

Quantitative Risk Assessment for Parc Pelenna Holiday Resort Development

CLIENT: Trivselhus UK Holdings Limited

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EXECUTIVE SUMMARY

Trivselhus UK Holdings Limited (Trivselhus) is planning a holiday park development off the B4434, Neath, SA11 4ET, in close proximity to the Dowlais to Dyffryn Clydach section of the Feeder 2 pipeline (reference WA02DODY). The pipeline section has a nominal diameter of 600 mm and is operated in accordance with IGEM/TD/1 (ref. [1]).

Trivselhus has requested that ROSEN(UK) carry out a quantitative risk assessment (QRA) for the interaction between the pipeline and development, in order to establish the individual and societal risk at the location, taking into account the increase in population due to the new development.

This report reviews and assesses this holiday park development and presents the findings of the quantitative risk assessment.

Conclusions

- The pipeline has known metallurgy issues relating to low temperature toughness, but previous work confirms that the standard methodology is appropriate and the acceptable result is valid for this pipeline.
- The maximum individual risk level for this assessment was determined to be 7.318×10^{-6} at the proposed site of one of the lodges approximately 60m from the pipeline., which is above the 1.0×10^{-6} per year level that is considered to be 'broadly acceptable'
- The FN curve for societal risk crosses the criterion line, therefore, a cost benefit analysis (CBA) has been performed. The PLL is calculated to be 2.254×10^{-4} , and the maximum number of casualties is 125.
- The optimised CPCA values obtained for both slabbing and thick-walled pipe are above the £47M criteria, therefore the costs are disproportionate to the benefits achieved and the risk is considered to be acceptable and ALARP.

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1 INTRODUCTION

Trivselhus UK Holdings (Trivselhus) is planning a new holiday park development off the B4434, Neath, SA11 4ET, in close proximity to the Dowlais to Dyffryn Clydach section of the Feeder 2 pipeline (reference WA02DODY). The pipeline section has a nominal diameter of 600 mm and is operated in accordance with IGEM/TD/1 (ref. [1]).

Trivselhus has requested that ROSEN(UK) carry out a quantitative risk assessment (QRA) for the interaction between the pipeline and development, in order to establish the individual and societal risk at the location, taking into account the increase in population due to the new development.

This report reviews and assesses this new holiday park development and presents the findings of the quantitative risk assessment.

2 METHODOLOGY

The methodology for reviewing and assessing the development is documented in NGT Hazard Assessment Methodology Manual, T/SP/HAZ/16 (ref. [2]).

The assessment has been completed using the following software:

- PIPESAFE Version 2.29.0 [3]

The risk from high pressure gas transmission lines is dominated by the rupture failure mode and this assessment analyses the risk from ruptures only. Historically, failures by rupture are mainly caused by external interference and ground movement, and these are the threats considered in this assessment

3 PIPELINE DETAILS

A summary of basic pipeline information is shown in Table 1 (ref. [4]). Where required, location specific data such as wall thickness or steel grade will be used in the assessment.

Data	Value
Pipeline Reference	WA02DODY
Feeder Number	2
Pipeline Section Name	Dowlais to Dyffryn Clydach
Nominal Diameter (mm)	600
Nominal Wall Thickness (mm)	Rhigos to Tonna 11.91
	Tonna to Aberdulais 9.52
Steel Grade	X52
Length (km)	42.15
MOP (bar)	70
Commissioning Date	March 1970
PSR Number	1636
Nominal depth of cover (m)	0.9

Table 1: Basic Pipeline Information

The pipeline has known metallurgy issues relating to low temperature toughness (ref. [4]), however, a previous study showed that this issue did not affect the application of the standard PIPESAFE methodology and its use is appropriate for this pipeline (ref. [5]).

4 RISK ASSESSMENT

4.1 Failure Frequency Analysis

Historical data indicates that the most likely causes of full bore rupture are third party damage and ground movement, and these will dominate the risk, so analysis of further causes has not been conducted.

A depth of cover of 0.9 m has been used along the entire interaction length. Due to the increase in population around the development, this QRA has been carried out using Type S parameters.

The failure frequencies used in this assessment are detailed in Table 2.

Failure Cause	Diameter (mm)	MOP (barg)	Wall Thickness (mm)	Grade	Area Type	Rupture frequency per million km years
Third Party	609.6	70	9.52	X52	S	67.0256
			11.91			9.2773
Ground Movement			9.52 / 11.91			0.5090
Total			9.52			67.5346
			11.91			9.7863

Table 2: Pipeline Failure Frequencies

4.2 Consequence Analysis

4.2.1 Hazard Distances

The boundary conditions used for the assessment are shown in Table 3. The principal hazard range criterion for people exposed to thermal radiation is taken as the distance from the fire from which there is a Significant Likelihood of Death (SLOD), equivalent to 1800 thermal dose units (TDU) [kW/m^2] or 12.8 kW/m^2 exposure for 1 minute. All people receiving this dose or greater are assumed to become casualties, suffering life-threatening burn injuries with approximately 50% assumed to become fatalities in a normal population. In calculating the escape distance, a lower threshold of 1 kW/m^2 ($320 \text{ Btu/ft}^2\text{h}$) is used, to which it is assumed that a person can be exposed to an indefinite period of time without injury. It is further assumed that people who are not inside buildings are able to escape the effects of the fire at a speed of 2.5 m/s.

Pipeline	U/S Boundary Condition	D/S Boundary Condition	Distance between (km)	D/S distance to location (km)
WA02DODY	Pressure Maintained at Gilwern	Pressure Maintained at Cilfrew Tie-in	54.79	50.18

Table 3: Pipeline Boundary Conditions

The resulting maximum hazard distances are given in Table 4.

Pipeline	Hazard Range	Distance (m)
WA02DODY	Escape Distance (1800 TDU, 2.5 m/s)	222.2
	House Burning Distance (Piloted Ignition)	200.3

Table 4: Maximum Hazard Distances

4.2.2 Population Details

Currently, within the assessment area, there is a farm and Tonna AGI. The 2 buildings located in the area of the new development North of the pipeline have not been included in the assessment.

The new holiday park development will consist of 120 lodges, and a hub including a swimming pool. 96 of the 120 lodges, and the hub fall within the hazard zone of the pipeline, along with a nearby farm. Aerial imagery from Google Earth of the proposed site is shown in Figure 1 and the proposed development plans for the holiday park shown in Figure 2. The plan overlaid on the satellite imagery is shown in Figure 3.

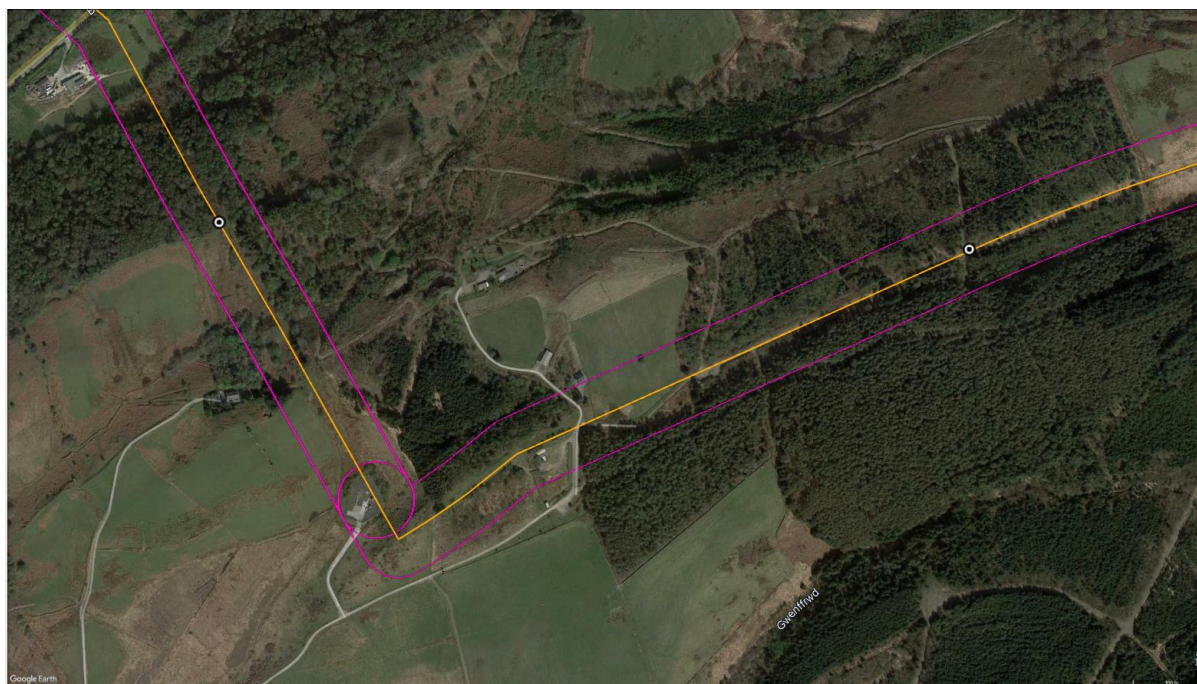


Figure 1: Aerial Imagery of Proposed Site

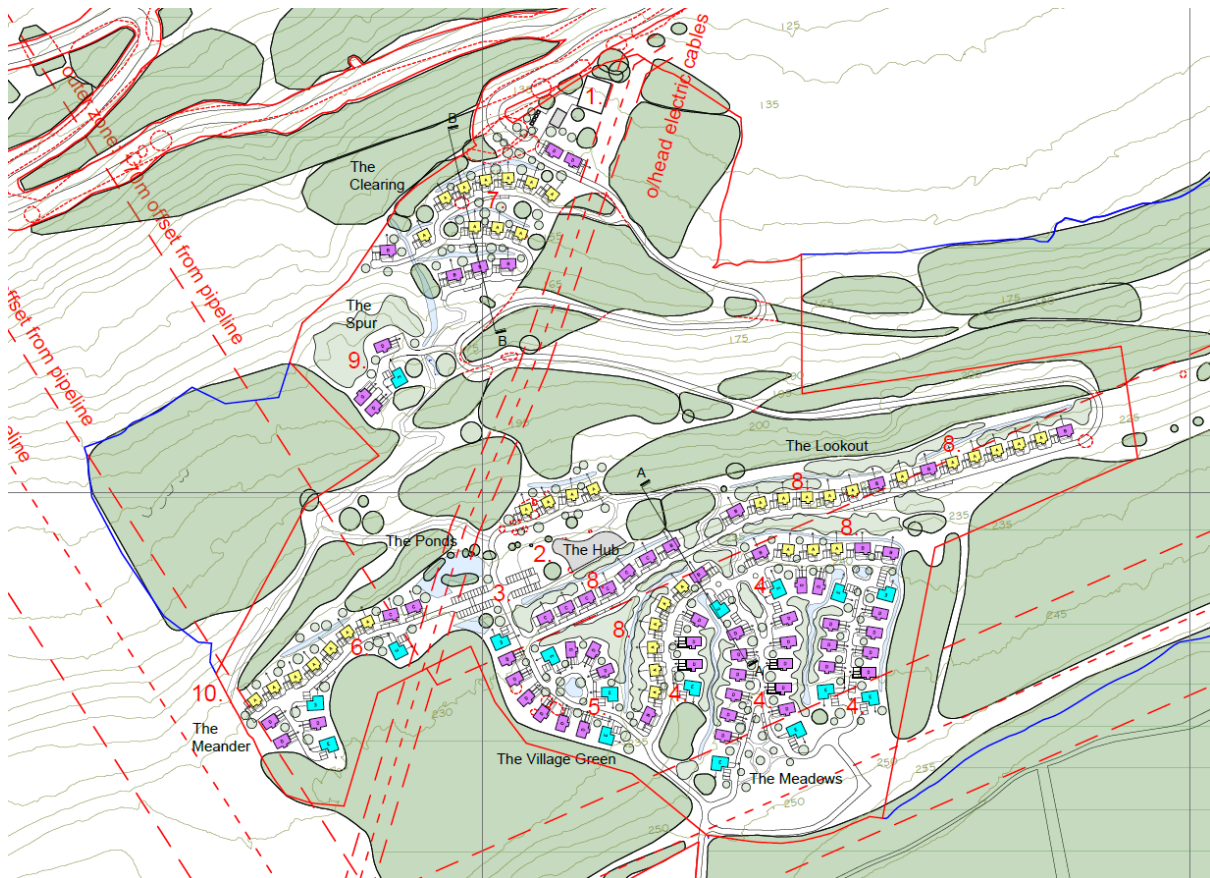


Figure 2: Plan of Spa Site (ref. [6])



Figure 3: Development Overlaid on Google Earth Imagery

The farm has been assigned the generic population and residency values from TP-HAZ-16 (ref. [2]). The occupancy of the lodges will vary seasonally as agreed with the client. Lodges will be of stone/brick construction and are assessed as providing shelter. Details have been provided in Table 5.

Description	Hours population present		Total Population	Proportion outdoors (%)
Farm	Working Day		4	60
	Non-working Day		6	10
	Night		6	1
Holiday Lodges – Type A	Spring/Autumn	Working Day	20	10
		Non-working Day	60	10
		Night		1
	Summer	Working Day	27	10
		Non-working Day	81	10
		Night		1
	Winter	Working Day	14	10
		Non-working Day	42	10
		Night		1
Holiday Lodges – Type B, C & D	Spring/Autumn	Working Day	40	10
		Non-working Day	160	10
		Night		1
	Summer	Working Day	53	10
		Non-working Day	212	10
		Night		1
	Winter	Working Day	27	10
		Non-working Day	108	10
		Night		1
Holiday Lodges – Type E	Spring/Autumn	Working Day	12	10
		Non-working Day	60	10
		Night		1
	Summer	Working Day	16	10
		Non-working Day	80	10
		Night		1
	Winter	Working Day	8	10
		Non-working Day	40	10
		Night		1
Hub Building	9am – 6pm		65	10

Table 5: Population details

The only roads within the hazard distance of the pipeline are those which are used to access the holiday park, the populations of which are assumed to be covered by the lodge populations, and a small dead-

end road accessing the farm and AGI which are assumed to be covered by the populations at those site points.

Figure 4 shows the population in close proximity to the pipe assessed as part of this risk assessment.

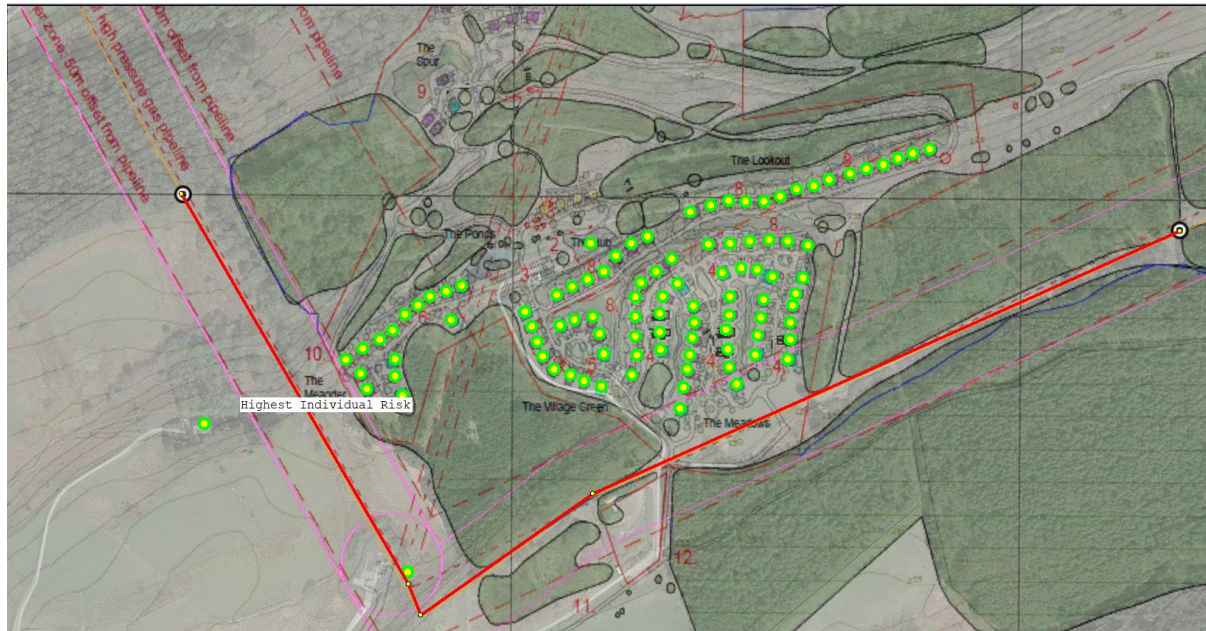


Figure 4: PIPESAFE Site Map

4.3 Risk Assessment Results

4.3.1 Individual Risk

The maximum individual risk was determined to be 7.318×10^{-6} at the proposed site of one of the lodges approximately 60m from the pipeline.

This is above the 1.0×10^{-6} per year level that is considered to be 'broadly acceptable' therefore a Cost Benefit Analysis (CBA) shall be performed.

4.3.2 Societal Risk

Societal risk is expressed as the relationship between frequency (F) of an event and the expected number of fatalities (N) in the form of a FN curve, the results are adjusted by a scaling factor, equal to 1.6 km divided by the pipeline interaction distance so that they can be compared against the acceptance criterion for broadly acceptable risk given in IGEM/TD/2 (ref. [7]) which applies to an assessment length of 1.6 km.

The FN curve is shown plotted against the National Gas risk criterion in Figure 5. The PLL is calculated to be 2.254×10^{-4} , and the maximum number of casualties is 125.

The FN curve crosses the criterion line, therefore, a cost benefit analysis (CBA) has been performed.

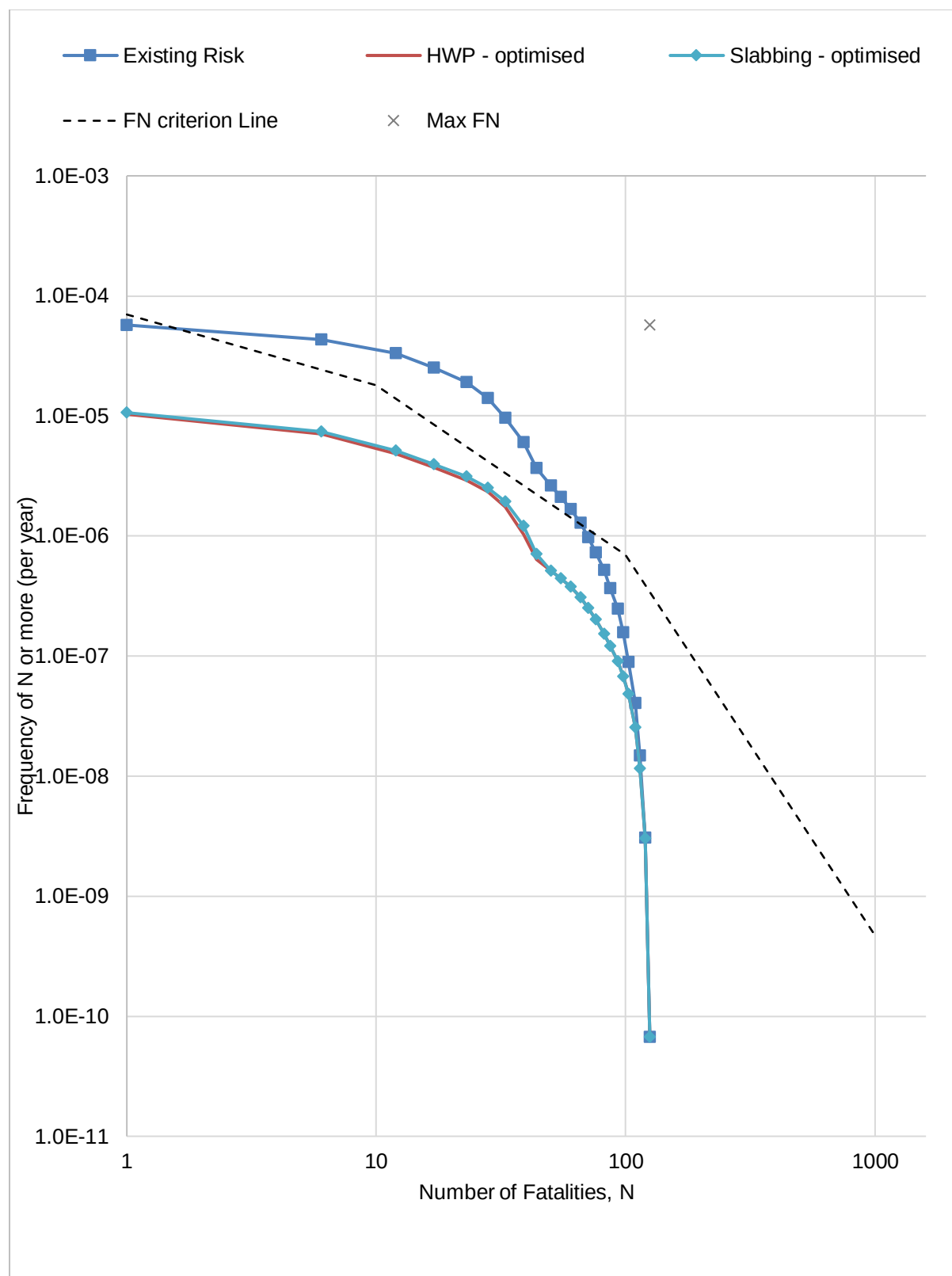


Figure 5: Societal Risk fN Curve for WA02DODY

4.3.3 Cost Benefit Analysis

Cost benefit analysis evaluates the ratio of the cost of a particular measure against the risk benefit expressed in terms of the difference in the Potential Loss of Life (PLL) to determine if the risk is As Low As Reasonably Practicable (ALARP). In the case of societal risk, the PLL is based on the sum of the calculated FN pairs.

The cost benefit analysis calculation is undertaken in the form of a Cost Per Casualty Averted (CPCA), based on the following:

$$CPCA = \text{Cost of mitigation measure} / RL \times (PLL_1 - PLL_2)$$

Where PLL_1 and PLL_2 are the values before and after mitigation. The Remaining Life, RL (of the asset) in the above equation, is taken as 40 years for the assessment (ref. [2]).

The mitigation measures considered in the assessment are installing impact protection slabs along the length of the development or re-laying the pipeline section with increased wall thickness. The costs associated with implementation of these mitigation measures are as follows (ref. [8])

- Impact Protection slabs - £1500/m + £20,000 set-up cost
- Increased wall thickness line pipe - £6000/m + £50,000 set-up cost

The reduction factors from IGEM/TD/2 are applied to update the rupture frequency estimated to calculate PLL_2 .

4.3.3.1 ALARP Criteria

The criteria that are applied for pipeline risk assessments are as follows (ref. [8]):

1. Where $CPCA < £15M$, ALARP is not demonstrated without further detailed cost benefit analysis;
2. Where $£15M < CPCA < £75M$, further consideration should be given by National Gas management to the need for mitigation measures;
3. Where $CPCA > £75M$, risks are considered ALARP.

Therefore, when cost benefit analysis is undertaken, the CPCA value is initially compared with a criterion value of £75M. If the CPCA value is below this criterion value, then a more detailed analysis is undertaken and consideration is given to the maximum number of casualties predicted as follows [A.14]:

- If the maximum number of casualties predicted is 10 to 100, a Gross Disproportion Factor (GDF) of 10 is used to give a revised CPCA criterion value of £24M;
- If the maximum number of casualties predicted is 101 to 1000, a GDF of 20 is used to give a revised CPCA criterion value of £47M;
- If the maximum number of casualties predicted is over 1000, a GDF of 30 is used to give a revised CPCA criterion value of £71M

4.3.3.2 Pipeline Details

The cost benefits of two risk reduction measures have been considered, installation of concrete slabbing and relaying the pipeline with thick-walled pipe.

Existing thick-walled sections on this pipeline are 14.27mm and 17.48mm. To remove the infringement, the design factor should be reduced to below 0.3, or 0.5 if the wall thickness is 19.05mm or greater. The cost benefit analysis (CBA) will use an increased wall thickness of 19.05 mm and a material grade of X60, resulting in a design factor of 0.29.

The CBA has been undertaken by applying concrete slabbing or increased wall thickness. Table 6 shows the revised failure frequencies that have been calculated for the pipeline.

Failure Cause	Diameter (mm)	MOP (barg)	Wall thickness (mm)	Grade	Area Type	Rupture frequency per million km years	Notes
Third Party	609.6	70	9.52	X52	S	67.0256	Standard pipe
			9.52			12.6463	Standard pipe, slabbed
			11.91			9.2773	Standard pipe
			11.91			1.7504	Standard pipe, slabbed
			19.05	X60		0.0187	HWP
Ground Movement			All	All		0.5090	-
Total			9.52	X52		67.5346	Standard pipe
			9.52			13.1553	Standard pipe, slabbed
			11.91			9.7863	Standard pipe
			11.91			2.2594	Standard pipe, slabbed
			19.05	X60		0.5277	HWP

Table 6: Pipeline Failure Frequencies

4.3.3.3 Protection over entire interaction length

The CBA has been undertaken by applying concrete slabbing or increased wall thickness along the entire interaction length.

The results of this CBA for applying protection along the entire interaction length are summarised in Table 7.

Parameter	Concrete Slabbing	Thick-Walled Pipe
Location of protection	Entire Length	
Length of protection (m)	1317	
Total cost (£)	1,995,500	7,952,000
EV before risk reduction (per year)	2.254×10^{-4}	
EV after risk reduction (per year)	4.58×10^{-5}	4.16×10^{-6}
CPCA (£million)	278	899

Table 7: Summary of CBA for Applying Protection Along Entire Interaction Length

4.3.3.4 Optimised protection at a specific location

The pipeline optimisation method has been used to determine the minimum CPCA value that is achievable. The results of this optimised CBA for applying slabbing protection or increased wall thickness at a specific location are summarised in Table 8 and the associated curve in Figure 5.

Parameter	Concrete Slabbing	Thick-Walled Pipe
Location of protection	Adjacent to "The Meander" (51.679828, -03.739781)	
Length of protection (m)	114	102
Total cost (£)	191,021	662,076
EV before risk reduction (per year)	2.254×10^{-4}	
EV after risk reduction (per year)	1.514×10^{-4}	1.430×10^{-4}
CPCA (£million)	65	201

Table 8: Summary of optimised CBA for applying protection at a specific location

The maximum number of casualties is between 100 and 1000, therefore a gross disproportion factor of 20 is used giving a revised CPCA criterion value of £47M.

The optimised CPCA values obtained for both slabbing and thick-walled pipe are above the £47M criteria, therefore the costs are disproportionate to the benefits achieved and the risk is considered to be acceptable and ALARP.

5 CONCLUSIONS

- The pipeline has known metallurgy issues relating to low temperature toughness, but previous work confirms that the standard methodology is appropriate and the acceptable result is valid for this pipeline.
- The maximum individual risk level for this assessment was determined to be 7.318×10^{-6} at the proposed site of one of the lodges approximately 60m from the pipeline., which is above the 1.0×10^{-6} per year level that is considered to be 'broadly acceptable'
- The FN curve for societal risk crosses the criterion line, therefore, a cost benefit analysis (CBA) has been performed. The PLL is calculated to be 2.254×10^{-4} , and the maximum number of casualties is 125.
- The optimised CPCA values obtained for both slabbing and thick-walled pipe are above the £47M criteria, therefore the costs are disproportionate to the benefits achieved and the risk is considered to be acceptable and ALARP.

6 REFERENCES

- [1] IGEM/TD/1 Edition 6. Steel Pipelines for High Pressure Gas Transmission. IGEM Communication 1789., 2021.
- [2] T/SP/HAZ/16. Specification for Hazard Assessment Methodology Manual Part 1 High Pressure Pipelines. National Gas Transmission July 2018.
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- [8] National Gas, ROSEN UK, "Email correspondence between Jody Harrison (NG) and Justin Sheppard (ROSEN UK)," 24/05/2024.