

Response to HSL Comments on GL Noble Denton Report 9551

(Prepared by GL Noble Denton on behalf of UKOPA)

Summary

Installing a physical barrier above an underground gas transmission pipeline, such as a concrete slab, is one of a number of possible measures available to reduce the risk of transmission pipeline failure due to external interference. GL Noble Denton ("GL") has undertaken work on behalf of UKOPA to quantify risk reduction factors for different barrier types and area types. This work was detailed in Report 9551, "A Revised Fault Tree Method for determining the Effectiveness of Slabbing".

This report has been reviewed by the Health and Safety Laboratory (HSL) on behalf of the HSE who have provided a draft note (dated 11th January 2011) detailing their comments. The HSL draft note suggests a number of revisions to particular event probabilities within the GL report to enable a more conservative approach. Using these revised conservative probabilities for a concrete barrier only, probabilities that the barrier is breached of 0.150 and 0.145 are calculated for rural and suburban areas respectively. The note concludes that given the acknowledged uncertainties in the probabilities assigned, a cautious best estimate for the probability of slabbing is breached is estimated to be 0.2.

The HSL draft note has been reviewed by GL and detailed comments on the conservative assumptions suggested by HSL are given below. A sensitivity study has been carried out to assess the impact of two particular suggestions which result in slight revisions to event probabilities in the analysis; these revisions involve:

- A non-zero lateral encroachment probability for excavators under 25t and backhoe loaders (Event 4).
- The inclusion of applicable violation producing conditions when considering the likelihood of the pipeline hazard being ignored (Event 9).

These revisions have resulted in the following changes to risk reduction factors:

Barrier Type	Probability that Barrier Fails			
	Report R9551		Revised Values	
	Rural	Suburban	Rural	Suburban
Concrete Slab Only	0.096	0.103	0.122	0.128
Concrete Slab and Marker Tapes	0.086	0.096	0.101	0.112

It should be noted that the above risk reduction factors are considered by GL to be a reasonable best estimate. The "conservative" higher value of 0.2 suggested by HSL will not necessarily lead to a more cautious assessment, because the HSL value implies a lower level of risk reduction for the same expenditure than the values derived by UKOPA. When applied in a cost-benefit analysis calculation to demonstrate ALARP, it could result in a decision being taken not to adopt the measure, where it would otherwise have been implemented using the UKOPA values, since the cost is more likely to be grossly disproportionate to the risk reduction estimated.

Responses to Specific Comments in Sections of HSL Draft Note

HSL Draft Note - Section 3.1.1 "Event 4 – Fails to prevent lateral encroachment"

For excavators less than 25t, the GL report assumes a lateral encroachment probability of 0. As described in the report, BG undertook 46 tests with excavators of mass 15 to 25 tonnes and contact appeared to be made with the slab in all the tests. Given this result and discussions at the UKOPA workshop, where it was agreed that IGEM/TD/1 slab design should prevent damage from such excavators, it was concluded at the workshop that a probability of 0 was appropriate for excavators. HSL have commented that this does not appear to be conservative given the relatively small sample size.

In addition, HSL have commented that one of the questionnaire responses has indicated that draglines and scrapers are likely to catch the slab edge and lift/move it which may cause damage to the pipe if contact is made. HSL therefore comment that the probability of lateral encroachment for these particular machines appears to be low given the operators' comments.

Two options were considered for assigning a probability of lateral encroachment for excavators less than 25t:

1. Assume that the probability is zero based on evidence from the BG tests where, for machines between 15-25t, lateral encroachment did not occur in any of the tests undertaken. This approach was further supported by the review during the UKOPA workshop in which lateral encroachment for excavators less than 25t was discounted based on the machine size and reach.
2. Make the conservative assumption that if an additional BG test had been undertaken, it would have resulted in the pipeline being hit before the slab and hence a probability of 1/47 (i.e. 0.02) would be assumed for Event 4.

Given that the top event probability is not sensitive to the above assumptions, the consensus of the group at the UKOPA meeting was adopted and the probability of lateral encroachment for excavators less than 25t was taken as zero. This sensitivity study uses a probability of 0.02, in line with option 2 above.

With regard to the comment on the lateral encroachment probability used for draglines and scrapers, it should be noted, that "lateral encroachment" is not hitting the slab before making contact with the pipeline. The questionnaire information that draglines and scrapers are likely to catch the slab edge and lift/move it which may cause damage to the pipe if contact is made, is an indication of how they can interact with the slab and potentially damage the pipeline. Such interaction is not lateral encroachment, as contact with the slab is made prior to damage to the pipeline. Hence, GL does not consider that this information should be used as justification to increase the lateral encroachment probability for such machines and considers that a lateral encroachment probability of 0.1 is a reasonable estimate.

HSL Draft Note - Section 3.1.2 "Event 5 – Machine able to breach barrier"

For excavators, HSL have commented that a value of 1.0 for the probability of a large excavator being able to breach the slab is stated in the text but a value of 0.9 is used in the analysis. In addition, HSL have commented that for scrapers, trenchers and bulldozers, a value of 0.5 for the probability of being able to breach the barrier appears to be low given both questionnaire responses stated that all three machines were capable of breaking through the slab.

GL confirms that a value of 0.9 is used in the analysis for the probability of a large excavator being able to breach the barrier. The value of 1.0 quoted in the text of 9551 is an error and should have been 0.9.

The value of 0.5 assumed for scrapers, trenchers and bulldozers was agreed at the UKOPA workshop following discussions. Although the questionnaire responses indicate that all three machines were capable of breaking through the slab, there is some uncertainty in the ability of the machine to breach the barrier due

to the different sizes of machine available. The questionnaire responses indicate that the size of trencher and bulldozer can affect the ability of the machine to break through the slab and it is also considered likely that the size of scraper has a similar effect. The chosen probability of 0.5 therefore reflects the possibility of such machines being able to breach the barrier and takes into account the uncertainty due to the different sizes of machine available.

HSL Draft Note - Section 3.1.3 "Event 6 – Operator fails to notice barrier due to type or size of machine"

For drills and large trenchers, HSL have commented that a value of 0.1 for the probability that the operator fails to notice barrier due to type or size of machine might not be conservative as questionnaire responses tend to indicate that although an operator might notice impact with the slab, it is likely that they would assume that they had hit rocky ground and continue.

GL's view is that this probability reflects the likelihood that the operator fails to notice the barrier and this value is appropriate. The possibility of continuing to use the machine after noticing the barrier is likely to be dependent on the state of knowledge of the operator (i.e. do they know of the presence of the pipeline in the vicinity) and this is reflected in the fault tree.

HSL Draft Note - Section 3.1.4 "Gate 19 – Operator fails to stop activity given barrier is noticed"

HSL indicate that human factors experts at HSL have looked at the analysis for Event 9 (Pipeline Hazard Ignored). Whilst they agree with the generic violation behaviours assigned, they think that some violating producing conditions (VPCs) should have been applied. In particular, HSL highlight VPCs associated with "inconvenience" and "no disapproving authority figure present" and indicate that use of these VPCs would result in the probability for Event 9 being higher.

With regard to the presence of a disapproving authority figure, GL consider that it is very likely that a disapproving figure would be present, particularly for the larger and more aggressive machines, which contribute most to the risk of breaching the barrier. It should also be noted that the maximum effect for this VPC is a factor of 2 which is relatively small.

GL considers that the applicability of inconvenience to the chosen generic violation behaviours is debatable and as a result it was not included in the base case as it was considered likely that inconvenience would tend to apply to a "work around" situation and it is unclear why it would be inconvenient for an operator to stop using a machine when they had noticed the barrier and were aware of it protecting a gas pipeline. It is considered reasonable to include the VPC of "inconvenience" as a sensitivity case and a "proportion of effect" is used in the current sensitivity study.

Given the considerations highlighted above, GL consider that the VPC of "inconvenience" could be considered to have a "proportion of effect" of 0.5 which results in a multiplication factor of 4. The VPC of "no disapproving authority figure present" is not considered applicable. Overall, this gives a revised probability for Event 9 of 0.04 for slabs only and 0.00056 for slabs with marker tapes.

HSL Draft Note - Section 3.2 "Sensitivity Study"

The HSL draft note evaluated the fault tree for concrete barrier only using the event probabilities shown in the Table below. The probabilities that have altered values are highlighted in red.

Probability values used in the sensitivity study by HSL

Machinery Scenario	Event 4	Event 5	Event 6	Event 9
Excavator (<5 te)	0.01	0.1	0.02	0.05
Excavator (<10 te)	0.01	0.28	0.02	0.05
Excavator (<15 te)	0.01	0.46	0.02	0.05
Excavator (<20 te)	0.01	0.64	0.02	0.05
Excavator (<25 te)	0.01	0.82	0.02	0.05
Excavator (>25 te)	0.1	1	0.1	0.05
Backhoe Loader	0.01	0.5	0.02	0.05
Drill	0.5	0.9	0.5	0.05
Spike	0.5	0.1	0.1	0.05
Dragline	0.2	0.9	0.9	0.05
Drainlayer	0.1	0.1	0.1	0.05
Scraper	0.2	0.9	0.5	0.05
Trencher	0.1	0.9	0.5	0.05
Bulldozer	0.1	0.9	0.5	0.05
Plough	0.1	0.1	0.1	0.05
Tracks	0.1	0.1	0.1	0.05

The HSL draft note indicated that if all changes suggested were made, then the probability that slabbing is breached increased by approximately 50% for the case of a concrete slab only. It should be noted that the values shown in Table 5 of the HSL draft note for combined changes appear to be inconsistent with the individual event changes as the value for rural is greater than suburban.

Given the GL responses detailed in the previous sections, the following revised values are suggested for concrete slabs only. The probability values that have changed from GL report 9551 are highlighted in blue.

Revised probability values used suggested by GL Noble Denton (Concrete Barrier Only)

Machinery Scenario	Event 4	Event 5	Event 6	Event 9
Excavator (<5 te)	0.02	0.1	0.02	0.04
Excavator (<10 te)	0.02	0.26	0.02	0.04
Excavator (<15 te)	0.02	0.42	0.02	0.04
Excavator (<20 te)	0.02	0.58	0.02	0.04
Excavator (<25 te)	0.02	0.74	0.02	0.04
Excavator (>25 te)	0.1	0.9	0.1	0.04
Backhoe Loader	0.02	0.5	0.02	0.04
Drill	0.5	0.9	0.1	0.04
Spike	0.5	0.1	0.1	0.04
Dragline	0.1	0.9	0.9	0.04
Drainlayer	0.1	0.1	0.1	0.04
Scraper	0.1	0.5	0.5	0.04
Trencher	0.1	0.5	0.1	0.04
Bulldozer	0.1	0.5	0.5	0.04
Plough	0.1	0.1	0.1	0.04
Tracks	0.1	0.1	0.1	0.04

It should be noted that these revised probability values are also applicable to a concrete barrier with marker tapes with the exception being the probability of Event 9, which would be 0.0005 for all machinery scenarios.

The revised probability values suggested by GL were used to carry out a sensitivity study on the probability that the barrier fails and the results are detailed below.

Barrier Type	Probability that Barrier Fails			
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