RESEARCH AND GUIDANCE FROM HSE

Preliminary results for ammonia pipeline releases to assist in planning possible JRIII trials

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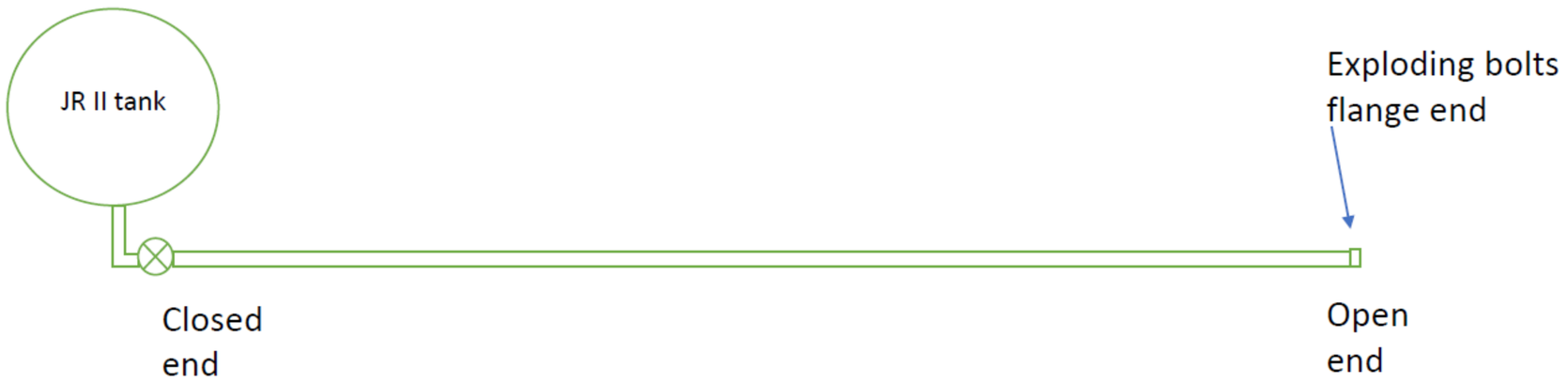
Research - HSE funded to provide evidence which underpins its policy and regulatory activities
Guidance - freely available to help people comply with health and safety law

Introduction

- In JRIII discussion on 13 October 2022, Joe Leung and Richard Barbarsky proposed four ammonia experiments:
  1. Horizontal release through 6” diameter hole in vessel
  2. Horizontal release through 6” short pipe attached to vessel
  3. Pipeline full bore rupture
  4. Pipeline puncture (50% opening area in flange end)



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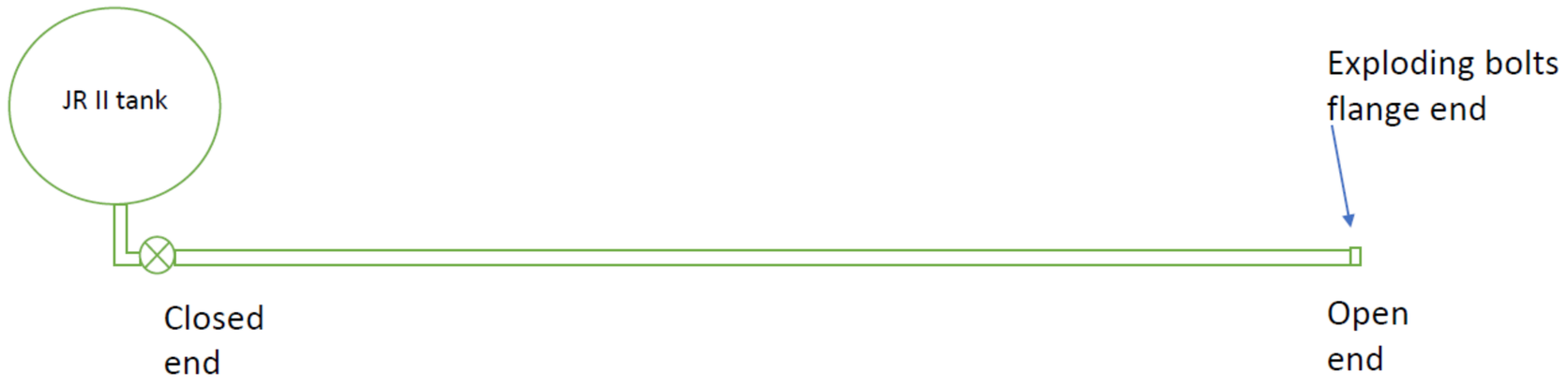
← Aim: run simulations to investigate these options

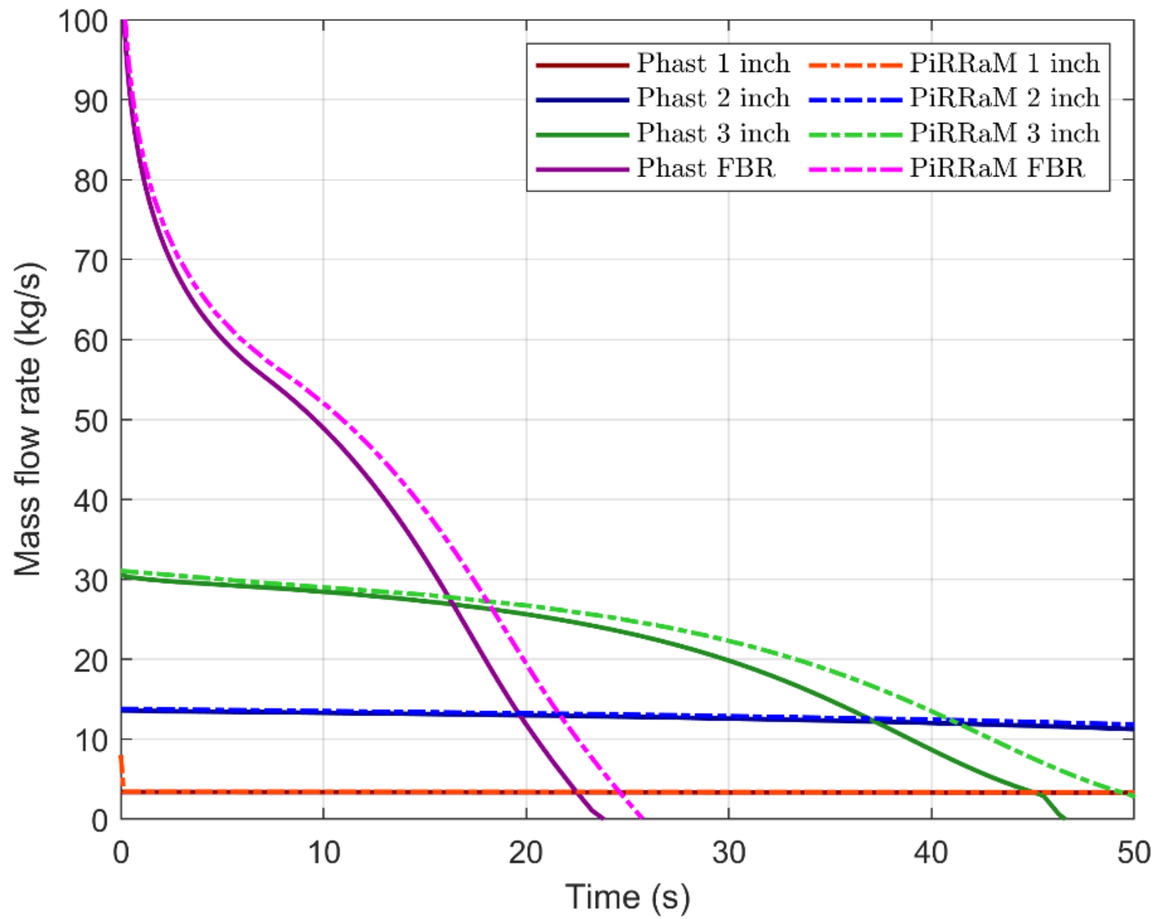


Ammonia pipeline simulations setup

Pipeline length	100 m
Internal pipeline diameter	6 inches
Orifice size	1, 2, 3, 6 inches
Pipeline pressure	200 psig
Pipeline temperature	20 °C (saturated)
Weather conditions	F1.5, D3

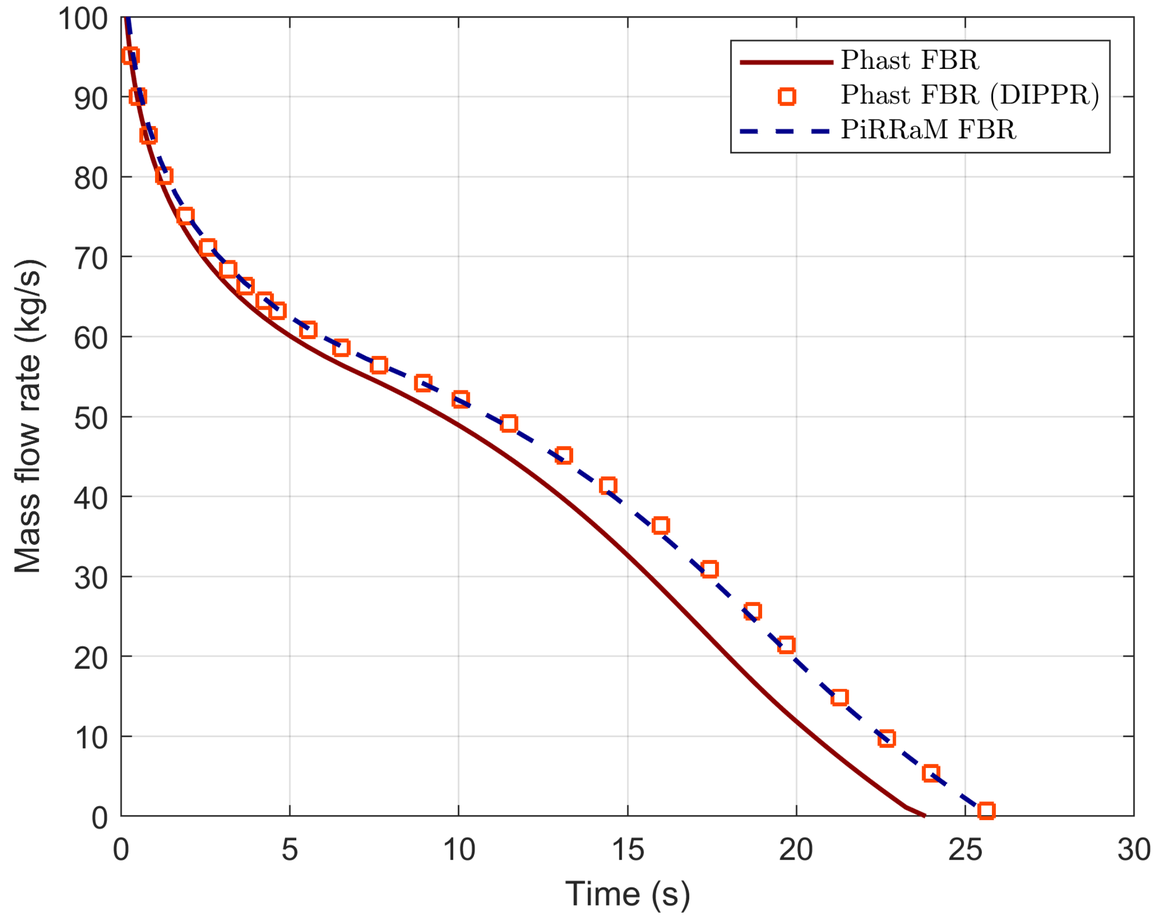
Predicted mass release rates

- Two models tested
  - Phast v8.61
  - PiRRaM
- Differences between models due to use of Peng-Robinson equation of state that is hard-coded into Phast Pipebreak model
- PiRRaM fluid properties taken from Reid *et al*. (1987) and Thomson *et al*. (1982)

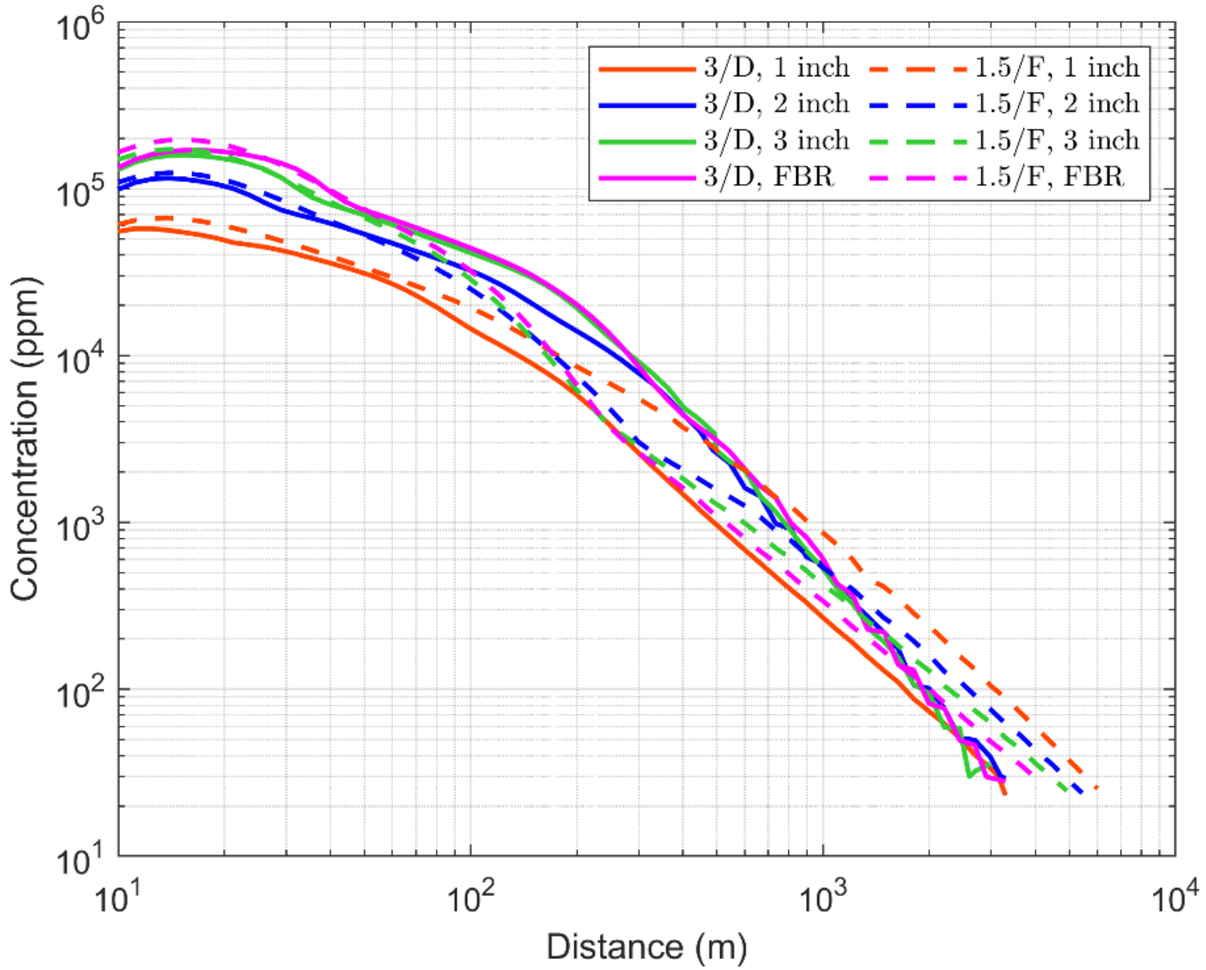


Predicted mass release rates

- Tests undertaken by DNV with Phast using DIPPR instead of Peng-Robinson EOS gave practically identical results to PiRRaM



Dispersion model predictions from DNV Phast



Hole size	Weather (Pasquill stability and wind speed)	Distance to AEGL levels		
		AEGL-1 (30 ppm)	AEGL-2 (220 ppm)	AEGL-3 (2700 ppm)
1 inch	D3	3143 m	1116 m	294 m
2 inch	D3	3193 m	1487 m	488 m
3 inch	D3	2598 m	1381 m	499 m
FBR	D3	2900 m	1492 m	539 m
1 inch	F1.5	5554 m	2087 m	499 m
2 inch	F1.5	4844 m	1686 m	323 m
3 inch	F1.5	4434 m	1479 m	311 m
FBR	F1.5	3970 m	1270 m	294 m

References

- DNV (2021). Pipebreak Model (Version 8.5) Theory Report. DNV.
- Mathias, P. M., Naheiri, T., & Oh, E. M. (1989). A density correction for the Peng—Robinson equation of state. *Fluid Phase Equilibria*, *47*(1), 77-87.
- Newton, A. (2022). Pipeline Release Rate Model (PiRRaM) for Pressure Liquefied Gases. In IChemE Hazards 32 Conference. https://www.icheme.org/media/19372/hazards-32-paper-02-newton.pdf
- Reid, R. C., Prausnitz, J. M., & Poling, B. E. (1987). The Properties of Gases and Liquids. McGraw-Hill Book Company, New York, NY
- Thomson, G. H., Brobst, K. R., & Hankinson, R. W. (1982). An improved correlation for densities of compressed liquids and liquid mixtures. AIChE Journal, 28(4), 671-676.
- Webber, D. M., Fannelop, T. K., & Witlox, H. W. M. (1999). Source terms from two-phase flow in long pipelines following an accidental breach. In International Conference and Workshop on Modelling the Consequences of Accidental Releases of Hazardous Materials, CCPS, San Francisco, California, September (pp. 145-168).

Thank you

Any questions?

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