Health and Safety Executive

HSE

The National Academies of Sciences, Engineering, and Medicine
Transportation Research Board

Criteria for Installing Automatic and Remote-Controlled Shutoff Valves on Existing Gas and Hazardous Liquid Transmission Pipelines

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STATEMENT OF TASK

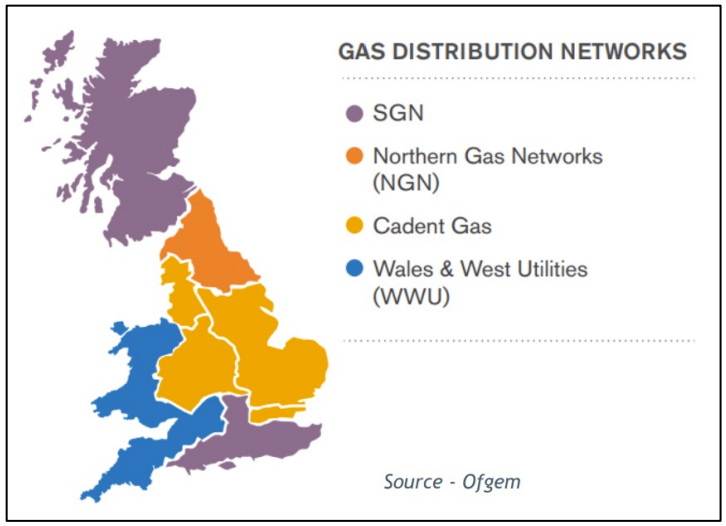
The committee will study current and potential methodologies and standards, including regulatory criteria, for deciding when an automatic shutoff valve (ASV), remote-controlled valve (RCV), or other equivalent Emergency Flow Restricting Device (EFRD) should be installed on existing gas transmission pipelines and on existing hazardous liquid pipelines in high consequence areas, as defined in federal regulation.

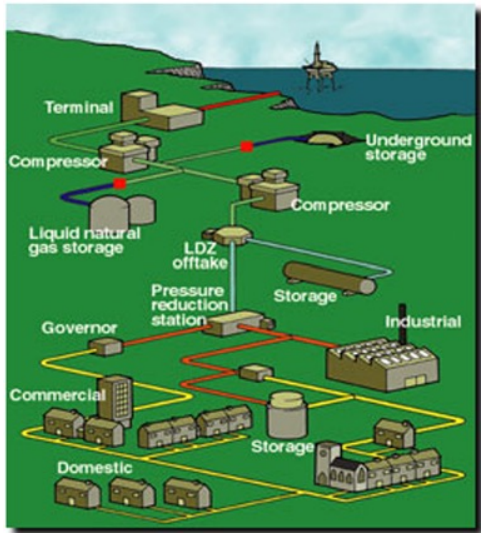
Agenda

1. Overview of Pipelines and Gas Networks in the U.K.
2. UK Legislation & Guidance - Regulatory Environment
3. Overview ASV/RCV Requirements
4. UK MAHP Population and Incidents
5. Emergency Planning
6. Environmental Considerations
7. Industry Risk Assessment
8. HSE Operator Risk Ranking
9. Conclusion
10. Questions?

1. Overview of Pipelines and Gas Networks in the U.K.

Overview of Pipelines and Gas Networks in the U.K.

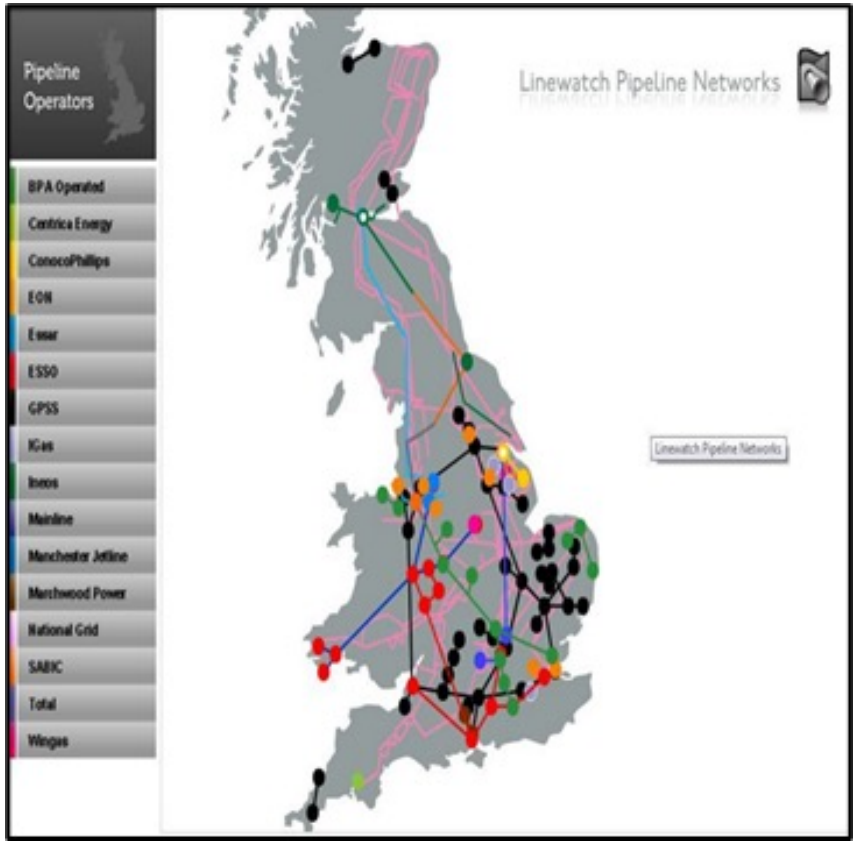




- UK Gas, Offshore installation to meter
- Gas national transmission system >6,000km
- Gas Network transmission and distribution system >270,000km
- Other pipeline operators

Other Networks

[Pipeline Safety Awareness | Linewatch]



Diverse & Interesting Locations

2. UK Legislation & Guidance - Regulatory Environment

UK Regulatory Environment

- Long standing set of ‘goal setting’ legislation and regulation
- Site specific risk assessments, no prescriptive requirements for ASV/RCV’s
- Regulatory requirement for off-shore - PSR 1996 Schedule 3 Regulation 19 Requirements for emergency shut-down valves where offshore pipeline reaches land

Relevant UK Legislation & Guidance

Legislation

- Health & Safety at Work Act (HASWA) 1974
- Gas Safety (Management) Regulations (GS(M)R) 1998
- Pipeline Safety Regulations (PSR) 1996
- Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) 2013

Industry Guidance

- Institution of Gas Engineers and Managers IGEM/TD/1 Steel pipelines and associated installations for high pressure gas transmission
- British Standards Institution (Published Document) PD 8010-1:2015 Pipeline Systems. Part 1: Steel pipelines on land - code of practice (+A1:2016)
- British Standards Institution PD 8010-4:2012 Pipeline Systems. Part 4: Steel pipelines on land and subsea pipelines – Code of practice for integrity management

Legislation

- HASWA 1974 – over arching legislation
  - Sections 2 -7 catch all duties for and to employers, employers and other persons

- PSR 1996 – Pipeline specific Regulation sets out among other things
  - definition of a pipeline; the general duties for all pipelines; including co-operation among pipeline operators; and arrangements to prevent damage to pipelines;

    and for major accident hazard pipelines
  - requirement for emergency shut-down valves (ESDVs) at offshore installations; major accident prevention document; and the arrangements for emergency plans;

GS(M)R 1996 Regulation 7 (13)

- There is no requirement to report data of this type on operators.
- There is a requirement for an investigation and report to HSE a timeline of actions maybe included, under GS(M)R 1996 Regulation 7 (13) A guide to the Gas Safety (Management) Regulations 1996 Guidance on Regulations (hse.gov.uk)
- GS(M)R incident reports are reviewed by Pipelines Team and followed up if any legal breaches are identified.
- Example time to attend site if excessive to locate and operate valve then this would be investigated

PSR 1996 Regulation 6 - Safety Systems

Regulation 6

The operator shall ensure that no fluid is conveyed in a pipeline unless it has been provided with such safety systems as are necessary for securing that, so far as is reasonably practicable, persons are protected from risk to their health or safety.

- Safety systems cover means of protection such as emergency shut-down valves and shut-off valves which operate on demand or fail safe in the closed position, so minimising loss of containment of the pipeline inventory

IGEM TD/1 Steel pipelines and associated installations for high pressure gas transmission

HSE

- 6.13 VALVES

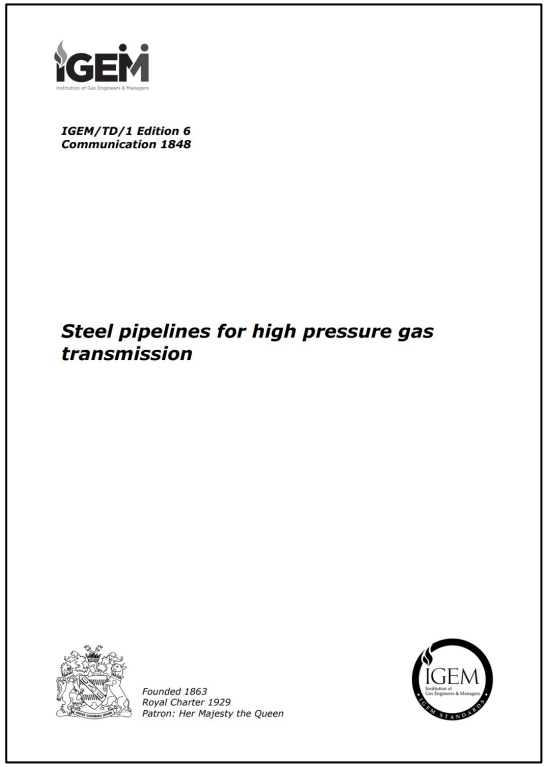
6.13.1 In a cross-country pipeline, valves shall be provided to limit inventory loss and facilitate maintenance, repair, modification, testing and commissioning.

  - Note: These may be hand-operated, automatic or remotely-controlled valves.

6.13.2 Section isolation valves (also referred to as “block valves”) shall be installed at a maximum spacing of 16 km unless a wider spacing is justified through assessment which should be based upon safety, environmental and commercial considerations. The assessment should take account of:

  - time taken to arrive at the valve site
  - the inventory of gas that will be released prior to being able to achieve isolation in the event of pipeline failure
  - continuity of service/supply
  - time to blow down/vent the isolated section of pipeline in case of emergency or maintenance

- *Note 1: Valves may reduce the total duration of a release. In terms of risk reduction, it would be necessary to install valves, with a rapid response to any failure, at short intervals along the pipeline to significantly reduce the risk level.*



https://www.igem.org.uk/technical-services/technical-gas-standards/transmission-and-distribution/igem-td-1-edition-6-steel-pipelines-for-high-pressure-gas-transmission/

BSI PD8010-1 (2015+A1:2016) Pipeline Systems – Part 1: Steel pipelines on land

- 6.12 Location of section isolating valves

For pipelines designed to convey category D, category E or toxic category B substances, automatic or remotely controlled section isolating valves should be installed unless non-installation can be justified to a statutory authority as part of a safety evaluation for the pipeline. Automatic or remotely controlled section isolating valves should be installed on pipelines conveying category C or non-toxic category B substances, when necessary.

https://knowledge.bsigroup.com/products/pipeline-systems-steel-pipelines-on-land-code-of-practice/standard

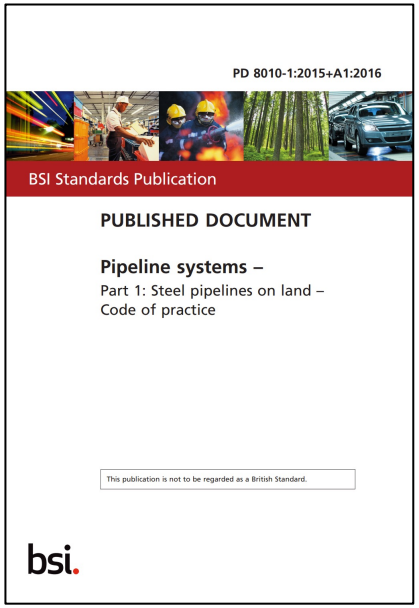


Table 1 **Categorization of substances according to hazard potential**

Category	Description	Typical examples
A	Typically non-flammable water-based fluids	Water, brine, dilute effluents
B	Flammable and/or toxic fluids that are liquids at ambient temperature and at atmospheric pressure conditions	Oil and petroleum products Methanol
C	Non-flammable fluids that are non-toxic gases at ambient temperature and atmospheric pressure conditions	Nitrogen, oxygen, argon and air
D	Non-toxic, single-phase natural gas	—
E	Flammable and/or toxic fluids that are gases at ambient temperature and atmospheric pressure conditions and are conveyed as gases and/or liquids	Hydrogen, carbon dioxide, natural gas (not otherwise covered in category D), ethane, ethylene, liquefied petroleum gas (e.g. propane and butane), natural gas liquids, ammonia and chlorine
	Mixtures of petroleum or chemical substances, having a Reid vapour pressure greater than 31 kPa absolute	Spiked or live crude oil

3. Overview ASV/RCV Requirements

New Pipelines

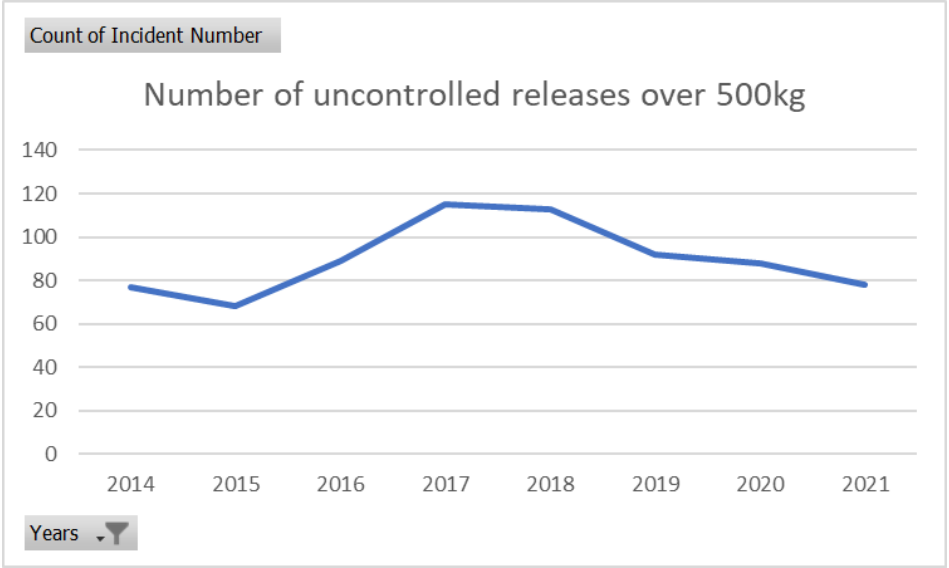
- For new pipelines the requirement for ASV/RCV's installation is based on risk assessment during the design phase, dependent on a number of factors including, but not limited to:
  - Route of pipeline
  - Population density
  - Volatility of liquid to be transported
  - Diameter and Pressure of pipeline
  - Construction material
- Reference to requirements in relevant legislation and guidance e.g. PSR 1996 and IGEM/TD/1

Existing Pipelines

- The existing is not applied retrospectively, however there is an expectation on operators that if conditions on site or operational parameters change a risk assessment will be undertaken in relation to these changes.
- If the risk assessment identified that controls need to be improved by the installation of ASV/RCV's then this should be undertaken.

Extract RIDDOR 2013 and >500kg release reports 2014-2021

Analysis of The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013 (RIDDOR) reports for release of gas



Extract from RIDDOR

Release of flammable liquids and gases

26. The sudden, unintentional and uncontrolled release –

(b) In open air, of 500kg or more of a flammable liquid or gas.

Very small number reported per km of pipeline, demonstrates approach is effective

4. UK MAHP Population and Incidents

Major Accident Hazard Pipelines(MAHP)

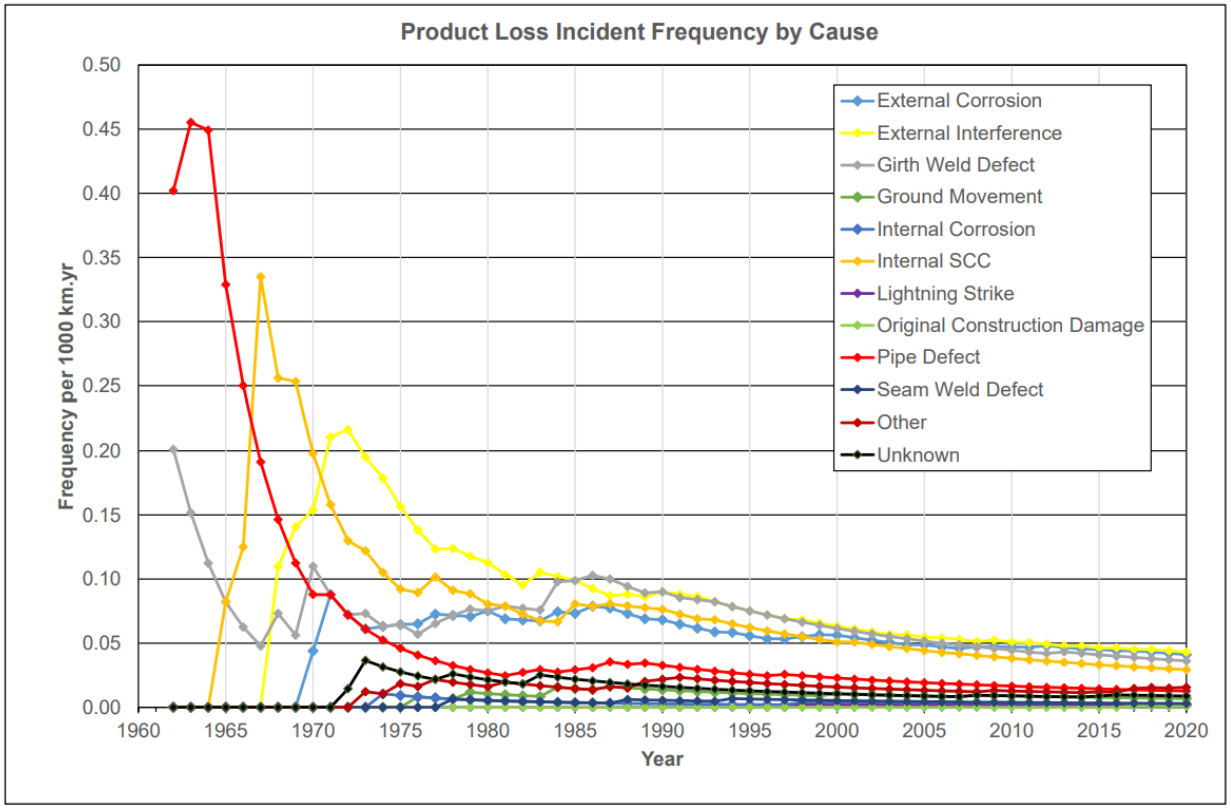
- MAHPs are defined by UK statutory legislation – The Pipelines Safety Regulations 1996 (PSR96) (7). For natural gas the classification is above 8 bar absolute.
- Total of 23,652km recorded in 2020

Product	Length (km)	%age of Total
Natural Gas (Dry)	21883.99	92.5
Ethylene	1139.69	4.8
Natural Gas Liquids	251.00	1.1
Crude Oil (Spiked)	224.19	0.9
Ethane	38.10	0.2
Hydrogen	14.04	0.1
Propylene	36.00	0.2
Condensate	24.00	0.1
Propane	21.23	0.1
Butane	19.50	0.1
TOTAL	**23,652**	**100.0**

- UKOPA data from UKOPA Reports | UKOPA – UKOPA link to Product loss incidents and fault report

MAHP Incident Frequency by Cause

- Product loss incident frequency by cause 1960 -2020



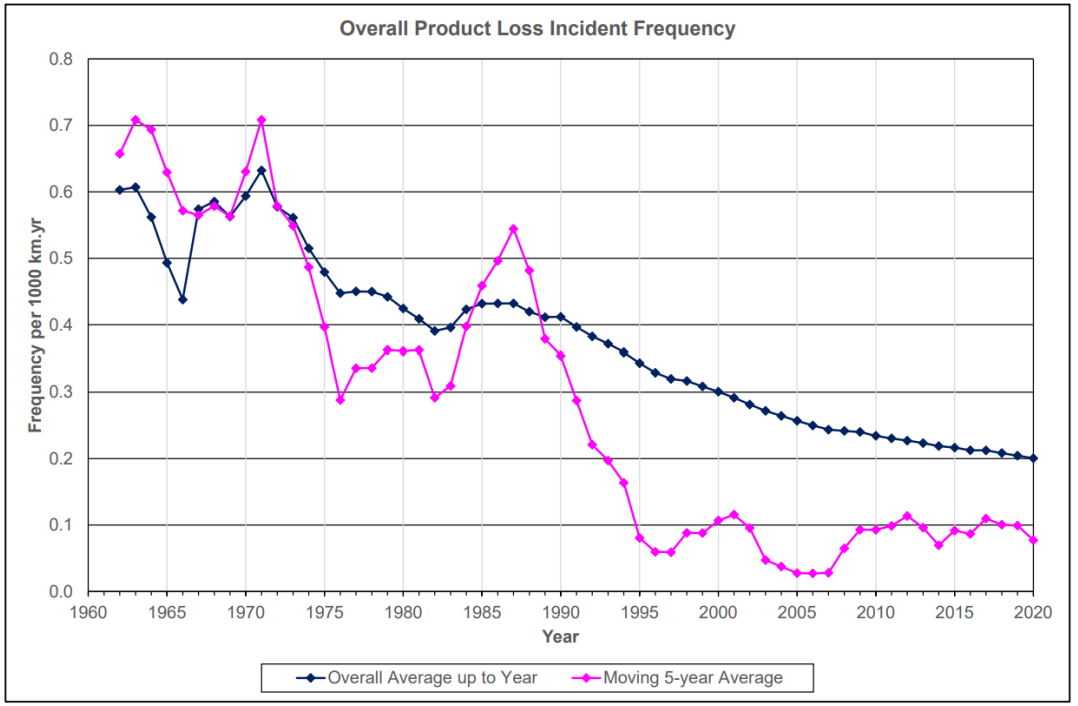
Product Loss Cause	No. of Incidents	%age of Total
External Corrosion	42	20.5
External Interference	44	21.5
Girth Weld Defect	37	18.0
Ground Movement	7	3.4
Internal Corrosion	2	1.0
Internal SCC	30	14.6
Lightning Strike	1	0.5
Original Construction Damage	1	0.5
Pipe Defect	13	6.3
Seam Weld Defect	3	1.5
Other[3]	16	7.8
Unknown	9	4.4
TOTAL	**205**	**100**

UKOPA data from UKOPA Reports | UKOPA – UKOPA link to Product loss incidents and fault report

5 year incident frequency on MAHP

The incident frequency over consecutive 5-year periods 1960 up to the end of 2020

Period	Number of Incidents	Total Exposure [km.yr]	Frequency [Incidents per 1000 km.yr]
1956 – 1960	0	2,624	0.000
1961 – 1965	6	9,535	0.629
1966 – 1970	21	33,306	0.631
1971 – 1975	25	63,036	0.397
1976 – 1980	28	77,627	0.361
1981 – 1985	40	87,167	0.459
1986 – 1990	33	93,202	0.354
1991 – 1995	8	99,233	0.081
1996 – 2000	11	103,122	0.107
2001 – 2005	3	108,741	0.028
2006 – 2010	10	107,788	0.093
2011 – 2015	11	120,123	0.092
2016 – 2020	9	116,654	0.077
TOTAL	**205**	**1,022,157**	**0.201**



UKOPA data from UKOPA Reports | UKOPA – UKOPA link to Product loss incidents and fault report

Overall incident frequency by hole size

Overall incident frequency by hole size over the period 1962 – 2020

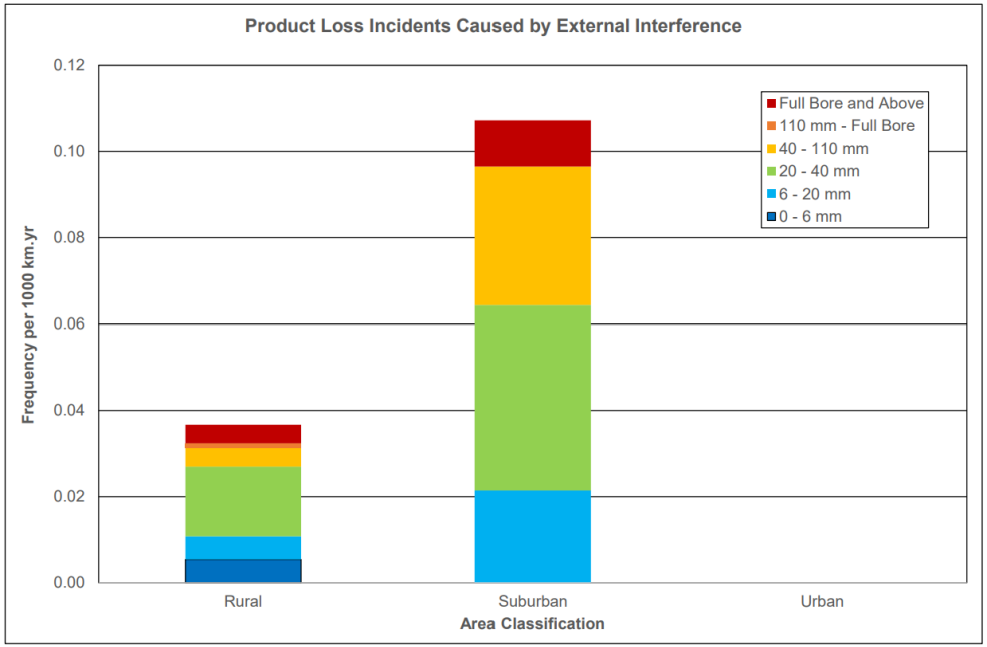
Equivalent Hole# Size Class	Number of Incidents	Frequency [Incidents per 1000 km.yr]
Full Bore* and Above	6	0.006
110 mm – Full Bore*	2	0.002
40 – 110 mm	9	0.009
20 – 40 mm	24	0.023
6 – 20 mm	30	0.029
0 – 6 mm	134	0.131
TOTAL	**205**	**0.201**

- *Full Bore ≡ diameter of pipeline
- # Equivalent hole size quoted in this report is the circular hole diameter in mm with an area equivalent to the observed (usually non-circular) hole size.

UKOPA data from UKOPA Reports | UKOPA – UKOPA link to Product loss incidents and fault report

External Interference Incidents

- Relationship between product loss incidents caused by external interference and location or area class (Data from UKOPA,1962-2020)



Area / Location Classification	Exposure [km.yr]	External Interference Incidents	Frequency [per 1000 km.yr]
Rural	926,420	34	0.037
Suburban	93,279	10	0.107
Urban	2,463	0	0.000
TOTAL	**1,022,162**	**44**	**0.043**

- Note: Rural = population density < 2.5 persons per hectare Suburban = population density > 2.5 persons per hectare and which may be extensively developed with residential properties, and includes data classed as semi-rural Urban = Central areas of towns or cities with a high population density

UKOPA data from UKOPA Reports | UKOPA – UKOPA link to Product loss incidents and fault report

Population Density Criteria

- Extract IGEM/TD/1

6.7 **AREA TYPES AND DESIGN CRITERIA**

6.7.1 **Area types**

6.7.1.1 The location adjacent to a pipeline should be categorized according to population density and/or the nature of the immediate surrounding area. The following designated areas should be used:

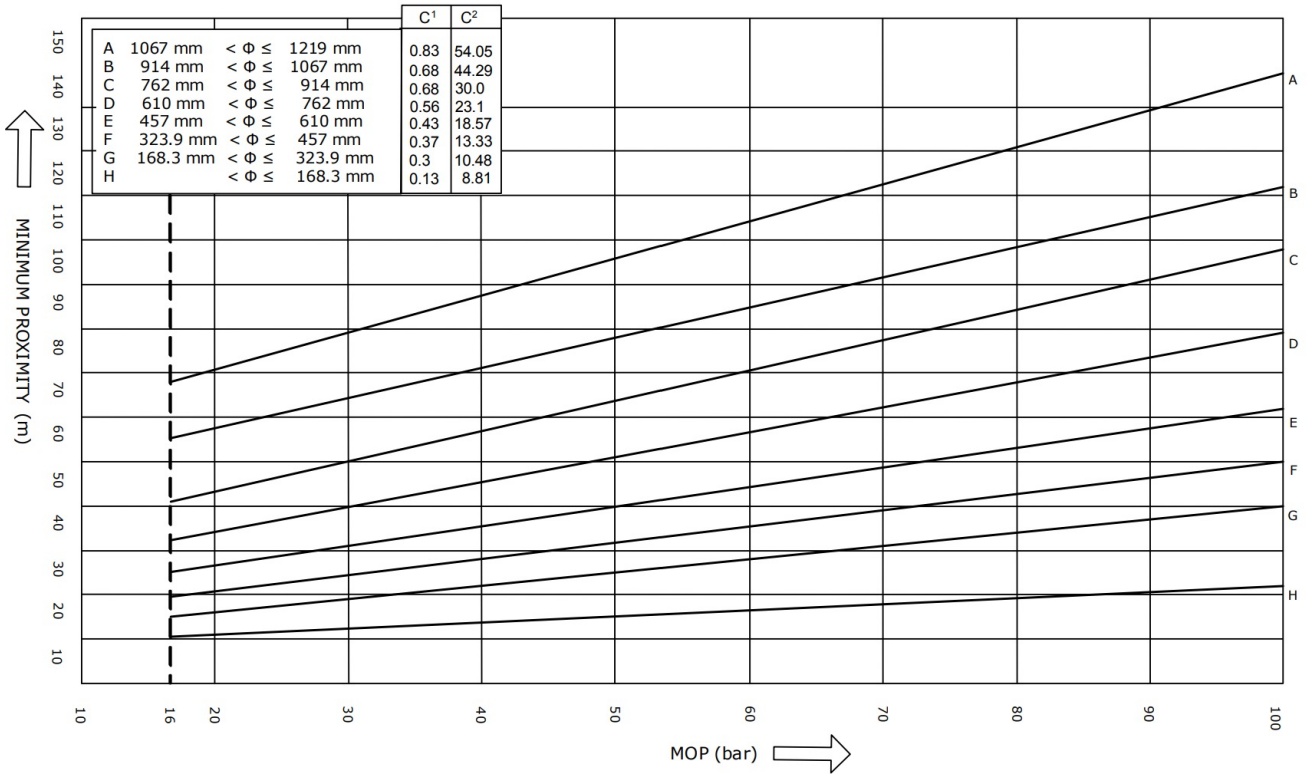
- Type R Rural areas with a population density not exceeding 2.5 persons per hectare
- Type S Areas intermediate in character between Types R and T in which the population density exceeds 2.5 persons per hectare and which may be extensively developed with residential properties, schools, shops etc.
- Type T Central areas of town or cities, with a high population density, many multi-storey buildings, dense traffic and numerous underground services.

Note: The area types require different design criteria, with particular reference to operating stress level and proximity.

Note: 1 hectare = 2.47 acres

Calculation BPD - Type R location

- Extract from IGEM/TD/1 - MINIMUM BPD = (C1 x MOP) + C2



- MINIMUM PROXIMITY DISTANCE TO NORMALLY-OCCUPIED BUILDINGS OF PIPELINES DESIGNED TO OPERATE IN TYPE R AREAS

5. Emergency Planning

Local Authority Guidance for MAHPP

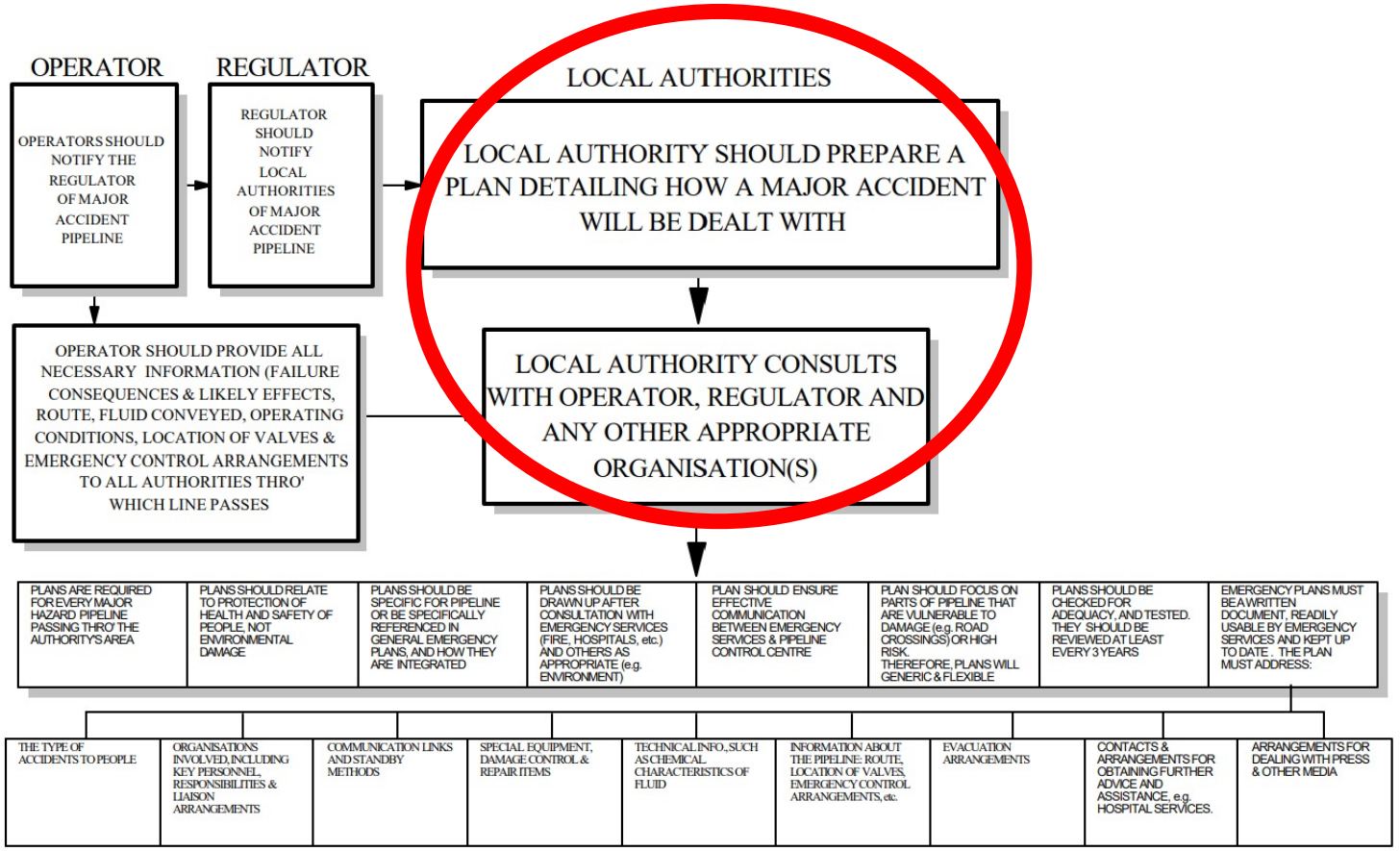
PSR Regulation 23

UKOPA Emergency Planning Working Group (EPWG) Good Practice Guide

Major Accident Hazard Pipeline (MAHP) Emergency Response Plan: Emergency Plan Template, UKOPA/GPG/011 Edition 1, April 2017

- Emergency Planning Working Group (EPWG) (ukopa.co.uk)

Key Elements of Emergency Planning



- Risk and Integrity management of a Transmission Pipeline, P Hopkins

6. Environmental Considerations

Environmental Considerations

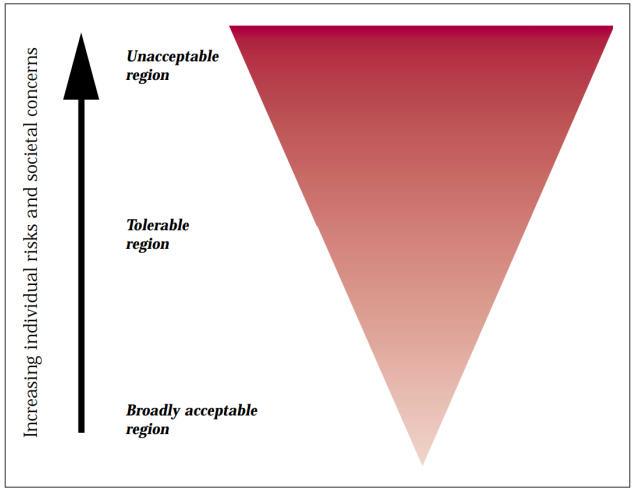
- The Pipelines Safety Regulations 1996, made under the Health and Safety at Work etc Act 1974, do not cover the environmental aspects of accidents arising from pipelines. However the Regulations, by ensuring that a pipeline is designed, constructed and operated safely, provide a means of securing pipeline integrity, thereby reducing risks to the environment.
- It is important that effects on the environment are considered at all stages in the life cycle of a pipeline.
- Environment Agencies for land remediation HSE responsibility for management of hazard only

7. Industry Risk Assessment

HSE Risk Assessment

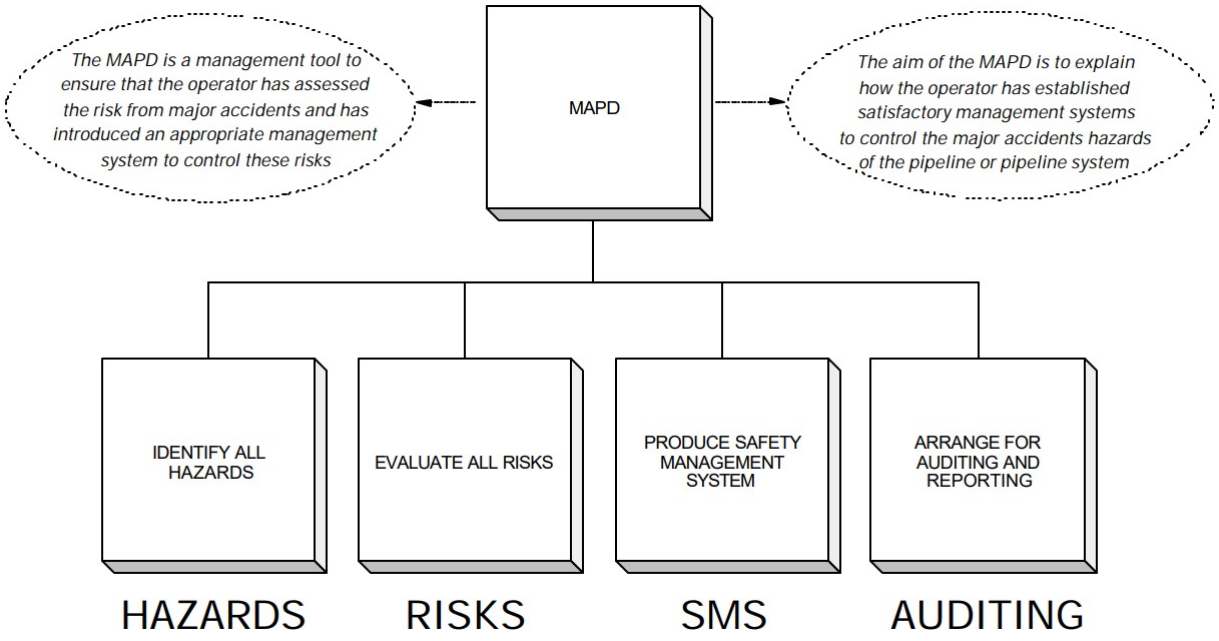
- HSE support Industry bodies in development of best practice, for example UKOPA and IGEM documents
- A framework of reducing risk to ‘as low as reasonably practicable’ (ALARP) is used in the UK
- These boundaries can be broadly be categorised into Unacceptable, Tolerable and Acceptable risk levels
- HSE high level risk assessment guidance is provided on documents such as, Reducing risks, Protecting people, HSE’s decision-making process, Reducing Risks: Protecting People - HSE's decision making process

Figure 1: HSE framework for the tolerability of risk



Major Accident Prevention Document

- A 'major accident' is defined as 'death or serious injury involving a dangerous fluid'.
- A MAPD is a requirement of PSR, Regulation 23, the requirements of a MAPD are:



Risk and Integrity management of a Transmission Pipeline, P Hopkins

IGEM/TD/1 - APPENDIX 3 : RISK ASSESSMENT TECHNIQUES

- An example that can be applied to pipeline protective devices such as ASV/RCV's includes the below criteria for assessment:
  - ASSESSMENT FRAMEWORK
    - Collect data and define case to be assessed
    - Determine credible failures
    - Evaluate failure frequencies
    - Evaluate consequences of failure
    - Estimate individual and societal risk
    - Cost benefit analysis (CBA)
    - Implementing new mitigation measures
    - Record and review results
    - Risk assessment of sleeving
    - Sample individual risk calculation
    - Sample cost per life saved calculation

8. HSE Operator Risk Ranking

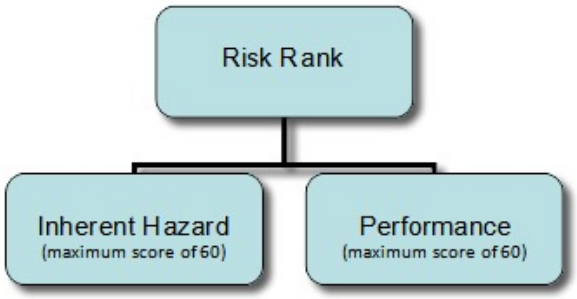
HSE Operator Risk Ranking

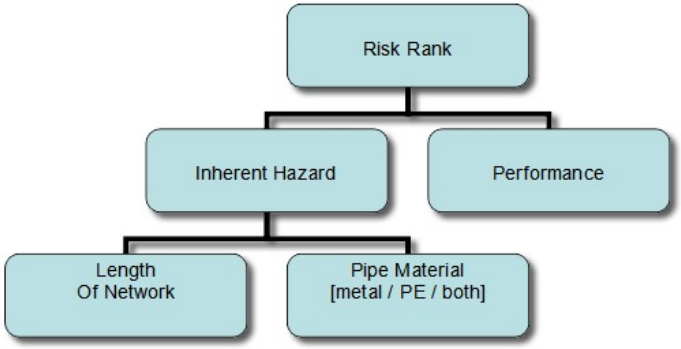
- SPC/Admin/77 Arrangements for risk ranking and performance rating operators of gas distribution networks and pipelines

- Enables risk ranking and performance rating of pipeline operators and specifically to:
  - risk rank operators, using a combination of inherent hazard and performance rating
  - performance rate operators
  - identify where improvements in arrangements for controlling major hazard risks are required and target resources where needed.

http://intranet.hse.int/operational/hid_circs/administration/spc_admin_77/

HSE Operator Risk Ranking





- Model utilises a combination of the inherent hazard and safety performance
  - The inherent hazard score is made of a number of elements, namely the dangerous fluid being conveyed and the population affected (i.e. the length of the network or pipeline) as a result of a failure of the plant.
  - The performance score captures how the operator is controlling those risks by reviewing the effectiveness of the key management and risk control systems.
  - The combination of the inherent hazard and performance scores allows each operator to be ranked so that further interventions can be targeted where needed.

9. Conclusions

Conclusion

- UK Legislation drives a site/pipeline specific Risk Assessment led approach to design and operation including for ASV/RCV's
- Goal setting approach is demonstrated as appropriate due to minimal incidents
- This approach in principle is applied for new designs/installs and existing pipelines where any changes are planned e.g. Building density/use change, etc.

10. Questions?