Gasoline Pipelines – Proposed UKOPA Methodology for Quantified Risk Assessment to obtain Land Use Planning Zones - Update

- July 2004 – HSE decided not to proceed with PSR changes
- 2005-2008 extensive QRAs of gasoline pipelines carried out
- Developed simple, easy-to-apply methodology, discussed with gasoline pipeline operators February 2007 in London
- Paper written, proposed methodology presented to HSE and HSL at Bootle in December 2007
- Several issues raised by HSE – awaiting response
- LUP zones expected as part of PSR changes 2009?

Gasoline Pipelines – Proposed UKOPA Methodology for Quantified Risk Assessment to obtain Land Use Planning Zones

Objectives of work since 2004

- To produce a realistic approach based on actual releases
- Simple, easy-to-apply methodology
- Sufficiently comprehensive to allow risk reduction measures to incorporated
- Generic, but able to be applied more specifically to site specific cases
- To gain operator buy-in to the approach

History / Background

- Reports analysed and discussed Gasoline operators meeting 25 November 2003
- Concerns with HSE’s approach – most of the risk due to pinhole release causing 100 metres diameter pool taking 24 hours to fill – no one escapes in area where pool burns in 15 minutes – also anomalies with PIPIN failure rates
- Concerns expressed to HSE 10 December 2003
- Further discussions with Steve Porter April / May 2004
- July 2004 Decision not to proceed with PSR amendments

Main Elements of Proposed Methodology

1 Inner Zone based on "equilibrium" pool fire

2 Middle & outer zones risk-based

3 Three hazards scenarios – spray fire, immediate ignition pool fire, delayed ignition pool fire

4 Failure rates based on UKOPA and CONCAWE data

5 Sprays formed for 16% of releases (Atkins report 1999)

6 Source of Ignition 0.1 for spray fires, 0.025 for immediate pool fires and 0.025 for delayed pool fires

7 Shut-off time 5 minutes for delayed pool fire

8 100% gasoline in pipeline

9 Ground soak-in 50% of the time, reduces pool diameter to 70% of no-soak-in case for average soil

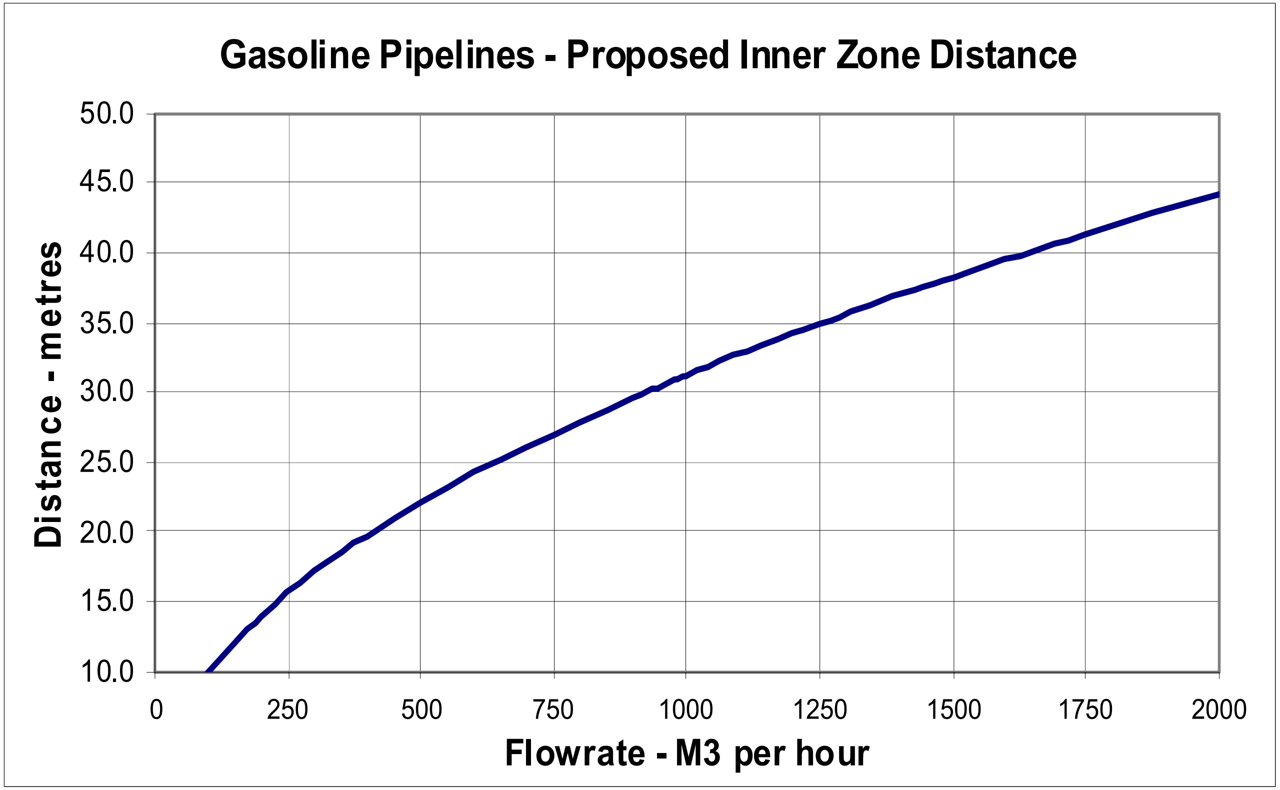
10 100% effect impact on population within fire and out to 14.7 kw/m2

Inner Zone – how do we define Inner Zone for Gasoline Pipelines?

- Other substances – Fireball Radius (ethylene, spiked crude)
- 2001-2 – Natural gas pipelines – changed to Building Proximity Distance as defined by IGE/TD/1
- For gasoline, worst case with low chance of escape (inside buildings) would be immediate ignition pool fire
- BUT size of pool fire is dictated by release rate from pipeline – which is dependent on pumping rate, NOT pipeline pressure
- Pipeline Operator declares maximum pumping rate as part of notified information, so this allows Inner zone to be calculated from equilibrium pool fire radius
- Assumes no ground soak-in

Resulting pool fire radii distances as shown:-

Flowrate m^3/hour	Inner Zone
50	7
100	10
200	14
300	17
400	20
500	22
600	24
700	26
800	28
900	30
1000	31
1200	34
1500	38
1750	41
2000	44



Proposed that these should be applied as Inner Zone Distances

Application of QRA to obtain Middle and Outer Zones

Key notification data for current MAHPs:

6 items:-

1 Pipeline diameter

2 Pipeline wall thickness

3 Maximum Allowable Operating Pressure

4 Population Classification – Rural or Suburban (R & S)

5 Depth of Cover

6 Material of Construction (steel grade)

and

- **Maximum throughput**

Key elements of Gasoline QRA Methodology

1. **Multiple scenarios give graduated risk with distance from pipeline**
   - simple models give more pessimistic zone distances

2 **Apply realistic scenarios based on actual experience**

3 **Allow for risk reduction effects / engineering improvements to reduce risk levels**

4 **Allow case specific planning applications to be assessed using factors relevant to specific locations**

Three hazard scenarios proposed:-

- **Spray fire**
- **Immediate ignition pool fire**
- **Delayed ignition pool fire**

1 Spray fire analysis in Proposed Methodology

- Sprays assumed to occur for 16% of releases
- Maximum effect distance = 2 x MAOP of pipeline
  (anywhere along length even though pressure is normally lower)
- Four equal-probability scenarios are evaluated, 100% of effect distance, 75%, 50% and 25%
- Elliptical shape with minor axis (width) = 80% of major axis (length)
- Probability of ignition = 0.1 (10%)
- Takes flash fire into account

2 Immediate Ignition Pool Fire

- **Diameter governed by release rate:-**

$$D_{max} = 2.\sqrt{m_r / \pi.m_f}$$

where D = maximum diameter of pool fire, metres
m_r = release rate of gasoline into pool kg/sec
m_f = burning rate of gasoline kg/sec.m^2 = 0.067 for large pool fires

Flow m3/hour	Diameter metres
200	28
300	34
400	40
500	44
1000	63
1500	77

- **Source of Ignition probability = 0.025 (2.5%) based on historical data**

3 Delayed Ignition Pool Fire in Proposed Methodology

- Release rate for 5 minutes before
  - Operator shuts off flow
  - Ignition occurs
- Pool depth 25 mm
- Probability of ignition 0.025 (2.5%)

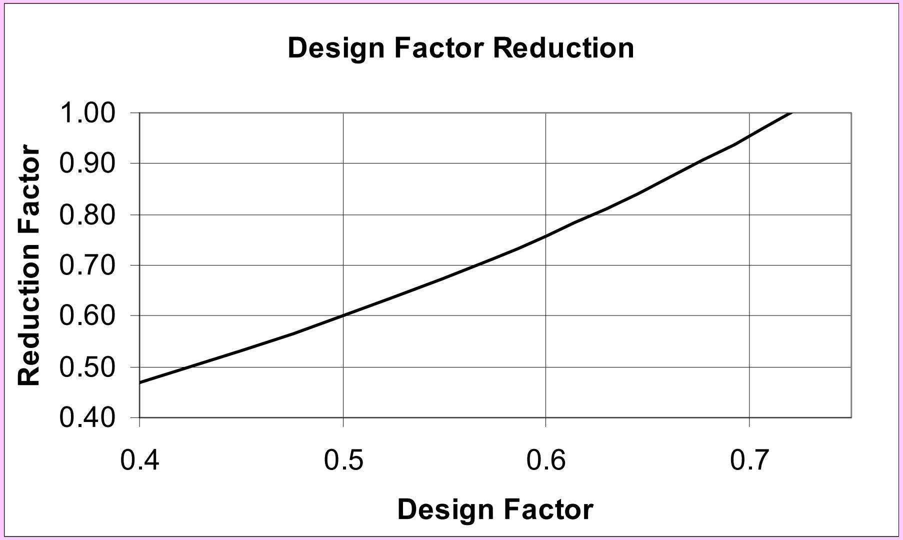
Failure Rates

Table 2 - Failure Rates per 1000 kilometre-years – Product Oil Pipelines in the UK

Spillage Cause	Pinhole	Hole	Rupture	Total
Mechanical	0.025	0.022	0.012	0.059
Corrosion	0.012	0.049	0.002	0.063
Natural	0.002	0.008	0.004	0.014
Third Party	0.026	0.054	0.022	0.102
Total	0.065	0.133	0.040	0.238

Allow for:-
> Thicker wall
> MAOP - Design factor
> Predictive modelling

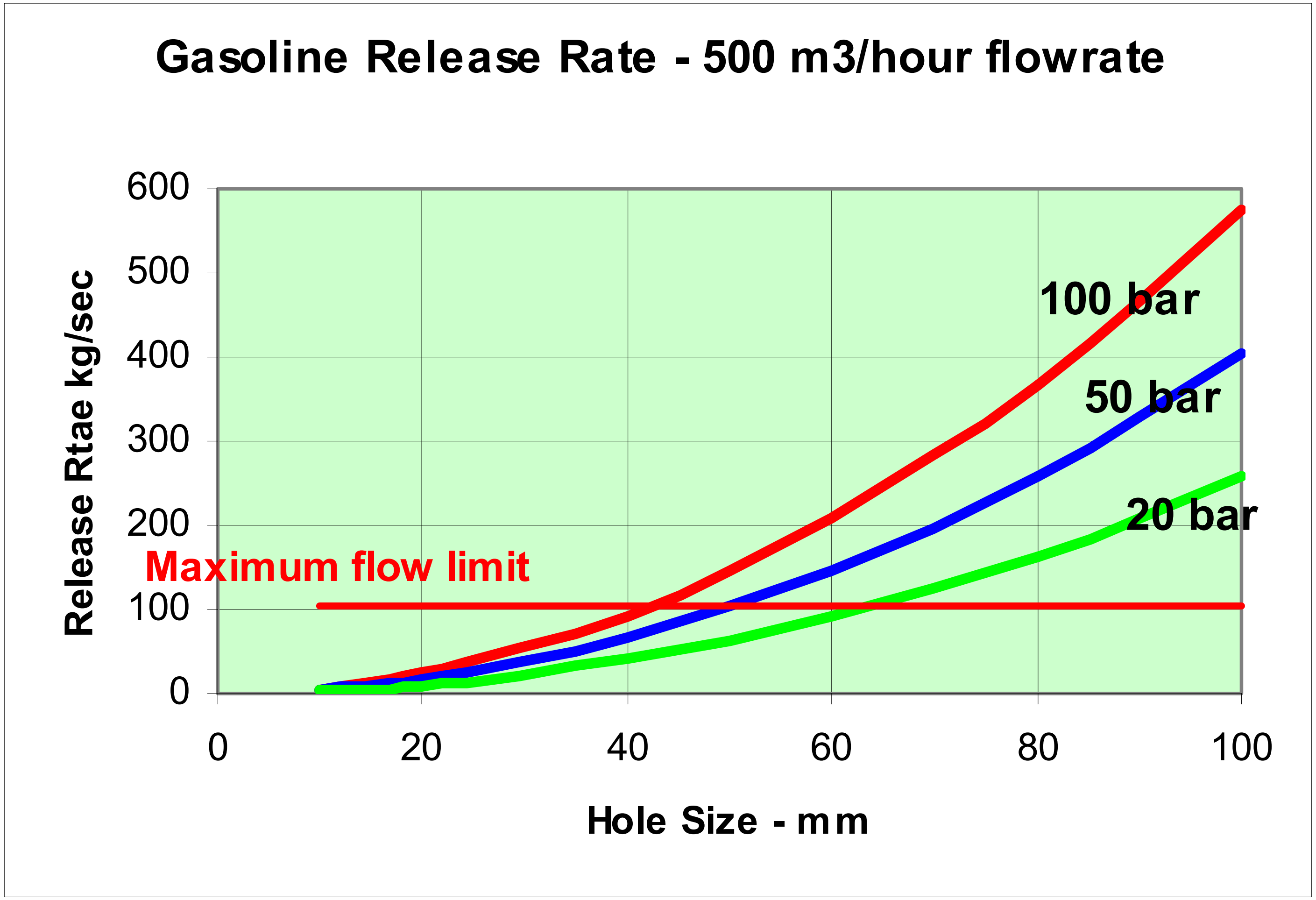
Figure 3 – Reduction in Failure Rate with Design factor



4 Failure Rate Data for Gasoline Pipeline

- 3rd party failure rate from UKOPA data Predictive models
- Mechanical and Corrosion failure rates from updated CONCAWE data for clean product pipelines in Europe (pending better data from UKOPA database)
- Ground movement failure rate from UKOPA as currently used by HSE (subject to further review by HSE?)

5 Liquid Release Rates from holes



Therefore maximum flowrate is discharged through 40+ mm hole

Therefore MAOP is less important than MAXIMUM FLOWRATE

DURATION OF RELEASE

– affects delayed ignition pool size

• assessment from visit to Pipeline Control Centre
• manned control room
• good leak detection system
• alarms always active
• previous (WS Atkins assessment) and confirmed

by current operations with updated leak detection systems

indicates maximum of 5 minutes to detect and shut down system

Gasoline Pool Fires

Calculate Pool Fire

PipeRisk™

	Wet Ground Conditions			Dry Ground Conditions			Delayed 5 mins	Delayed 5 mins
Hole diameter	10 mm	Puncture	Rupture	10 mm	Puncture	Rupture	wet	dry
Burning rate kg/s/m2	0.067	0.067	0.067	0.067	0.067	0.067	0.067	0.067
Release rate into pool kg/sec	4.8	139.78	143.97	4.8	139.78	143.97		
Wind velocity - metres /second	5	5	5	5	5	5	5	5
Maximum Pool Diameter metres	9.6	51.5	52.3	6.7	36.1	36.6	54.5	38.2
Flame height with wind tilt	13.3	45.7	46.2	10.2	35.2	35.6	47.7	36.7
Flame tilt angle to vertical	54	39	39	56	43	43	38	42
Atmospheric humidity	50	50	50	70	70	70	70	70
Hazard distance wind neutral	**15.9**	**73.1**	**74.1**	**11.5**	**52.9**	**53.7**	**77.0**	**55.7**
Distance adjustment wind tilt	5.4	14.3	14.4	4.2	11.9	12.0	14.7	12.3
Hazard distance wind towards	**21.3**	**87.4**	**88.5**	**15.7**	**64.9**	**65.7**	**91.7**	**68.0**
Hazard distance wind away	**10.5**	**58.7**	**59.6**	**7.2**	**41.0**	**41.7**	**62.3**	**43.4**
Distance from poolfire	**11**	**47**	**48**	**8**	**35**	**35**	**50**	**37**
Thermal radiation KW/M2	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7
Distance from poolfire	11.1	47.3	47.9	8.1	34.9	35.4	49.7	36.6
View Factor	0.171	0.190	0.190	0.168	0.186	0.185	0.190	0.186
Transmissivity of atmosphere	0.86	0.776	0.776	0.88	0.794	0.793	0.77	0.791

Distance to 14.7 kW/m2 used for 100% effect indoors and outside

6 Pool Fire Methodology for Gasoline Pipeline

- Conventional pool fire radiation calculation, based on burning rate 0.067 kg/m2
- Pool fires calculated for impermeable/ waterlogged soil 100% diameter with probability of 50%, and 70%, and 70% diameter for average soil with 50% probability
- Wind tilt correlations for 5 m/sec wind to give thermal radiation distances to 14.7 kw/m2 assuming 50% neutral to observer, 25% towards and 25% away from observer
- IMPACT - 100% fatal effects to persons in fire zone, either indoors or outdoor, and out to 14.7 kw/m2

7 Source of Ignition Probability for Gasoline Pipelines

For Land use Planning Zones assume:-

	Prob of Ignition	Prob of escape
Immediate Ignition Pool Fire	0.025	0
Delayed Ignition Pool Fire	0.025	0
Spray Fires (16% of total)	0.1	0
Total	0.058	

8 Scope for Site Specific Assessments for Gasoline Pipelines

- Pipeline characteristics – e.g
  - Pipewall thickness – affects 3rd party failure rates
  - Risk mitigation measures – slabbing?, depth of cover? etc, – affects 3rd party failure rates
  - Pipe condition characteristics, OLI inspection results, - – affects mechanical / corrosion failure rates
- Ground characteristics
  - Sloping areas / Urban areas / Watercourses
- Usage characteristics
  - Flowrates /Actual pressures / Leak detection aspects
  - Proportion of time gasoline

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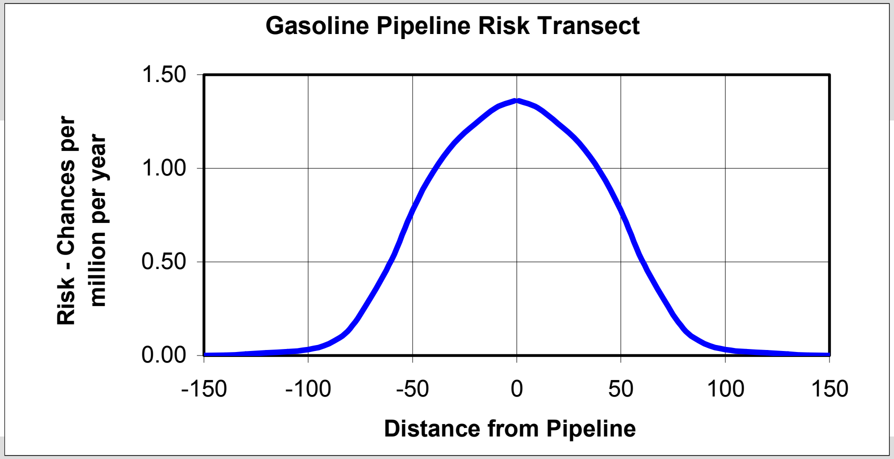
Gasoline Pipeline Risk Assessment

Calculate

Pipeline Diameter	mm	406
Pipeline MAOP	barg	71
Maximum Flowrate	m3	680



LUP Zones	
Inner Zone 10-5	26
Middle Zone to 10-6	40
Outer Zone to 3 x 10-7	71

Gasoline Pipeline - Release Rates

Density of Unleaded	kg/m3	740
10 mm hole release rate	kg/sec	4.8
100% Flowrate	kg/sec	139.8
103% Flowrate	kg/sec	144
Pool diameter for 5 min release - 25 mm deep	metres	54.52
Duration of release	mins	5