Supplements to IGEM TD/1 and PD 8010 - Codified Approach for the Application of Pipeline Risk

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Risk Assessment Issues and the Need for Code Guidance

Quantified Risk Analysis is widely used as a tool for risk management of pipelines, but -

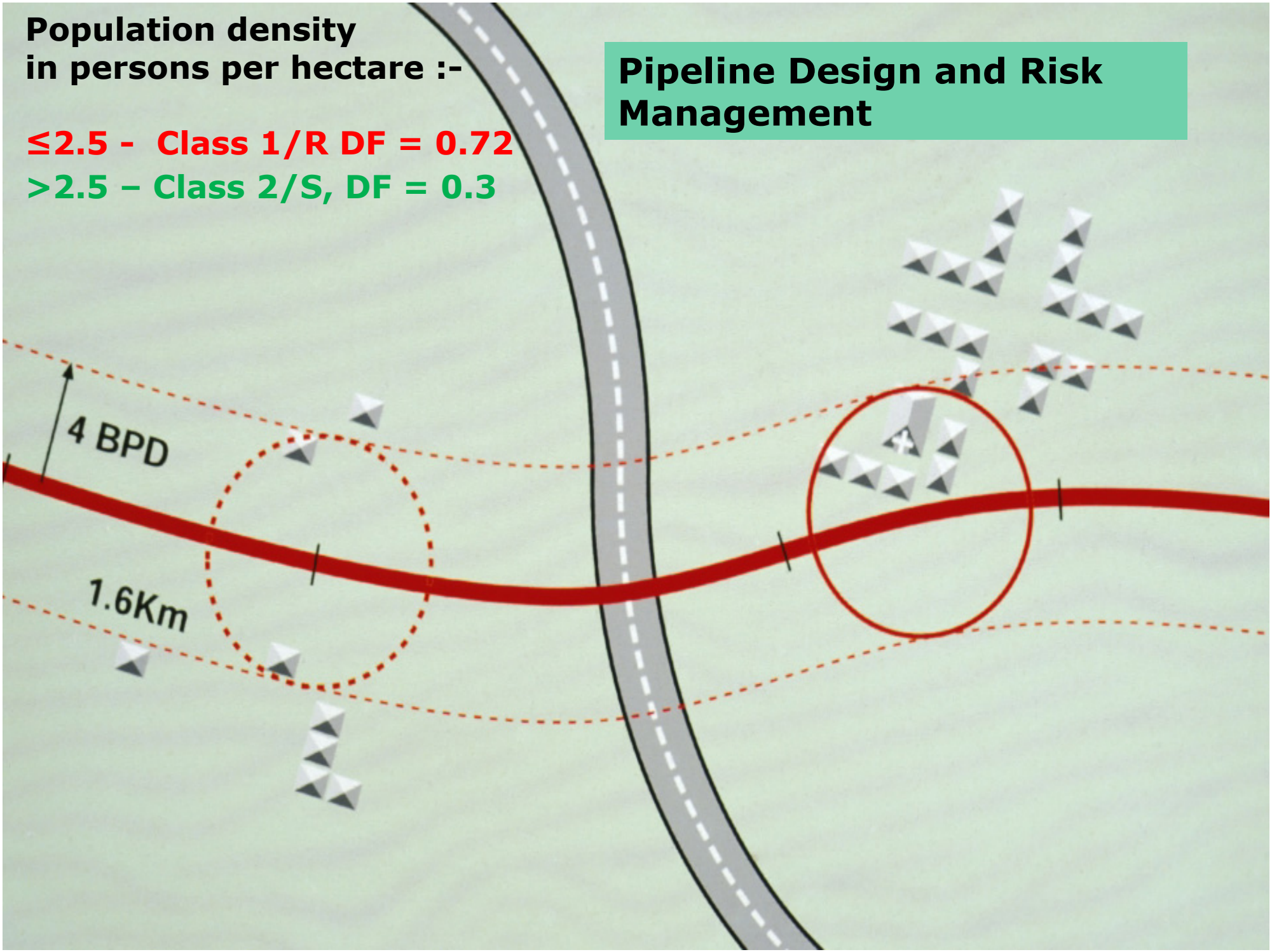
- It is specialist, expert, subject to opinion and disagreement
- Acceptance criteria are not well understood
- UK legislation and codes are risk-based
- HSE use specified risk levels to define LUP zones, and advice is risk based
- Operators, Developers and LA Planners need to assess the risk to proposed developments, and consider how this can be minimised
- Requirement for an agreed methodology for pipeline risk assessment

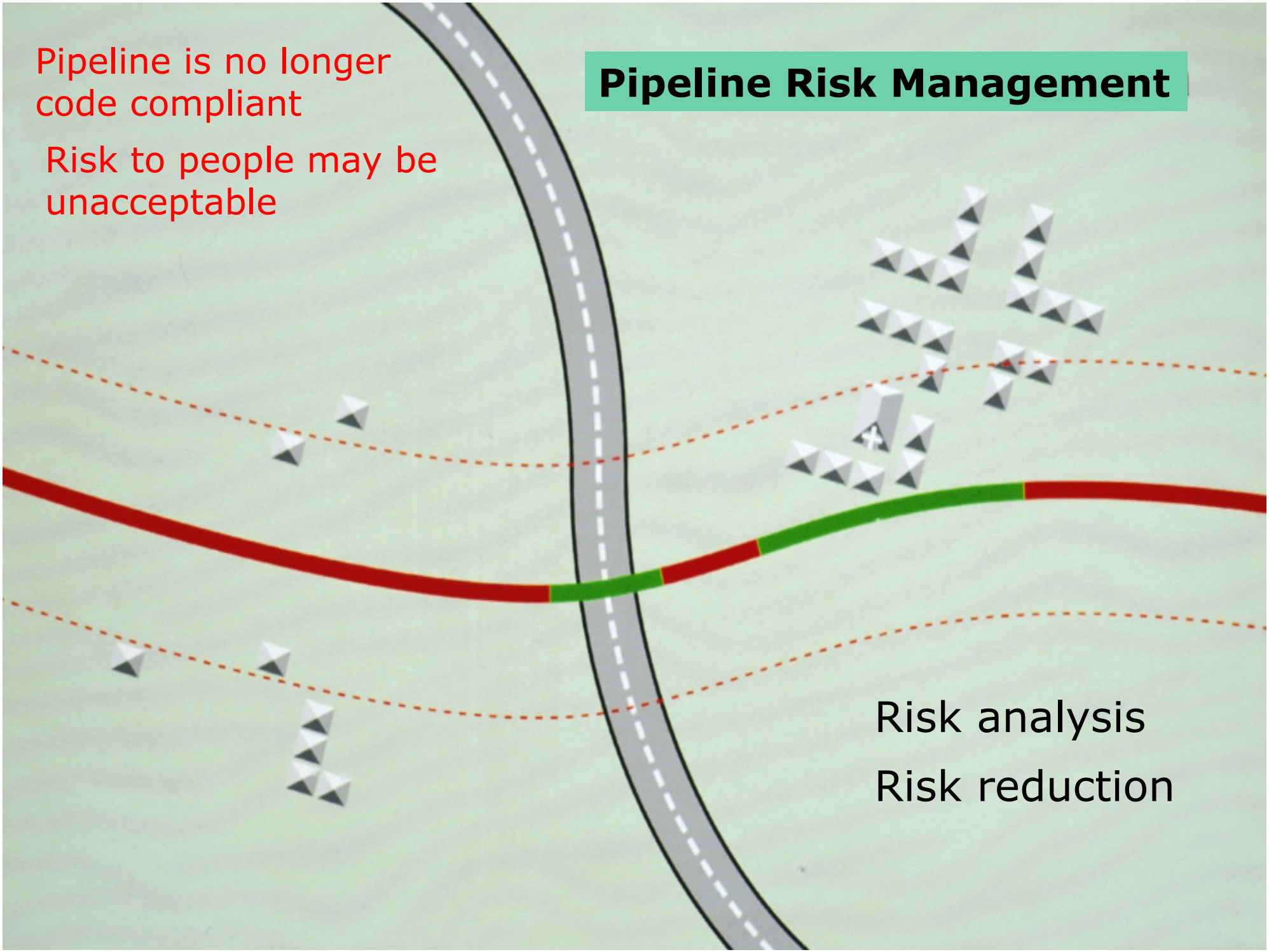
Pipeline Design and Risk Management

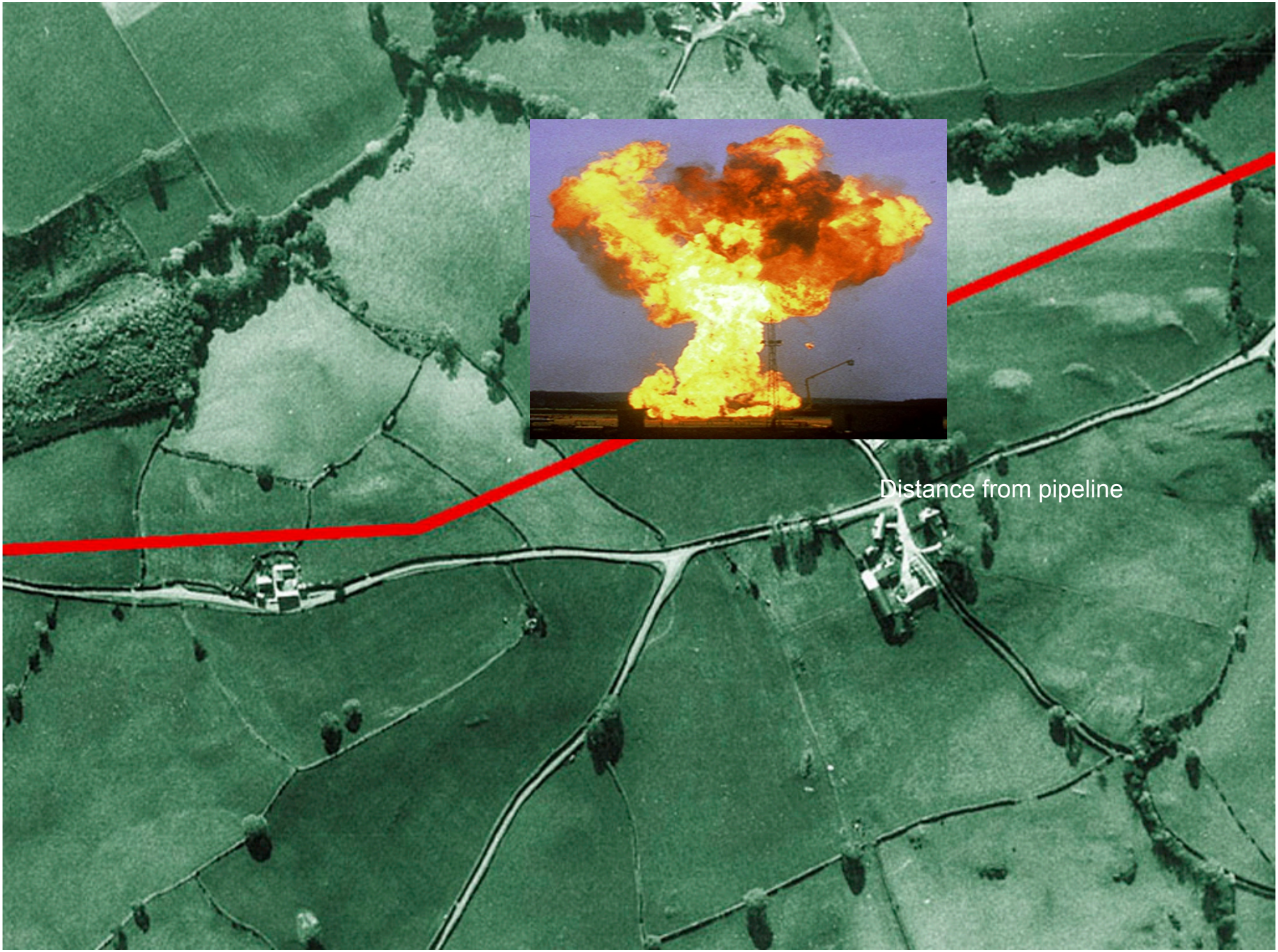
Population density in persons per hectare :-

≤2.5 - Class 1/R DF = 0.72

>2.5 – Class 2/S, DF = 0.3




Pipeline is no longer code compliant
Risk to people may be unacceptable
Pipeline Risk Management
Risk analysis
Risk reduction


Distance from pipeline

UKOPA – RA Issues & Initiatives

Issues

- Risk Assessment methodology
- Recommended inputs and assumptions
- Recommended criteria and mitigation measures
- Consistency in results and decisions

Initiatives

- Industry expert group – open discussions with HSE
- Pipeline Fault Database and published failure data
- Technical studies
- Development of pipeline code supplements – publication of pipeline fault data and results of studies

The Role of Engineering Codes

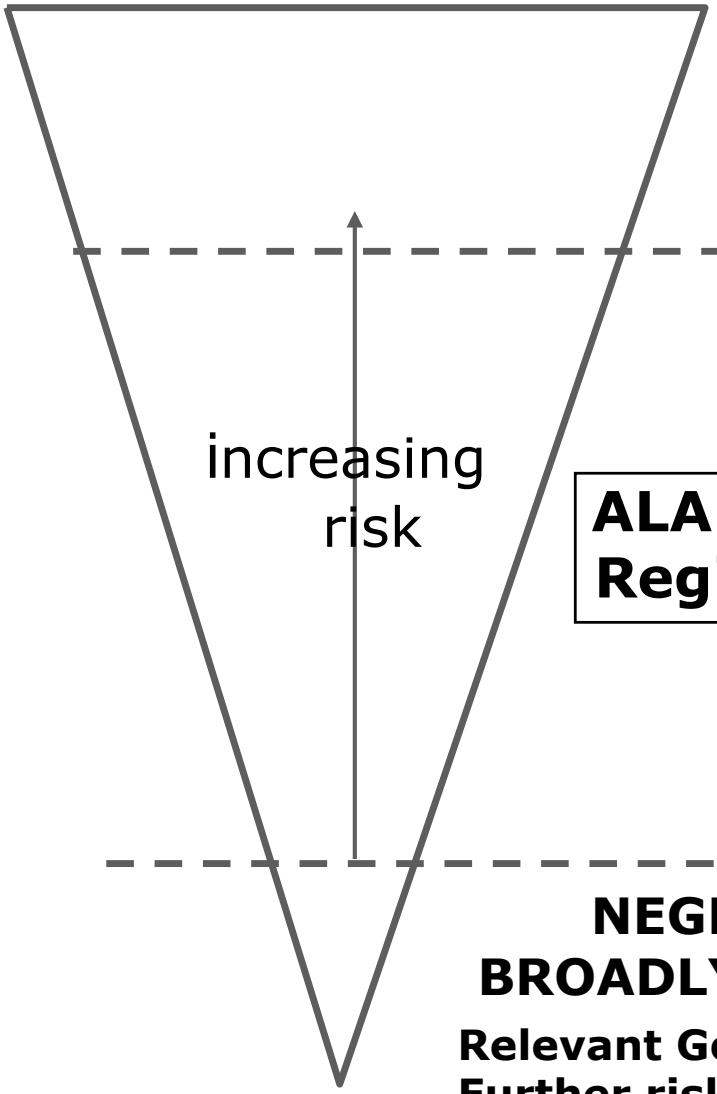
- Proceduralise the application of engineering principles in a safe, validated manner
- The use and application of recognised codes is a prerequisite for compliance with safety legislation
- Approved standards are used to set safety standards

UK Pipeline Codes

Prior to major pipeline development in the UK (mid 60s) UK pipeline codes were simple interpretations of American ASME Codes

UK codes were developed to establish more rigorous safety standards for pipelines in more densely populated land:-

i) Area classification and routing to avoid population
ii) Use of BPD – minimum separation distance between pipeline and surrounding population
iii) Stress limits (design factor)
iv) Testing requirements (level and length)
iv) Increased precautions to minimise risk of failure (depth of cover, increased wall thickness, protection)
v) Requirements for surveillance, monitoring and inspection to detect and repair damage
vi) Requirements for monitoring route and managing changes in risk



Must reduce the risk or stop operating

UNACCEPTABLE

Individual risk
10^{-3} (worker)
10^{-4} (public)

ALARP Region

i) Pipeline risks are assumed to be "As Low As Reasonably Practicable" providing design, construction, operation and maintenance are in accordance with code requirements

ii) Pipelines with risk levels which may exceed 10^{-6} are classed as MAHP under PSR, and additional duties apply

10^{-6} per year Individual Risk

NEGLIGIBLE OR BROADLY ACCEPTABLE

Relevant Good Practice must be applied
Further risk reduction need not be considered

Why Codify Risk Assessment?

Expert knowledge	=	Good Practice
		⇩
Share and agree common approach	=	Best Practice
		⇩
Agree rules and establish code	=	ALARP

IGEM
Institution of
Gas Engineers & Managers

IGE/TD/1 Edition 4 Supplement 2
Communication XXXX

APPLICATION OF PIPELINE RISK ASSESSMENT TO PROPOSED DEVELOPMENTS IN THE VICINITY OF MAJOR HAZARD PIPELINES – HIGH PRESSURE GAS PIPELINES

BSI
British Standards

Code of practice for pipelines –
Part 3: Guide to the application of pipeline risk assessment to proposed developments in the vicinity of major hazard pipelines containing flammables – Supplement to PD 8010-1:2004

TD/1 and PD 8010 Code Supplements - Structure

Scope – Safety Risk due to Flammable Substances

↓

Risk Assessment of Buried Pipelines

Consequences -
Prediction
Probability of ignition
Thermal radiation and effects

Failure of a hazardous pipeline -
Event tree
Prediction of failure frequency

↓

Risk calculation and criteria –
Individual Risk
Societal Risk

↓

Factors affecting risk level –
Failure frequency
Failure frequency reduction factors
Implementation of risk mitigation measures

TD/1 and PD 8010 Code Supplements - Structure

Supporting Appendices/Annexes:-

- Summary of HSE methodology for provision of LUP advice
- Failure Frequencies for UK Pipelines
- Example of site specific risk assessment
- Benchmark cases

Some Key Features:-

- Risk Criteria – Individual and Societal
- Guidance on pipeline specific failure frequencies based on current UKOPA data

Individual Risk Criteria

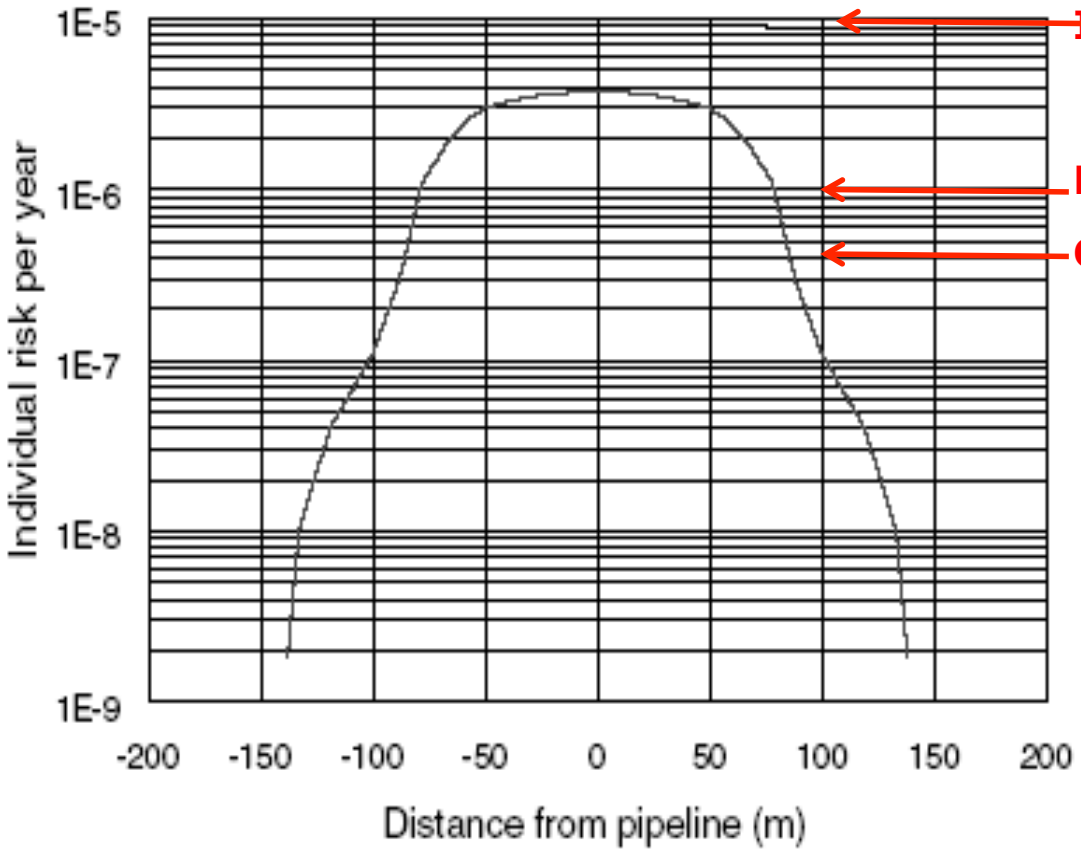
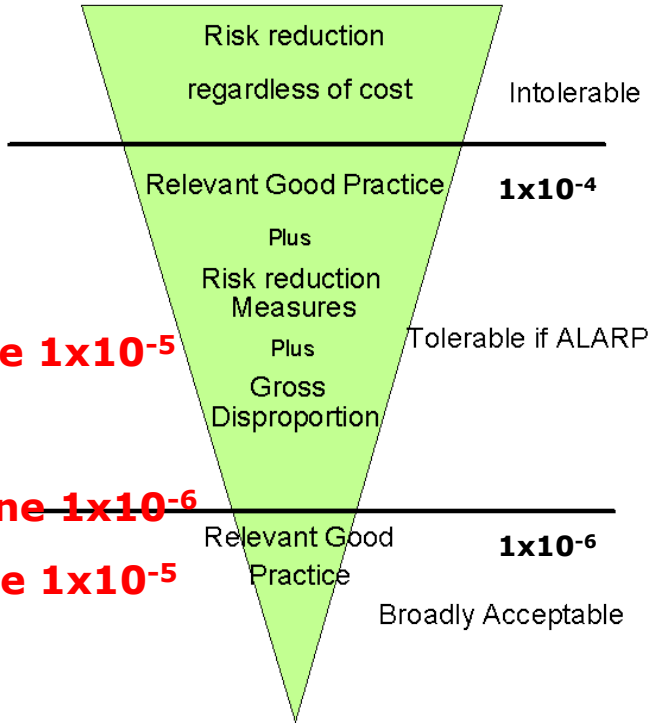


Figure 1: Types of ALARP Demonstration



Societal Risk Criteria:-

TD/1 Supplement:-
Refers to existing Figure 20

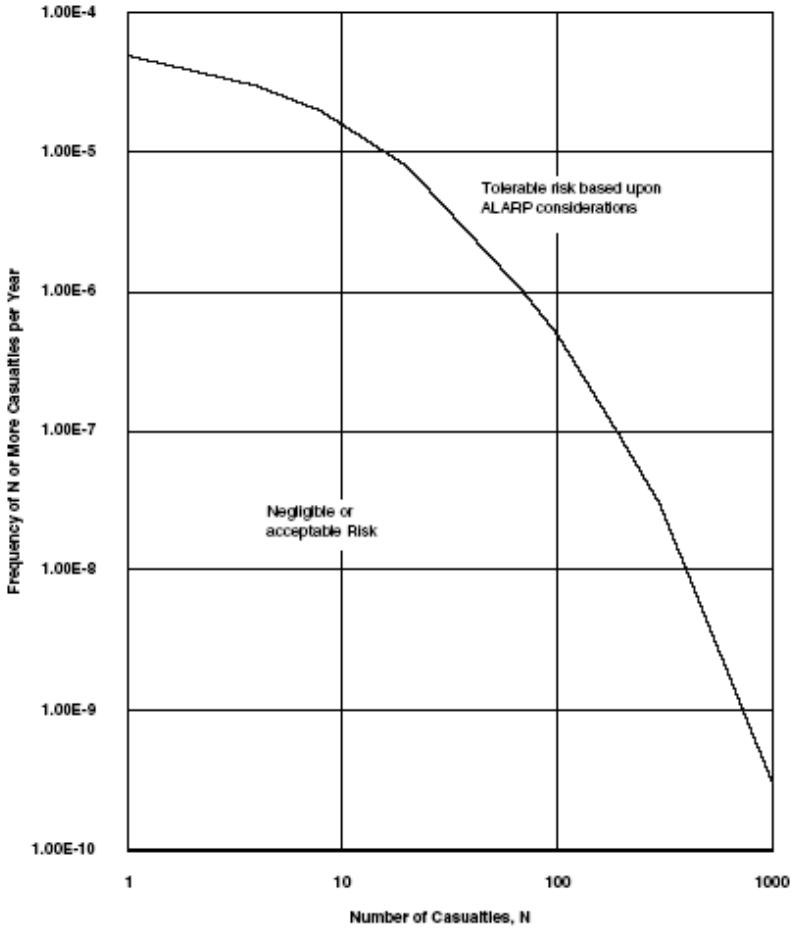
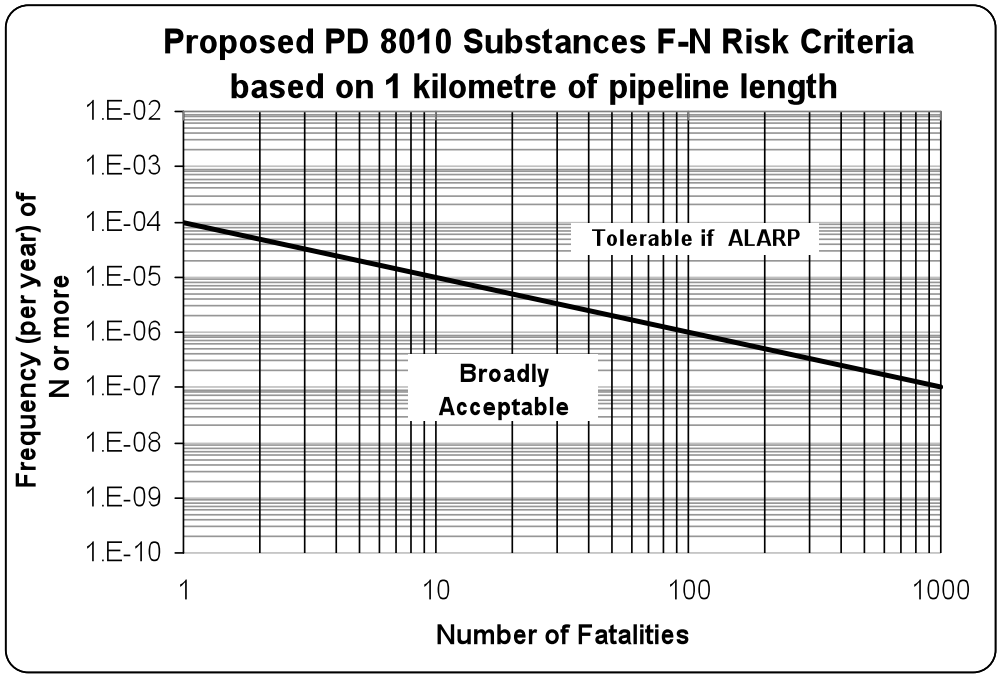


Figure 20 - Sample FN criterion (based on extensive application of previous editions of IGE/TD/1)



PD 8010 Supplement – includes new FN Curve

UKOPA Failure Data

Damage Mechanism	Total Failure Rate (1000 key)	% Total	% Pin	% Hole	% Rupture
3rd Party	0.057	21.6	2.3	15.2	4.2
External Corrosion	0.046	17.4	13.3	3.4	0.8
Internal Corrosion	0.003	1.1	1.1	0.0	0.0
Material & Construction	0.076	28.8	23.9	4.9	0.0
Ground Movement	0.009	3.4	1.1	1.5	0.8
Other	0.073	27.7	19.7	7.2	0.8
Total	0.264	100.00	61.4	32.2	6.4

Guidance on Failure Frequencies of UK Pipelines in Supplements

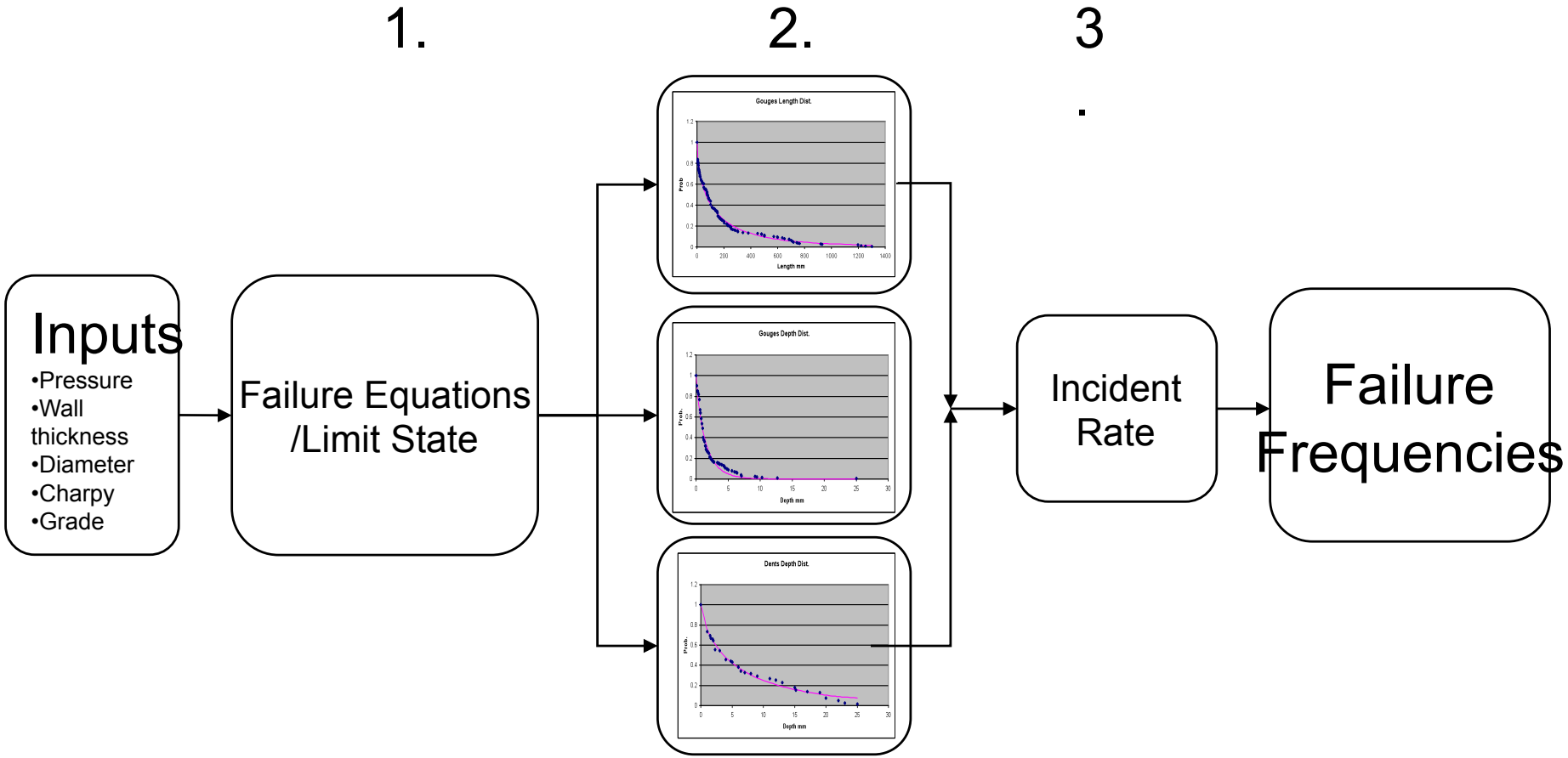
- 3rd Party – Random, use predictive approach
- External corrosion – dependent on wall thickness and age (guidance included)
- Material and Construction – dependent upon wall thickness and age (guidance included)
- Ground movement – depends upon susceptibility to natural landsliding – recommended background rate – 2.1×10^{-4} per 1000 km-y

For the above damage mechanisms, the supplements include specific guidance for derivation of pipeline specific failure rates

Prediction of Failure Frequency due to 3rd Party Interference

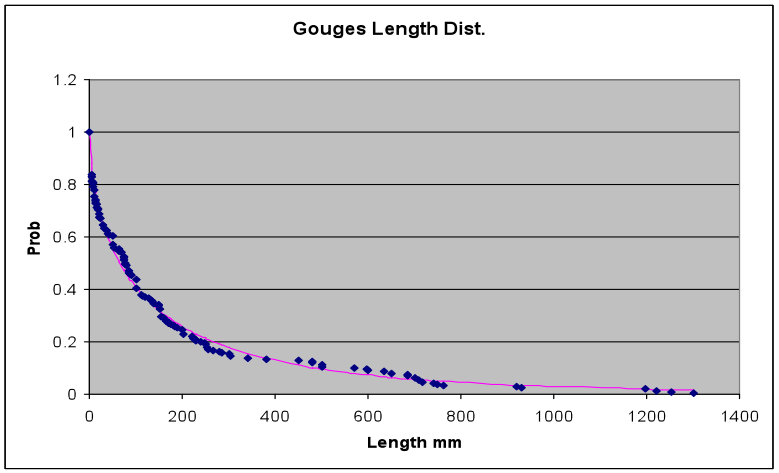
- Failure data is sparse
- Damage mechanism is random
- Failure is dependent upon wall thickness, pressure, diameter, material properties etc
- Reduction factors for wall thickness, design factor, depth of cover, slabbing and surveillance are included
- Recommended predictive tool is FFREQ
- Simple guidance is provided to allow users to determine conservative estimate for a specific pipeline

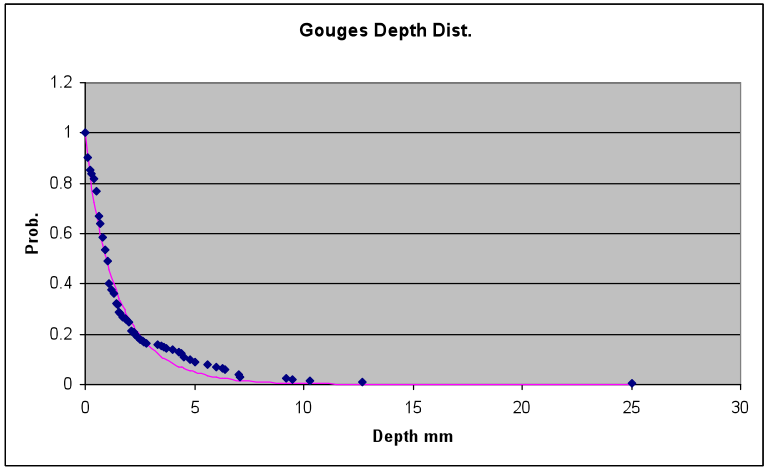
Predictive Model

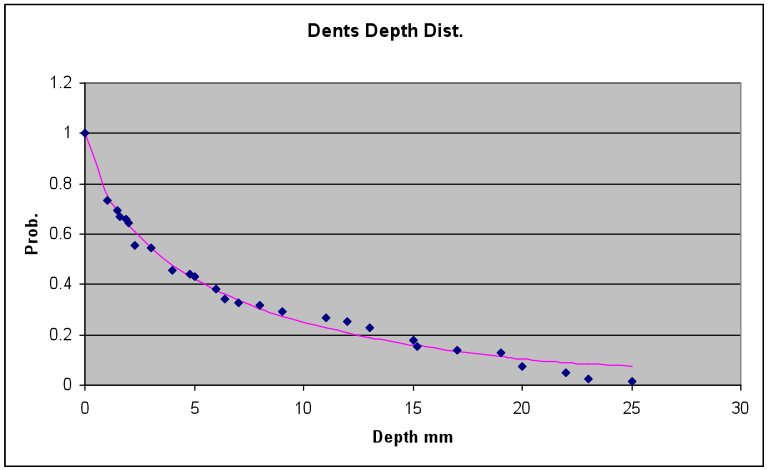


Failure:- 1 – Conditions 2 – Probability 3 - Frequency

UKOPA Fault Data Statistics

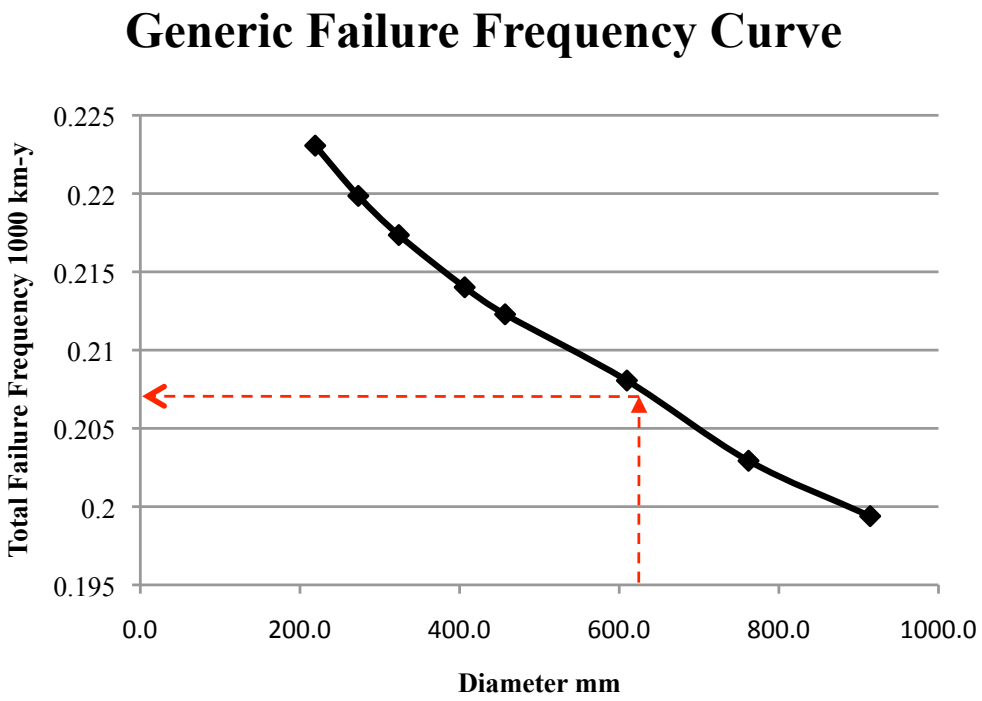






Probability of getting a dent /gouge fault of certain size

Simple Guidance on Estimation of 3rd party Failure Frequency

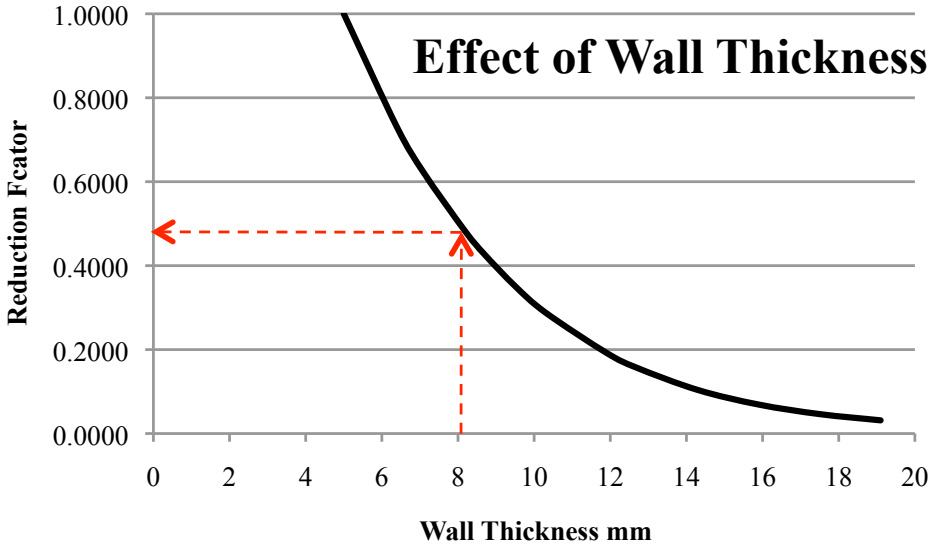


Curve based on:-
Maximum design factor – 0.72
Minimum wall thickness 5mm
High grade (X65)
Minimum toughness

Failure frequency for
610 mm diameter pipe
= 0.208 per 1000km-y

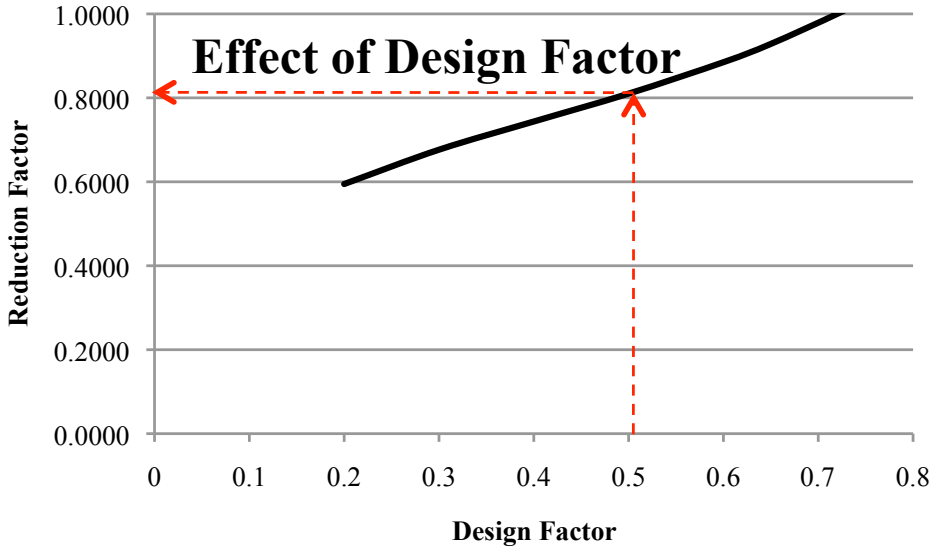
Example – estimate failure frequency for 610 mm diameter, 9.5mm wall thickness pipe operating at a DF = 0.5

Reduction factors for Wall Thickness and Design Factor



Reduction due to wall thickness of 7.9mm = 0.5

Reduction due to design factor of 0.5 = 0.81



Estimated total failure frequency for 609mm diameter 7.9mm wall thickness pipe operating at design factor 0.5 is:-

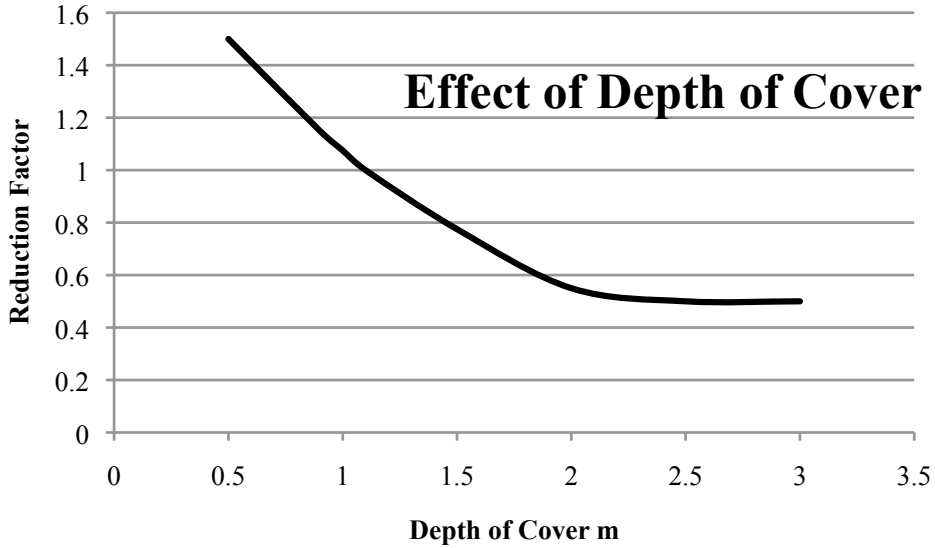
Total Failure Freq = 0.208 x 0.5 x 0.81 = 0.084 per 1000 km-y

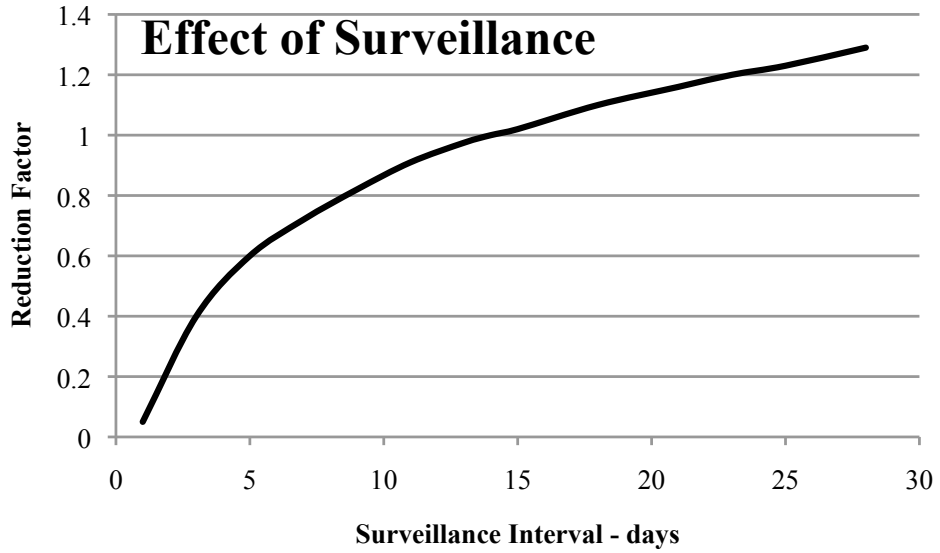
Of which 0.7 of rate is conservatively assumed to be due to ruptures

Comparison with FFREQ:-

Pipe Case	Estimated total FF	FFREQ prediction	Estimated rupture freq	FFREQ Rupture freq
609mm dia, 7.9mm wt, df = 0.5	0.084	0.061	0.059	0.02

Other Site Specific Reduction Factors:-





Protection Measure	Reduction Factor
Concrete slab	0.16
Concrete slab + visible marking	0.05

The pipeline specific failure frequency is reduced further through the application of mitigation measures:-

Eg - depth of cover – 2m and installation of concrete slabbing with visible marking:-

Failure freq – 0.084 x 0.5 x 0.05 = 2.1 x 10^{-3} per 1000 km-y

Further reduction in failure frequency due to more frequent surveillance may be appropriate in some circumstances

Role of the UK Pipeline Codes PD 8010 and IGE TD/1

- Compliance with PD 8010 (all substances) and IGE TD/1 (natural gas) demonstrates compliance with PSR 96.
- Compliance with the above pipeline codes demonstrates that the risk is **A**s **L**ow **A**s **R**easonably **P**racticable (ALARP).
- Supplements will ensure above principles extend to the application of pipeline QRA in the management of pipeline risks and land use in the vicinity of MAHPs

Development of Code Supplements

- Purpose - to provide a codified approach to pipeline risk assessment for use by all stakeholders
- Aim - to ensure a standard and consistent approach and reduce potential for technical disagreements and inconsistencies in results and decision making
- Objectives - to provide authoritative and accepted guidance on :-
  - site specific risk assessment (wall thickness, depth of cover, damage mechanisms and failure frequency
  - Application and effect of risk mitigation measures
  - Establish the means of recording, publishing and developing best practice

Strategy for Development

- Common for BSI & IGEM
- Joint technical working group:
  - First draft (based on natural gas)
  - Parallel development of code supplements
- Separate public consultation
- Co-ordinated publication programme

The Standards Bodies defined a series of structured consultation, acceptance and revision steps to ensure successful publication of the code supplements

Risk Assessment Code Supplements – Current Status

- Drafting is complete
- Public comment has been received and addressed
- Documents are finalised
- Publication is planned for July 2008