# Notes of Risk Assessment Working Group Meeting with HSE CI5 held on 24th February 2006 at National Grid Offices at Warwick

Present:-

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| Nigel Riley | - | HSE CI5 |
| Ian Hirst | - | HSE CI5 |
| Glyn Hawkins | - | HSE CI5 |
| Neil Jackson | - | National Grid, Chairman, RAWG |
| Roger Ellis | - | Shell |
| Rod McConnell | - | Independent Consultant, UKOPA |
| Bob Andrews | - | Advantica |
| Jane Haswell | - | PIE Ltd |
| Geoff Leach | - | PIE Ltd (Items 3 and 4 |

## 1 Purpose

Neil Jackson opened the meeting by thanking all for their attendance, and stated that the purpose of the meeting was to progress discussion on actions relating to the UKOPA mechanical damage limit state model and the work carried out by National Grid on pipeline failure rates due to natural landsliding.

I Hirst requested that an additional item on the HSE ethylene risk assessment methodology be covered, and R Ellis requested that time be allocated to discussion of risk mitigation methods.

## 2 Mechanical Damage Limit State

### 2.1 Presentation

Bob Andrews presented the work carried out by Advantica to develop a mechanical damage limit state function for UKOPA. B Andrews completed his presentation stating that there were some outstanding issues under consideration, including how additional empirical data now available may affect the statistical fit of specific parameters and the range of geometries from which these are derived, and in particular the sensitivity of the limit state to the correlation of Charpy data.

The presentation given by B Andrews is attached (Attachment 1).

The following questions were raised and answers given during the presentation:

G Hawkins stated that the new limit state model appeared to be a good step forward, although HSE would need to take independent advice on this before making any changes to their current

approach. In particular, HSE may wish to query how some elements of the limit state have been constructed and the assumptions recommended. B Andrews emphasised that the construction of the limit state rigorously follows the expert framework as specified in recognized fracture mechanics codes (BS 7910 and R6).

N Riley and G Hawkins asked whether there was any European interest and/or experience in applying this or a similar limit state, which could be used to validate the current work. N Jackson stated that users of the recognized international gas industry risk assessment code PIPESAFE had access to the original limit state model on which the current development is based. He stated that this model (known as FFREQ) is used by Gasunie, but the original validation was carried out and published by the UK gas industry

B Andrews stated that the current limit state updates the failure assessment approach in line with current codes, and includes the modeling of a microcrack in the base of the gouge, in line with the model developed by Atkins for incorporation in the HSE PIPIN software. He noted that EPRG are reviewing existing dent and gouge models, and PRCI were also looking at developments in this area.

G Hawkins stated that he had a number of queries on Advantica Report R7423. It was agreed these should be discussed at the meeting. A summary of the queries and responses is given below:-

Have predictions obtained using the limit state been compared with other published data?
R McConnell confirmed that as part of the work to develop code supplements for TD/1 and PD 8010, recorded and predicted pipeline failure were being considered and compared. He noted that the development of predictive models was driven by the need to have failure frequencies for large diameter thicker wall pipelines. In may cases, operational data existed for small diameter thinner wall pipelines, and comparison of this data with predictive models indicate the models were conservative. Detailed comparison of predictions obtained using the current model would need to be carried out.

With regard to the flow stress assumption quoted in the Advantica Report, recent research papers have indicated alternative formulations, have these been considered?
B Andrews confirmed that the assumption applied related to steel grades up to X65, and not to higher grades. He stated though that extensive work carried out in this area confirmed that the standard assumption (ie flow stress = 1.15 x SMYS) is reasonable. In this respect, B Andrews stated that the use of the term Lr (rather than Sr) avoided the problem, as Lr is defined using SMYS.

How robust is the Charpy correlation?
B Andrews stated that the fit was not considered robust and Advantica were undertaking further work on this. He noted that this is a recognized problem area in fracture mechanics, as there is no physical relationship between Charpy as a measured material parameter and the fracture mechanics parameter Km, and in addition early empirical data in some cases does not accurately record

Charpy data. The further work being undertaken by Advantica would take account of recent published work carried out by A Cosham of Penspen Integrity.

What evidence exists to support the residual stress field modeling incorporated in the limit state, and could this be further explored?
B Andrews stated that the model was based expert engineering judgment informed by the approaches recommended in the recognized fracture mechanics codes. He advised it would not be feasible to explore this in the short term, as this would require experimental work, but he proposed that the significance of this aspect of the modeling should be considered in sensitivity studies.

Does the reference stress defined for the limit state take into account a corrosion allowance?
B Andrews stated that generally, nominal wall thickness would be used. J Haswell stated that this was a user input for calculations using the limit state, and could be addressed in the recommended procedure for its use. R Ellis stated that if the model was agreed, recommendations and required sensitivity studies could be used to control its application.

How was the basis for the microcrack model derived, as the data set used did not include microcrack measurements?
B Andrews agreed, and stated that while published work indicated microcracks of 0.5mm may exist in the work hardened material, this aspect may be worth further consideration.

How was the recommended gouge radius derived?
B Andrews stated this was based on judgment assuming gouges were created through digger machine teeth, and he recommended that this parameter could be investigated through sensitivity studies.

G Hawkins and N Riley asked whether current European research is considering these issues.
B Andrews stated that EPRG have initiated work to review mechanical damage modeling parameters, as existing models are based on work carried out in the early 1980s, and will consider work to update assumptions if this is justified.

G Hawkins asked whether the Charpy correlation incorporated in the existing EPRG (1980s) model is likely to be based on Charpy values measured at room temperature? If so, how would local cooling due to the depressurization of a gas release affect this?
B Andrews confirmed that the Charpy correlations included in the EPRG models are based on room temperature Charpy values. As the model is applicable to surface breaking defects only, this issue should not affect its application.

G Hawkins referred to Figures 3 and 4 in the Advantica model, noting that this shows data below the failure assessment line, and asked if this indicated use of the proposed limit state could be in some cases unconservative. If this is the case, HSE may need to take a different interpretation.

N Jackson stated that in risk assessment, best estimate rather than worst case was taken for parameter values. B Andrews stated that it may be more productive to consider whether the curve was a failure assessment or failure avoidance curve. With regard to the current work, the curve had been generated as a failure assessment curve which was a best (mean) fit with empirical failure data.

N Jackson asked how accessible the EPRG work would be. B Andrews stated that where members request, EPRG publishes the results of its research, and he encouraged UKOPA members National Grid, Shell and BP to request early publication.

### 2.2 Actions

G Hawkins and I Hirst agreed that the existing HSE mechanical damage model should be compared with the new limit state model. If the variance is small, there will be little impetus to change.

Action G Hawkins/N Jackson
A report on the results of Advantica's consideration of outstanding issues to be issued to HSE for review. This work is scheduled for completion mid-April.

Action B Andrews/N Jackson.

HSE to respond to UKOPA as to what HSE would see as a route to validating or accepting the new UKOPA limit state model.

Action G Hawkins.

## 3 Visit to National Grid Control Centre

Attendees participated in a visit to the National Grid Operational Control Centre.

## 4 Pipeline Failure Frequency Due to Natural Landsliding

### 4.1 Presentation

G Leach (independent specialist in geotechnical engineering) presented work carried out by PIE Ltd for National Grid to develop pipeline failure frequencies due to natural landsliding on the National Grid high pressure transmission pipeline network.

The presentation given by G Leach is attached (Attachment 2).

The following questions were raised and answers given during the presentation:

N Riley asked how the numerous mineworkings in the UK are taken into account. G Leach and Neil Jackson confirmed that the work considered natural landsliding only, mineworkings and subsidence are handled by procedures which involve continuous monitoring of ground movement and pipeline response.

N Riley noted that the locations of land instability do not include areas where major slopes exist, for example Scotland and Wales. G Leach stated that the areas reported relate only to a 500m buffer zone centred on the existing National Grid pipeline routes. N Jackson stated that this confirms that pipelines are not routed through such areas.

G Hawkins asked how realistic the landslide dimensions used in the study were. G Leach stated that the dimensions used to characterize landslides were taken from the BGS technical report, and the interpretation of the main dimensions to be applied in the study was discussed with the BGS. He commented that landslide dimensions require careful consideration, and noted that there is scope for reinterpretation, especially regarding the larger landslides; A typical example is the Esscroft landslide in West Yorkshire, in which a large landslide area (474 metres wide x 295 metres long) is recorded as a single landslide but clearly contains a number of discrete small landslide events.

With regard to pipeline survival, G Leach described the assessment of the 24" diameter Keighley to Burley Bank pipeline (11.9mm wall thickness x X52, constructed in 1972), which was affected by a total of 2 metres (1993 + 2000) of movement (cumulative, in 1993 and then 2000). This pipeline was monitored and remained in operation throughout the landsliding events. G Hawkins asked if the strains induced in the pipeline were measured. G Leach confirmed that strains were monitored (using centre hole drilling technique) and were found to be within tolerable limits, this was confirmed by the integrity of the pipeline throughout the event. He stated though, that due to the significance of the predicted landslide event, a pipeline diversion was actioned and carried out by the gas network.

G Hawkins asked how the landslide movement characteristics were defined. G Leach explained that BGS provided ranges of land slide movement between a minimum of 0.1m and a maximum of 1m, 5m and 10m. The BGS had advised that use of the average range in each case would be an appropriate approximation, so landslide movements of 0.5m, 2.5m and 5m were applied in the study.

G Hawkins asked if the structural model took account of geometric deformation. G Leach explained that the structural analysis was carried out in a number of discrete steps, in which the deformed shape calculated as the output for one step became the undeformed shape assumed at the start of the next. This allows the alignment of the applied load to the structural geometry to be taken into account progressively.

G Hawkins noted that the work assumes girth weld quality is significant, and asked what would be the effect of a crack in a girth weld? G Leach and J Haswell explained that the work takes into

account two girth weld quality levels, "poor" quality welds, the other current standard "good" quality welds. The data used for poor quality welds was taken from a study of 100% grossly defective welds. In terms of the study, this data was used to define the failure criterion of all girth welds constructed in or before 1972. After this date, consistent application of the industry welding standard P2 was assumed. This standard requires 100% inspection, and specifies minimum requirements for weld strength, toughness and quality.

G Hawkins asked if the results of in-line inspection could be used to determine weld quality for pipelines located in zones susceptible to landsliding. N Jackson and J Haswell confirmed that the majority of in-line inspection is carried out using the MFL (magnetic flux leakage) pig as the priority was to detect, locate and size metal loss. This type of pig does not detect cracks, although current sensitivity levels allow girth weld anomalies to be identified. Where reported the defects are assessed and investigated. In most cases these relate to the misalignment and poor penetration which occurred in pre 1972 girth welds, which are defined in the industry as "P18" welds.

### 4.2 Actions

HSE to be provided with a summary report of the work presented.

Action N Jackson.

HSE agreed to consider the conclusions of this work and how it could be incorporated into their risk based land use planning advice.

Action HSE

## 5 Pipeline Failure Frequency Due to Landsliding Caused by 3rd Party Activity

### 5.1 Presentation

N Jackson presented work carried out by Advantica for National Grid to investigate the likelihood of landslides initiated by 3rd party activity. N Jackson emphasized that the factors affecting pipeline failure rate due to ground movement induced by 3rd party activity are yet to be quantified, but these are expected to reduce the rate by 2 orders of magnitude.

The presentation given by N Jackson is attached (Attachment 3).

The following questions were raised and answers given during the presentation:

R Ellis stated that this work could be used in conjunction with the infringement database to understand work which may be curtailed by surveillance.

I Hirst stated that CI5 would be interested in this work, particularly as it may relate directly to locations were development applications were being considered. He stated in this respect, HSE may wish to assume the rates involved should apply to all development locations, as construction activity would be carried out here. R McConnell stated that this is not the case, as the information presented related to activities which had not been notified, whereas for planned developments, the activity would be notified to and supervised by the pipeline operator.

### 5.2 Actions

National Grid to report findings of study to UKOPA and HSE.

Action N Jackson

## 6 HSE Consideration of Ethylene Release Rate

### 6.1 Presentation

I Hirst presented the results of calculations carried out by HSE using four different computer programs to investigate the release rate from a ruptured ethylene pipeline. He said that HSE had confidence in predictions obtained for ruptures from the UCL software PIPETECH, and that HSE intend to use PIPETECH for the rupture release calculations in their re-evaluation of the LUP zones for the ethylene pipelines. I Hirst noted that results obtained from this software gave lower release rates and hence smaller fireball and jet fires than did the PRAM methodology which had been used in setting the current LUP zones for these pipelines. This would partly offset the effects of the higher rupture rates that are now perceived (ie rupture rate (2006) ~$2.7.10^{-7}$ per metre per year, ref CONCAWE and PIPIN) compared to previously used (ie rupture rate (1988) ~$2.2.10^{-8}$ per metre per year, ref Shell Safety Evaluation Report for the NWEP). I Hirst asked if the basis for the 1988 rupture rate assumption was available. R Ellis agreed to look into this.

### 6.2 Actions

HSE to explore the reasons for the apparent discrepancy in failure rates and to discuss with UKOPA
[Note: I understand that UKOPA have published papers on their approach to assessing the failure frequencies for non-natural gas pipelines. Can these papers be made available to HSE?]

Action G Hawkins/N Jackson.

Basis for rupture rate assumption used in Shell Safety Evaluation Report (1988) to be investigated.

Action R Ellis

## 7 Conclusion

N Jackson concluded the meeting by thanking all for their contributions and participation in constructive discussion. He stated that UKOPA would arrange a further meeting to progress actions agreed as soon as practicable. Risk mitigation issues would be discussed at this meeting, as requested by R Ellis.

Action N Jackson

JVH 22.03.06