**National Grid Approach to Managing Societal Risk around Gas Transmission Pipelines.**

**Introduction**

The National Grid National Transmission System (NTS) is comprised of approximately 7,700 km of steel pipeline which operates at pressures up to 94bar. High pressure pipelines are major hazard assets and so are subject to safety legislation including the Pipelines Safety Regulations which formally class them as Major Accident Hazard Pipelines (MAHPs).

Failure of these pipelines could give rise to major incidents involving the release of potential dangerous materials, the release of energy (such as fires and explosions) or both. These can affect workers and members of the public who reside nearby, and can also have significant impacts on the environment. As a result, National Grid has a duty under the Pipeline Safety Regulations to manage the risks associated with MAHP and because pipelines are long distributed assets with a low likelihood of failure, societal risk is the most appropriate means of measuring the risk.

**Requirement for Risk Assessment**

The Pipeline Safety Regulations puts the responsibility on the duty holder to manage the risks associated with their assets. This responsibility includes a requirement on the duty holder to understand the risks associated with their operations and to ensure that these risks have been made ‘As Low as Reasonably Practicable’ (ALARP).

For high pressure pipelines National Grid meets these duties by designing, constructing, operating and maintaining its pipelines in line with IGEM/TD/1. This approach is supported by the use of quantified risk assessment (QRA) to aid decision making and to adequately manage the risk. The principal circumstances where pipeline risk assessment is applied are outlined below

* **MAPD and QRA:** The Pipeline Safety Regulations (PSR), 1996 require that operators of pipelines transporting dangerous fluids shall prepare a Major Accident Prevention Document (MAPD) for their ‘major accident hazard’ pipelines (MAHP), for gas pipelines this requirement applies to all pipelines with pressures above 7 bar absolute.

The guidance for the regulations states that the MAPD is a management tool to ensure that the duty holder has assessed the risks from major accidents and has introduced an appropriate safety management system to control these risks. In order to support this requirement, National Grid Gas Transmission carries out a QRA of the Transmission System (HATS) which includes a risk assessing all pipelines in the NTS.

**IGEM/TD/1 Infringements:** National Grid operates its transmission pipeline network in accordance with the requirements of IGEM/TD/1. There may, however, be locations along the pipeline where the requirements of IGEM/TD/1 cannot be complied with, this is usually because development has occurred since the pipeline was constructed that has resulted in proximity infringements or population density infringements. There may also be some circumstances where the operator elects to operate the pipeline to a later edition of the IGEM/TD/1 than the one that the pipeline was originally constructed to. In these circumstances it may be appropriate to justify that any non-compliances with the later edition of IGEM/TD/1, (e.g., requirements for extended lengths of thicker wall pipe at road crossings, are acceptable.) by carrying out Quantified Risk Assessment.

* **Land Use Planning:** Determining the acceptability of new proposed developments in the vicinity of high pressure pipelines is the responsibility of the Local Authority. Their advice would be supported by guidance provided by the HSE. This guidance is summarised in the HSE’s Planning Advice for Developments near Hazardous Installations (PADHI) document.

For new large and/or sensitive developments next to the pipeline National Grid may choose to undertake a quantitative risk assessment in order to put itself in an informed position when discussing the proposed development with the developer, the HSE or the Local Authority.

* **Uprating:** IGEM/TD/1 allows pipeline operators to uprate pipelines above their nominated Maximum Operating Pressure provided it is supported by the appropriate technical justifications. These technical justifications would normally include a risk assessment to demonstrate that the risks to individuals located in the vicinity of the pipeline continue to be acceptable at the uprated pressure

**Risk Assessment Methodology**

A full risk assessment involves the estimation of the frequency and consequences of a range of hazard scenarios and of the individual and societal risks associated with them. Each assessment has the following basic steps:

* Collect and define cases to be assessed.
* Identify credible failure causes.
* Identify credible failure modes.
* Evaluate failure frequencies.
* Evaluate consequences of failure.
* Evaluate individual and societal risk.
* Assess the acceptability/tolerability of the risks.
* Implement any new mitigation measures required as a result of the assessment.
* Record and review results.

**Pipeline Failure Causes**

A thorough understanding of pipeline damage behaviour has been developed from National Grid’s extensive operational experience in combination with fault data from other UK and European pipeline operators. This knowledge has enabled detailed predictions of failure frequencies and failure modes to be made for a range of damage causes.

Data collected through EGIG (European Gas Industry Group) and UKOPA (United Kingdom Onshore Pipeline operators Association) has been utilised to determine most common pipeline failure causes.

The following have been identified as the main potential causes of pipeline failure:

* Third party interference.
* Corrosion (both internal and external).
* Loss of ground support / ground movement.
* Material or construction defects.
* Over-pressurisation.
* Stress Corrosion Cracking (SCC).

For the majority of pipeline risk assessments, the risk is dominated by the risk from a full bore pipeline rupture. The historical data indicates that the most likely causes of full bore pipeline rupture are either third party interference or ground movement

Pipeline Failure due to Third Party Interference

A methodology for the prediction of pipeline failure frequencies due to third party interference has been developed based on work originally carried out for, and published by, British Gas. The methodology is comprised of 3 main components:

1. Fracture mechanics failure model for damaged pipes.
2. Probability distributions of damage size - derived from operational damage data.
3. A damage incidence rate, based on operational data.

This methodology forms part of the National Grid Pipeline Risk Assessment Tool – PIPESAFE.

Pipeline Failure due to Ground Movement

The likelihood of a pipeline failure due to ground movement is dependent upon the susceptibility of the ground to natural ground movement at the location of interest. Data is taken from a model developed by the British Geological Society which categorises locations into landslide susceptibility zones in order to derive a failure frequency.

**Pipeline Failure Consequences**

In the unlikely event of a pipeline failure, National Grid use predictive models to assess the following

1. Outflow modelling: The outflow of gas from a pipeline failure, and how the release rate decays with time.
2. Ignition Probability: An assessment of the probability that a gas release from a pipeline will ignite
3. Thermal Radiation: A calculation to determine the thermal radiation from an ignited gas release from a pipeline, and how it varies with distance and time.
4. Thermal Dose: A model that predicts how people and structures are affected by thermal radiation over time, and assesses the likelihood of casualties or damage.

**Pipeline Risk Assessment Tool – PIPESAFE**

National Grid uses the models described above in a knowledge-based hazard and risk assessment package for gas transmission pipelines called PIPESAFE. PIPESAFE has been developed jointly by an international group of gas transmission companies. The models in PIPESAFE are linked together in a logical manner which can be used to calculate the individual and societal risks associated with transmission pipelines. A simplified overview of the way in which these models are combined in PIPESAFE is shown below. The models are based on extensive research into the causes and consequences of transmission pipeline failures, including experimental validation at both small and large scale.

If failure of a pipeline occurs, a number of different outcomes are possible depending on the failure mode, whether the release is impacted or not, whether ignition occurs and, if it does, whether it is immediate or delayed.



**Risk Criteria**

National Gird have developed societal risk criterion in the form of an fN curve, which shows the cumalitive frequency ‘f’ (usually per year) of accidents causing N or more fatalities. The criterion curve that National Grid use is shown below

The criteria were developed with the objective of representing an acceptable risk consistent with the design, construction and operation of the NTS which is generally in accordance with IGEM/TD/1. In addition they were intended, as far as possible, to be consistent with the philosophy adopted by the HSE in its use of individual risk criteria for land-use planning in the vicinity of fixed major hazard installations, in which developments for sensitive (or vulnerable) persons were required to be at a lower risk than for the average population.

Once the fN curve has been calculated for an assessment location, it can be compared with the National Grid societal risk criterion envelope. In cases where the fN curve from an assessment is well within the criterion envelope, the risk would be deemed to be acceptable. However, where the fN curve is close to, or crosses the criterion envelope, as good practice National Grid carry out cost-benefit analysis in order to demonstrate whether the societal risk is ‘As-Low –As-Reasonably –Practicable’ (ALARP).

The demonstration of ALARP is a cost benefit calculation, which examines the cost and effect of risk reduction measures. The approach taken by National Grid only considers the safety benefits that arise from the implementation of risk reduction measures. As third party interference is the cause of pipeline failure that is most preventable, the risk reduction measures considered are ones to reduce the likelihood of this failure cause (e.g., using a thicker walled pipeline or concrete slabs to protect the pipeline. The reduction in risk is the difference in the PLL (Potential Loss of Life) values between the thin walled and thicker walled case. For a cost benefit calculation this reduction in risk needs to be considered over the lifetime of the pipeline, which for design purposes, is usually assumed to be 40 years. For example, if the PLL for the thin and thick walled cases are respectively PLL1 and PLL2 then the cost benefit calculation is:



The result of the cost benefit calculation is a cost per casualty averted (CPCA) value, sometimes referred to as a cost per life saved value.

Depending upon the results of the cost-benefit-analysis, the approach followed is as follows.

* Low CPCA – ALARP is not demonstrated and risk reduction measures required
* Borderline CPCA – Further more detailed cost-benefit-analysis required
* High CPCA – ALARP is demonstrated, no risk reduction measures required.

**Conclusion**

This note has described the methodology that National Grid Gas Transmission follows to manage societal risk around Gas Transmission pipelines. It is a logical and structured approach and follows industry, national, legislative criteria. It enables National Grid to follow a consistent approach to managing the risks with its Major Accident Hazard Pipelines and to demonstrate that the risks are ‘As-Low-As-Reasonably-Practicable’.