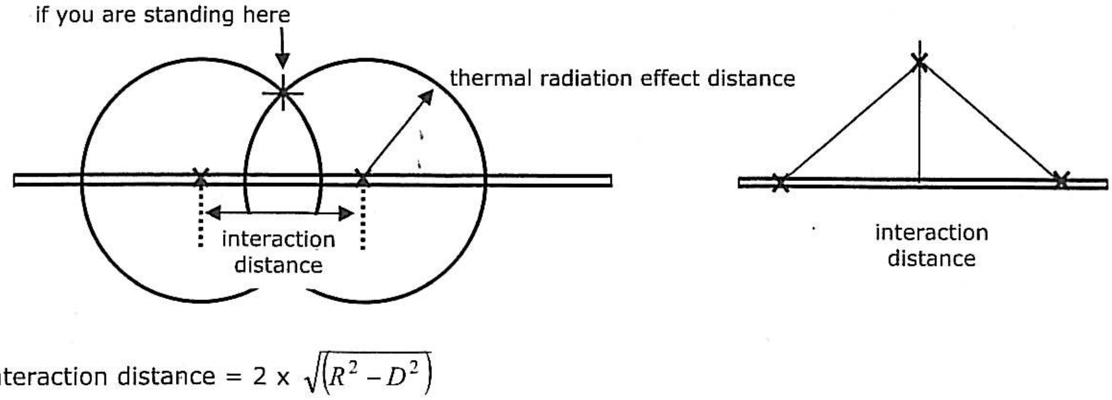
The risks from the various failure scenarios (ruptures and various holes sizes causing fireballs, crater fires and jet fires) should be collated and the individual risk profile at various distances plotted on a graph. From this plot, it is possible to identify the risk of a specific effect, for example fatality or dangerous dose, to an individual at a given distance from the pipeline. Shown in cross-section perpendicular to the pipeline, the risk levels are known as the risk transect.

Pipelines present a hazard along the pipeline route and, therefore, the full length over which a pipeline failure could affect any specific location should be considered in the risk assessment. This length is known as the interaction distance.

For a simple model where wind speed conditions are zero, the consequences are circular and the interaction distance is calculated as shown in Figure 4. The interaction distance shown can be multiplied by the pipeline failure frequency, the probability of ignition and the probability of effect to obtain the risk at any distance from the point of release. Distances to "Dangerous Dose or worse" risk levels of 10^{-5}, 10^{-6} and 3×10^{-7} can then be obtained from the Risk Transect.



Interaction distance = 2 x radius of circle = length of pipeline that could affect you



interaction distance = $2 \times \sqrt{(R^2 - D^2)}$

FIGURE 4 - CALCULATION OF PIPELINE LENGTH WHICH CAN AFFECT AN INDIVIDUAL AT VARIOUS DISTANCES FROM A PIPELINE

Criteria for individual risk [of fatality] levels have been determined by HSE in the UK. The framework for the tolerability of individual risk published by HSE, based on historical risk of death (see A2.3 Ref 13), is shown in Figure 5.

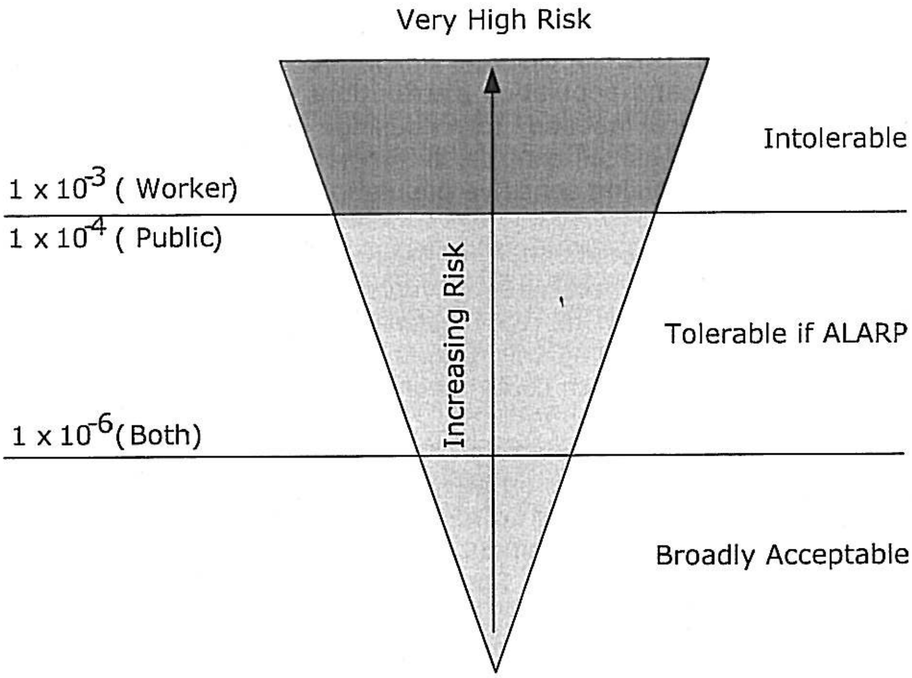


FIGURE 5 - HSE FRAMEWORK FOR TOLERABILITY OF RISK

HSE sets land use planning zones for major hazard sites, including high pressure pipelines transporting defined hazardous substances based on ["Dangerous Dose or Worse"] individual risk levels. Three risk-based zones, the inner, middle and outer zones are defined by HSE based on the "dangerous dose or worse". The outer zone is defined as the consultation distance within which the risk implications of planning developments should be considered by the LPA. Land use planning zones applied to major accident hazard pipelines in the UK defined by HSE are discussed in Appendix 3.

APPENDIX 1 : GLOSSARY, ACRONYMS, ABBREVIATIONS, SYMBOLS, UNITS AND SUBSCRIPTS

A1.1 GLOSSARY

For the purposes of this Standard, the following definitions apply. The definitions are included as a general guide to terms used and are related to terms found in British Standards, etc.

IGEM/G/1 is freely available with copies of IGEM/TD/2.

building burn distance . . . . . –

dangerous dose	A dose of 1050 thermal dose units ((kW $m^{-2})^{4/3}$ s) which results in: "severe distress to almost everyone; a substantial fraction (of people exposed to it) requiring medical attention; some people (exposed to it) are seriously injured requiring prolonged treatment; any highly-susceptible people (exposed to it) might be killed."
event tree	A systematic way of identifying all of the possible outcomes from a hazardous event. In this case, the initial event for a pipeline would be the release itself. The tree is then used to identify the likelihood of leak/rupture, ignition, the possible types of release, etc.
failure cause	The reason for a pipeline reaching a "limit state". Examples are external interference, external corrosion and growth of defects due to fatigue.
maximum operating pressure (MOP)	The maximum pressure at which a system can be operated under normal conditions.
operating pressure (OP)	The pressure at which the gas system operates under normal conditions.
proximity distance	Minimum distance permissible between the pipeline and any normally occupied building or traffic route as derived from Figures 6 and 7 of IGEM/TD/1 Edition 5.
societal risk	The relationship between the frequency and number of people in a given population suffering a specified level of harm from the realisation of specific hazards.
steady state	The final state which a pipeline system attains when the effects of external disturbances have ceased.

A1.2 ACRONYMS AND ABBREVIATIONS

AC	Alternating current.
ALARP	As low as reasonably practicable.
BPD	Building proximity distance.
CP	Cathodic protection.
DC	Direct current.
dia	diameter.
FFREQ	Failure frequency.
GB	Great Britain.
HSE	Health and Safety Executive.
IGEM	Institution of Gas Engineers and Managers.
LPA	Local Planning Authority.
LUP	Land use planning.
MAHP	Major accident hazard pipeline.
MAPD	Major Accident Prevention Document.
MOP	Maximum operating pressure.

APPENDIX 2 : REFERENCES

This Standard is set out against a background of legislation in force in GB at the time of publication. Similar considerations are likely to apply in other countries where reference to appropriate national legislation is necessary. The following list is not exhaustive.

All relevant legislation must be complied with and relevant Approved Codes of Practice (ACoPs), official Guidance Notes and referenced codes, standards, etc. shall be taken into account.

Where British Standards, etc. are quoted, equivalent national or international standards, etc. equally may be appropriate.

Care shall be taken to ensure that the latest editions of the relevant documents are used.

A2.1 UK LEGISLATION

A2.1.1 Regulations and Orders

- Notification of Installations Handling Hazardous Substances Regulations
- Pipelines Safety Regulations 1996 SI 1996 No 825 (and associated Guidance HS (L) 82)
- Town and Country Planning Act (General Permitted Development) Order 1995 SI 1995 No 48.

A2.2 HSE ACOPS AND GUIDANCE

- HS(G)48 Reducing error and influencing behaviour ISBN 0-7176-2452-8

A2.3 TECHNICAL REFERENCES

1 Corder, I. The Application of Risk Techniques to the Design and Operation of Pipelines, Paper No C502/016/95, Proceedings of International Conference on Pressure Systems: Operation and Risk Management, Institution of Mechanical Engineers, London, October 1995, p. 113-125.

2 Corder, I., Fearnehough, G.D. and Knott, R.N. Pipeline Design Using Risk Based Criteria, Institute of Gas Engineers 129th Annual General Meeting and Spring Conference, Communication 1492, Eastbourne, UK, May 1992.

3 Lyons, C., Haswell, J.V., Hopkins, P., Ellis, R. and Jackson, N. A Methodology for the Prediction of Pipeline Failure Frequency due to External Interference. Proceedings of International Pipeline Conference, Calgary, Canada, 2008.

4 Acton, M., Baldwin, T. and Jager, E.R. Recent Developments in the Design and Application of the PIPESAFE Risk Assessment Package for Gas Transmission Pipelines. Proceedings of International Pipeline Conference, Calgary, Canada, 2002.

5 Arunakumar, G. UKOPA Pipeline Fault Database. Pipeline Product Loss Incidents 1962-2006 – 5th report of the UKOPA Fault Data Management Group. Advantica Report 6957. Loughborough: Advantica. August 2007.

6 European Gas Pipeline Incident Data Group. *Gas Pipeline Incidents - 6th Report of the European Gas Pipeline Incident Data Group 1970-2004.* EGIG 05 R.0002. European Member States: EGIG. December 2005.

7 Baum, M., and Butterfield, J.M. Studies of the Depressurisation of Gas Pressurised Pipes During Rupture. Journal of Mechanical Engineering Science, Vol 21 No 4 1979 IMechE.

8 Acton, M.R., Baldwin, P.J., Baldwin, T.R., and Jager, E.E.R., The Development of the PIPESAFE Risk Assessment Package for Gas Transmission Pipelines, Proceedings of the 2nd International Pipeline Conference, Calgary, Canada, 1998.

9 Acton, M.R., Hankinson, G., Ashworth, B.P., Sanai, M. and Colton, J.D. A Full Scale Experimental Study of Fires following the Rupture of Natural Gas Transmission Pipelines. Proceedings of the 3rd International Pipeline Conference, Calgary, Canada, 2000.

10 Anon. An Overview of the PIPESAFE Risk Assessment Package for Natural Gas Transmission Pipelines, Advantica Report R 8224, November 2005, (Available from Advantica).

11 Lees, F.P. Loss Prevention in the Process Industries. Second Edition. London, Butterworths-Heinemann, 1996. ISBN 0 7506 1547 8.

12 Bilo, M. and Kinsman, P. MISHAP – HSE's Pipeline Risk Assessment Methodology. Pipes and Pipelines International, July-August 1997.

13 Bilo, M. and Kinsman, P. Risk calculation for pipelines applied within the MISHAP HSE computer program. Pipes and Pipelines International, March-April 1998.

14 Acton, M.R. and Baldwin, P.J. Ignition Probability for High Pressure Gas Transmission Pipelines, Proceedings of the 7th International Pipeline Conference, Calgary, Canada, 2008.

15 Spencer, H. and Rew, P.J. Ignition Probability of Inflammable Gases. Contract Research Report CRR146. London. WS Atkins for HSE 1997.

16 Spencer, H., Daycock, J. and Rew, P.J. A Model for Ignition Probability of Flammable Gases. Contract Research Report CRR203. London. W. S. Atkins for HSE, 1997.

17 Bilo, M. and Kinsman, P. Thermal Radiation Criteria used in Pipeline Risk Assessment. Pipes and Pipelines International, November-December 1997.

18 Carter, D.A. Aspects of Risk Assessment for Hazardous Pipelines Containing Flammable Substances. Journal of Loss Prevention in the Process Industries, January 1991, Volume 4.

19 Health and Safety Executive. Reducing Risks, Protecting People – HSE's Decision Making Process. London. HSE Books, 2001, ISBN 0 7176 2151 0.

20 Lyons, C. and Haswell J.V. The Influence of Pipe Design Factor and Geometry on the Failure of Pipelines Subject to 3rd Party Damage, PIE/2005/R104, Issue 1.0, October 2005. (Available from UKOPA).

21 Haswell L, J.V.; Failure Frequency Reduction Factors for Design Factor and Wall Thickness. PIE/07/TN051 V0, 14 September 2007. UKOPA Reference.

22 Cosham, A., Haswell, J. and Jackson, N. Reduction Factors for Estimating the Probability of Failure of Mechanical Damage due to External Interference. Proceedings of International Pipeline Conference, Calgary, Canada, 2008.

23 Hopkins, P. The Application of Fitness for Purpose Methods to Defects Detected in Offshore Transmission Pipelines. Conference on Welding and Weld Performance in the Process Industry, London, 1992.

24 Corder, I. Chatain, P. EPRG Recommendations for the Assessment of the Resistance of Pipelines to External Damage, Proceeding of the EPRG/PRC 10th Biennial Joint Technical Meeting On Line Pipe Research, Cambridge, UK, April 1995.

methodology. The guidance in this Standard is provided for use by pipeline operators, LPAs, developers and any person involved in the risk assessment of developments in the vicinity of existing high pressure gas pipelines. It is based on the established best practice methodology for pipeline risk assessment.

A3.8 It is recommended that the methodology be used for the prediction of site-specific risk levels for consideration as required for the re-assessment of LUP developments, so that specific local conditions can be taken into account. The process is shown in Figure 11.

HSE has adopted a risk-based approach for calculating the distances to the zone boundaries from the pipeline, defining the levels of risk at each boundary as follows:

a) boundary between inner and middle zone – based on the greater of:
   - an individual risk of (1×10^{-5}) per year of dangerous dose or worse to the average householder and
   - the pipeline BPD;

Note: Because of the low levels of risk, some MAHPs will not have an inner zone based on an individual risk level of 1×10^{-5} per year. However, an inner zone equivalent to the BPD has been applied by the HSE to MAHPs. This distance is calculated in accordance with Sub-Section 6.7 of IGEM/TD/1 Edition 5.

b) boundary between middle zone and outer zone – an individual risk of (1×10^{-6}) per year of dangerous dose or worse to the average householder;

c) boundary between outer zone and no restrictions – the lesser of:

   - an individual risk of (0.3×10^{-6}) per year of dangerous dose or worse to the average householder and
   - notified outer zone distance.

Note 1: In cases where the calculation of risks indicates risk levels are lower than (1×10^{-6}) per year and therefore there is no middle zone, the inner and middle zones are made equal to the BPD. Similarly, where risk calculations show levels lower than (0.3×10^{-6}) per year, all three zones, inner, middle and outer, are made equal to the BPD (IGEM/TD/1 Edition 5, Sub-Section 6.7).

Note 2: The location of very large sensitive developments, for example very large hospitals, schools, and people's homes, is restricted to the outer zone (see also Section 7),

Dangerous dose is defined by HSE as a dose of thermal radiation that would cause:

- severe distress to almost everyone in the area or
  - a substantial fraction of the exposed population requiring medical attention or
  - some people being seriously injured, requiring prolonged treatment or
  - any highly susceptible/sensitive people being killed.

Note 1: Due to the uncertainties associated with such predictions, the use of the "dangerous dose" concept is used by HSE to define LUP zones. Normally, a "dangerous dose" for thermal radiation is defined as 1000 tdu. These criteria are based on the assumption that the exposed people are typical householders and indoors most of the time.

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 three zones set by HSE that are based on the details given in the pipeline notification. Where local pipeline details differ from notified details, HSE risk assessors might be willing to reconsider the case using the details relevant to the pipeline near the development.

DIAMETER (mm)	PIN	HOLE	RUPTURE	TOTAL
100	0	0.119	0.03	0.149
250	0.022	0.072	0.022	0.116
400	0	0.079	0	0.079
560	0.01	0.01	0.01	0.03
700	0	0.028	0	0.028
860	0	0	0.031	0.031
1200	0	0	0	0

Units in failures per 1000 km yr.

TABLE 4 - FAILURE FREQUENCY DUE TO EXTERNAL INTERFERENCE vs DIAMETER

Wall Thickness

~~DIAMETER~~ (mm)	PIN ≤ 6mm	HOLE 6mm < ≤ Ø	RUPTURE > Ø	TOTAL
< 5	0	0.162	0.061	0.223
5 to 10	0.012	0.049	0.006	0.067
10 – 15	0	0.012	0.004	0.016
> 15	0	0	0	0

Units in failures per 1000 km yr.

Note: Failure frequency predictions based on assessment of current operational fault and failure data are published by UKOPA.

TABLE 5 - FAILURE FREQUENCY DUE TO EXTERNAL INTERFERENCE vs WALL THICKNESS

A4.2.1 GENERIC PIPELINE FAILURE FREQUENCY CURVE FOR EXTERNAL INTERFERENCE

A generic pipeline frequency curve for external interference which can be used with the failure frequency reduction factors for design factor and wall thickness given in Figures 7 and 6 respectively is derived by predicting the failure frequency for pipelines of varying diameter with a constant design factor of 0.72, a constant wall thickness of 5 mm and material grade of X65 i.e varying pressure. This curve is shown in Figure 16. The generic failure frequency curve has been generated using probabilities of failure produced using the original dent-gouge model (see A2.3 Refs 1 and 3). The failure model is 2-dimensional, and predicts through-wall failure, not whether the failure mode is a leak or a rupture. A conservative assumption for the proportion of ruptures which applies to the generic failure frequency curve is 0.7. However, the leak/rupture failure mode is dependent upon the critical length of an axial defect, which is dependant upon both the diameter and the wall thickness. So the proportion of ruptures of 0.7 has to be treated as an upper bound, and will be significantly less for large thick-walled pipe. Review of the data presented in A4.2.3 to select a more representative value is recommended.

Note 1: Predicted failure frequencies due to external third party interference increase with material grade due to the consequent reduction in wall thickness, so the generic curve given in Figure 16 can be conservatively applied to pipelines with material grades of X65 and lower.

Note 2: The generic curve given in Figure 16 provides failure frequencies for pipelines in R areas. Failure frequencies for pipelines in S areas may be derived by multiplying the R area failure frequency by a factor of 4, as recommended in clause 8.1.7.

Use of the generic failure frequency curve with a fixed proportion of ruptures of 0.7 is conservative. Where risk levels are critical, a pipeline-specific analysis needs to be carried out using a recognised failure frequency prediction tool. The failure frequency prediction tool recommended by UKOPA is FFREQ (see A4.2.3).

A4.2.3 PIPELINE EXTERNAL INTERFERENCE FAILURE FREQUENCY PREDICTIONS FOR SPECIFIC PIPE CASES

The use of a generic failure frequency curve for external interference described in A4.2.1 and A4.2.2 allows conservative failure frequency estimates for specific pipeline cases to be readily estimated. However, the approach is approximate and, where possible, predictions for the specific pipe case under consideration needs to be carried out using a recognised failure frequency prediction model.

The current tool for the prediction of pipeline failure frequency due to external interference, recommended by UKOPA, is FFREQ. Failure frequency predictions generated using FFREQ for pipe cases selected to represent the range of pipe parameters for Natural Gas pipelines in the UKOPA database given in Table 6 are given in this section for reference and application.

Outside diameter (mm)	Wall thickness (mm)	Material grade
168.3	6.35	X42
219.1	6.35	X46
273	6.35	X52
323.9	6.35	X52
406.4	7.9	X52
508	7.9	X52
609	9.52	X60
762	9.52	X60
914	11.9	X65
914	19.1	X65

TABLE 6 - PIPE CASES

The FFREQ failure frequency predictions given in Tables 7, 8 and 9 and Figures 17, 18 and 19 are for pipelines located in R areas. Detailed predictions, including results for pipelines located in S areas, are given in A4.2.5. No they are not!

Note: *Comprehensive FFREQ predictions are published on the UKOPA website.* No where I can find.

Design factor	Diameter (mm)							
	168.3	219.1	273	323.9	406.4	508	609	762
0.72	0.1473	0.1531	0.1532	0.1537	0.1026	0.1029	0.0605	0.0621
0.6	0.1041	0.1078	0.1081	0.1105	0.0612	0.0649	0.0414	0.0452
0.5	0.0766	0.0813	0.0869	0.0889	0.0497	0.0559	0.0320	0.0373
0.4	0.0605	0.0629	0.0716	0.0759	0.0421	0.465	0.0291	0.0333
0.3	0.0453	0.0492	0.0530	0.0559	0.0301	0.0369	0.0196	0.0236
0.2	0.0351	0.0380	0.0416	0.0480	0.0225	0.0265	0.0144	0.0168

TABLE 7 - FFREQ PREDICTIONS FOR TOTAL EXTERNAL INTERFERENCE FAILURE FREQUENCY FOR PIPE CASES DEFINED IN TABLE 6 (per 1000 km yr)

DIAMETER (mm)	WALL THICKNESS (mm)	MATERIAL GRADE	CRITICAL DEFECT LENGTH (mm)	CRITICAL HOLE DIAMETER LIMIT RUPTURE/LEAK (mm)
168.3	6.35	X42	30.92	2.42
219.1	6.35	X46	33.79	2.98
273	6.35	X52	35.21	3.42
323.9	6.35	X52	38.33	4.05
406.4	7.9	X52	47.92	5.09
508	7.9	X52	53.53	6.35
609	9.52	X60	63.55	7.50
762	9.52	X60	71.13	9.39
914	11.9	X65	82.38	10.56

TABLE 10 - CRITICAL DEFECT LENGTHS AND EQUIVALENT HOLE DIAMETERS FOR UKOPA PIPELINE CASES OPERATING AT A DESIGN FACTOR R_{df} = 0.72

A4.3 **PIPELINE FAILURE FREQUENCY DUE TO EXTERNAL CORROSION**

A4.3.1 **External corrosion**

UKOPA data for external corrosion is given in Table 11. The failure frequency due to corrosion in the UK is dependent upon the year of construction and hence the age and applicable coating, corrosion protection design standards and corrosion control procedures. Corrosion control procedures include:

- monitored and controlled CP and
- regular in-line inspection and
- defect assessment and remedial action.

The data shows that to date there is no operational experience of rupture failure due to corrosion in the UK.

~~DIAMETER~~ Wall thickness (MM)	PIN	HOLE	RUPTURE	TOTAL
< 5	0.262	0.04	0	0.302
> 5 ≤ 10	0.031	0.015	0	0.046
> 10 ≤ 15	0	0	0	0
> 15	0	0	0	0

Units in failures per 1000 km yr

TABLE 11 - FAILURE FREQUENCY DUE TO EXTERNAL CORROSION vs WALL THICKNESS

For pipelines commissioned pre-1980, it is recommended that the corrosion rates in Table 11 be applied unless corrosion control procedures have been applied. For pipelines of wall thickness up to 15 mm commissioned after 1980 and with corrosion control procedures applied, the corrosion failure frequency rate can be assumed to reduce by a factor of 10. For pipelines of any age with wall thicknesses greater than 15 mm and with corrosion control procedures in place, the corrosion failure frequency can be assumed to be negligible.

A4.3.2 **Internal corrosion**

Review of UKOPA data confirms that the incidence of internal corrosion in MAHPs in the UK to date is low. The likelihood of occurrence of internal corrosion is low for pipelines which transport sweet dry Natural Gas.

- depth of cover - 1.1 m
- area classification - rural (Type 'R' Area)

The BPD is calculated to be 80.25 m in Type 'R' areas.

Consequence analysis

For societal risk, the consequences of pipeline rupture only have been assessed; calculations performed for ignited punctures on this pipeline have shown that none of the houses lie within the hazard range for punctures and therefore they are not considered further in the societal risk analysis.

It is assumed that in the event of failure, the pressure would be maintained at the upstream end of the pipeline and blocked downstream, with no backflow. It is further assumed that the rupture occurs midway along the pipeline and the event is modelled as a two-ended, full-bore "balanced flow" release, with no pipeline misalignment.

It has been assumed that ignited ruptures will ignite immediately 50% of the time and will be delayed by 30 seconds for the remaining 50% of the time. For the pipeline in this case study, the total ignition probability in the event of rupture has been calculated to be 0.8, giving probabilities of both immediate and delayed ignition of 0.4.

The 1800 tdu casualty criterion was used in the assessment, with an assumed escape speed of 2.5 m s^{-1}.

The results from the consequence analysis are:

- building burning distance - 226 m
- escape distance - 345 m.

For the section of pipeline where all the development would be inside the "building burning distance" in the event of a rupture, the analysis assumes that no safe shelter is available. For the remaining section of pipeline within the interaction distance, the shelter density has been taken to be equivalent to the density of houses in the half of the development that is furthest away from the pipeline, i.e. approximately 40 shelters per hectare.

Failure frequency

The pipeline failure frequency data due to third party damage has been calculated using the model FFREQ with the following additional assumptions:

- 2/3 Charpy Energy - 27 J (FFREQ default)
- Seam type - LSAW.

The third party damage rupture frequency in Type 'R' areas is calculated to be (4.82×10^{-3}) per 1000 km yr

A background ground movement rupture frequency has also been included of (2.1×10^{-4}) per 1000 km yr

The total rupture frequency is, therefore, (5.03×10^{-3}) per 1000 km yr

Risk analysis

Individual Risk of death has been calculated at the location of the nearest house (86 m) for a person who is present all the time and outdoors for 10% of the time and was found to be 9.1×10^{-7} per year. The individual risk reduces from this value with increasing distance from the pipeline. On this basis, the assessment has focussed on societal risk and this is discussed in more detail below.

Correspondence

Comments from Mike Acton on Peter Waite's Proposals

Page 14 - PARTLY ACCEPTED

The suggestion is not correct, because the risk transect could be constructed for different dose criteria, not just "Dangerous Dose or Worse", as described in the third paragraph on the same page. It is factually correct as written, but it would be better to amend the last sentence just to say:

"Distances to specified Individual Risk levels can then be obtained from the Risk Transect."

Page 15 - NOT ACCEPTED

1st comment - para 1

It is clear from the description in the following sentence that the HSE Individual Risk criteria presented in Figure 5 are based on the "historical risk of death" so no change is necessary.

2nd comment - para 2

Again, this is clear from the text of the following sentence that says the zones are based on the "dangerous dose or worse" and so no change is necessary.

Page 28 - ACCEPTED

Building burning distance - The criterion for damage to property is either the 'spontaneous ignition' of wood where self-ignition occurs, or 'piloted ignition' where ignition occurs at lower flux levels due to the presence of materials that ignite at lower levels of thermal radiation (such as plastic, fabric and vegetation) and then act as a pilot flame.

Secretariat Note: Definition to be included in IGEM/G/4

The results in Appendix 5 and Appendix 6 should also state that they are for the piloted ignition of wood.

Pages 30 and 31 - NO RESPONSE REQUIRED

Page 34 - ACCEPTED

Agreed as suggested.

Page 41 - PARTLY ACCEPTED

Agree that "Diameter" should be "Wall Thickness" in Table 5.

However, I don't think we need to repeat the definition of "Pin", "Hole" and "Rupture" every time as long as they are defined where first used, i.e. under Table 3 (which does need the note to be linked to the table properly).

Page 44 - ACCEPTED

Delete "Detailed predictions, including results for pipelines located in S areas, are given in A4.2.5."

I suggest replacing it with:

"An estimate of the failure frequency for S Area pipelines can be obtained by multiplying the R Area hit rate by a factor of 4 (Section 8.1.5). More accurate predictions can be obtained using the FFREQ model, which is available to all UKOPA members via the UKOPA website."

Page 49 - ACCEPTED

Agreed as suggested.

Page 53 - NOT ACCEPTED

The casualty criterion used in this example is defined above on the same page, and does not to be repeated. In any case, we are using the 1800 TDU criterion.

He has missed a couple of other points which I would like to add to the list:

Pages 37 and 38

The x-axes for all figures should be labelled "Pressure (bar)".

Page 51

The first description in Table 13 has the words "affected by" repeated twice. Delete one of them!

The caption for Table 13 is incorrect. It should read:

"Table 13 - Pipeline Rupture Failure Frequency due to Natural Landsliding"

Secretariat Note: Amendment already issued in February 2009 for title to Table 13.

Proposed Amendments

IGEM/TD/2
COMMUNICATION 1737
2008

The following amendments (January 2009) apply to all copies of IGEM/TD/2 published in December 2008.

Table 3 **Delete table and notes entirely and substitute:**

DAMAGE MECHANISM	PIN*1	HOLE*2	RUPTURE*3	TOTAL	% Pin	% Hole	% Rupture
Third Party	0.006	0.04	0.011	0.057	10.5	70.2	19.3
Ext Corr	0.035	0.011	0	0.046	76.1	23.9	0.0
Int Corr	0.003	0	0	0.003	100.0	0.0	0.0
Mat & Con	0.063	0.013	0	0.076	82.9	17.1	0.0
Ground Move	0.003	0.004	0.002	0.009	33.3	44.4	22.2
Other	0.052	0.019	0.002	0.073	71.2	26.0	2.7
Total				**0.264**			

*1 Equivalent hole diameter up to 6 mm
*2 Equivalent hole diameter greater than 6 mm but less than pipe diameter
*3 Equivalent hole diameter equal to or greater than pipe diameter
Units in failures per 1000 km yr

Table 5 **Delete table and notes entirely and substitute:**

WALL THICKNESS (mm)	PIN	HOLE	RUPTURE	TOTAL
< 5	0	0.162	0.061	0.223
5 to 10	0.012	0.049	0.006	0.067
10 – 15	0	0.012	0.004	0.016
> 15	0	0	0	0

A4.2.3 **3rd paragragh, delete:**

Detailed predictions, including results for pipelines located in S areas, are given in A4.2.5.

and substitute with:

An estimate of the failure frequency for S Area pipelines can be obtained by multiplying the R Area hit rate by a factor of 4 (Section 8.1.5). More accurate predictions can be obtained using the FFREQ model, which is available to all UKOPA members via the UKOPA website.

Table 11 **Delete table entirely and substitute:**

WALL THICKNESS (mm)	PIN	HOLE	RUPTURE	TOTAL
< 5	0.262	0.04	0	0.302
> 5 ≤ 10	0.031	0.015	0	0.046
> 10 ≤ 15	0	0	0	0
> 15	0	0	0	0

Units in failures per 1000 km yr

Proposed Amendments

Table 13 **1st Column, 2nd row delete text in the cell entirely and substitute:**

Slope instability is negligible or unlikely to occur, but may be affected by slope movement on adjacent areas

Suggested Improvements for Next Edition

Section 5 **Delete the following sentence from the 5th paragraph:**

Distances to risk levels of 10^{-5}, 10^{-6} and 3×10^{-7} can then be obtained from the Risk Transect.

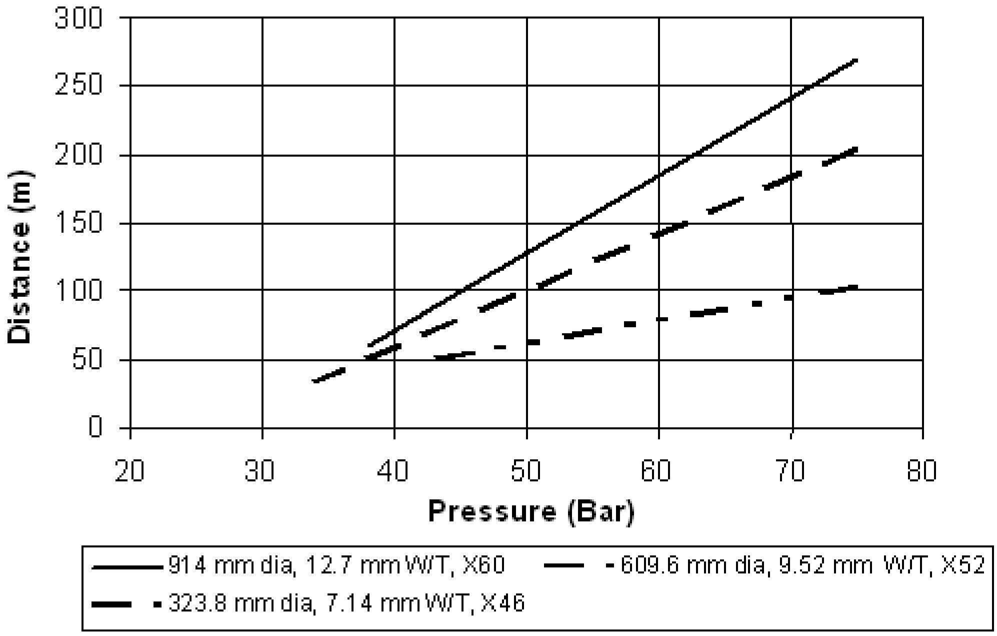
and substitute:

Distances to specified Individual Risk levels can then be obtained from the Risk Transect.

A3.8(c) **Delete Note 2 to second indent and substitute:**

Note 2: The location of very large sensitive developments, for example very large hospitals, schools, and old people's homes, is restricted to outside the outer zone (see also Section 7),

Figure 12 **Delete figure entirely and substitute:**



Suggested Improvements for Next Edition

Figure 13 **Delete figure entirely and substitute:**

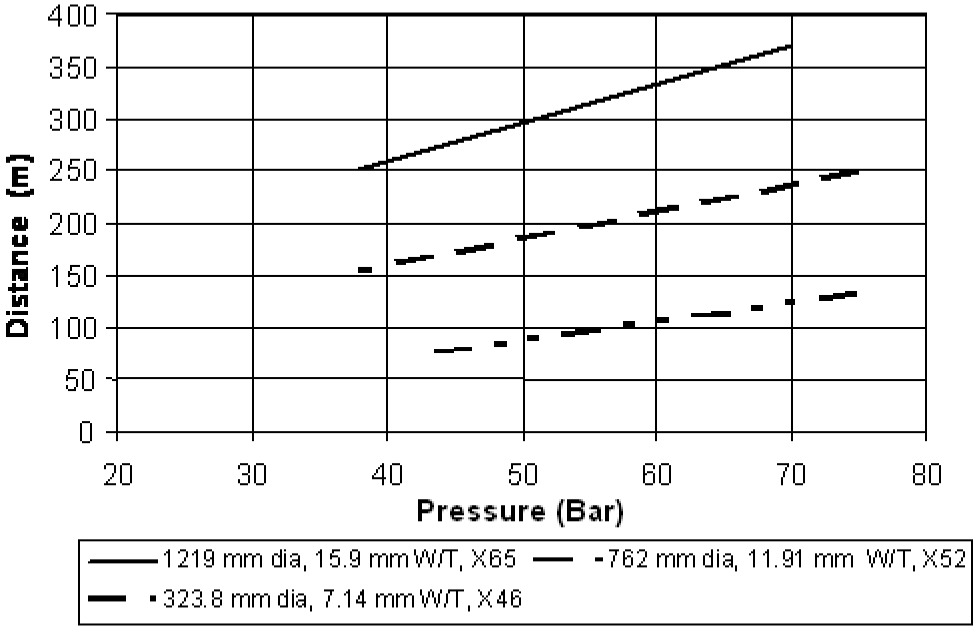
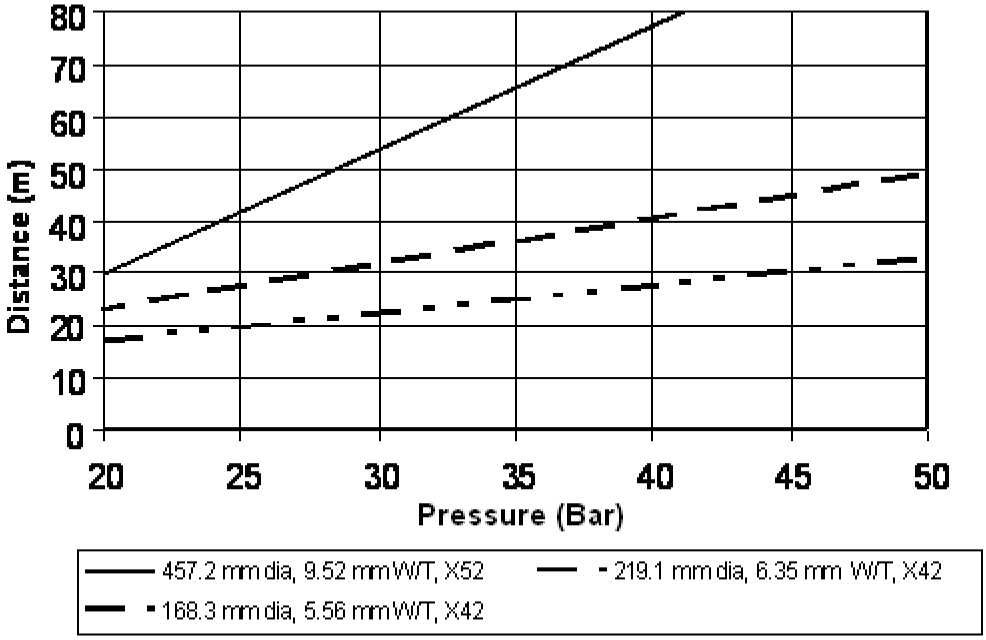
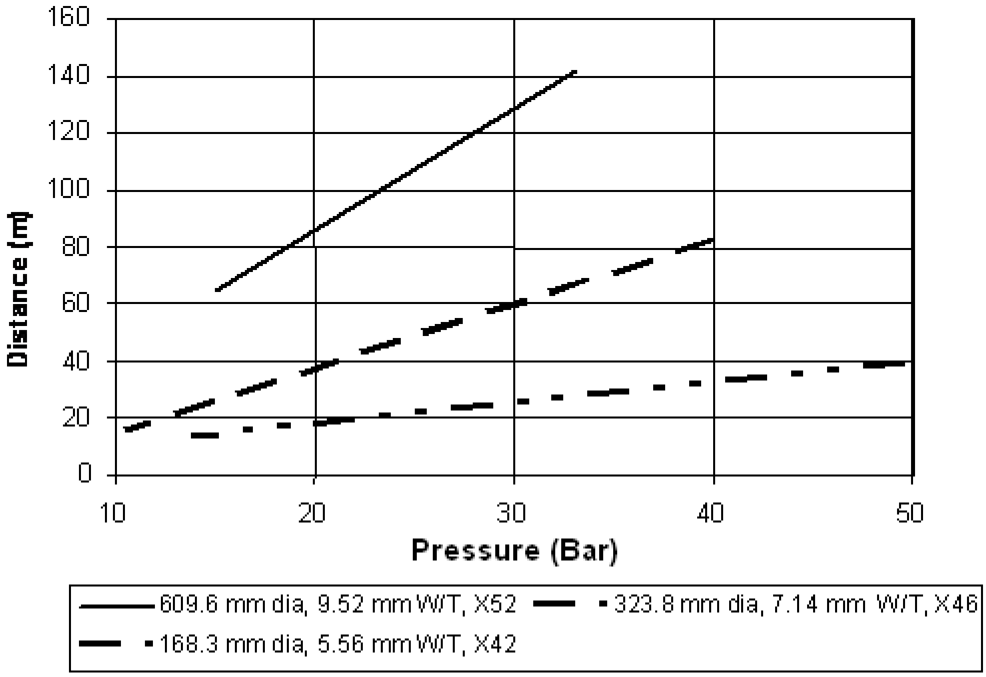


Figure 14 **Delete figure entirely and substitute:**



Suggested Improvements for Next Edition

Figure 15 Delete figure entirely and substitute:



Appendix 5 Add under title of Appendix:

Note: The results in this Appendix are for the piloted ignition of wood.

Appendix 6 Add under title of Appendix:

Note: The results in this Appendix are for the piloted ignition of wood.