Carbon Capture, Utilization and Storage (CCUS): Policy Perspectives and Science

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Outline

- Pipeline Safety Regulations (PSR) 1996
- Policy perspectives on CO_2 pipelines
- Previous scientific work on CCUS at HSL
- Future directions?

Pipeline Safety Regulations (PSR) 1996

- PSR provides a risk-based goal-setting approach to regulating pipelines in Great Britain
- The regulations cover:
  - Definition of a pipeline
  - General requirements for all pipelines (design, construction, operation etc.)
  - Requirement for co-operation amongst pipeline operators
  - Measures to prevent damage to pipelines
  - Amendments to other regulations

Pipeline Safety Regulations (PSR) 1996

- Major Accident Hazard Pipeline (MAH) is one which conveys a dangerous fluid
- Classification of dangerous fluid given in Schedule 2 of PSR (see next slide)
- PSR sets out requirements for MAH pipelines:
  - Emergency shut-down valves
  - Notifications
  - Major accident prevention document
  - Emergency procedures
  - Emergency plan

Dangerous Fluid (PSR Schedule 2)

1. Flammable, boiling point < 5°C at 1 bar(a) and conveyed in the pipeline as a liquid.
2. Flammable, conveyed in the pipeline as a gas at above 8 bar(a)
3. Liquid with vapour pressure > 1.5 bar(a) at temperature of pipeline or 20°C
4. Toxic/very toxic fluid which is gas at 20°C and 1 bar(a) and is conveyed as a liquid or a gas
5. Toxic with vapour pressure > 0.4 bar at 20°C h and is conveyed in the pipeline as a liquid
6. Acrylonitrile
7. Very toxic with saturated vapour pressure > 0.001 bar(a) at 20°C or is conveyed in the pipeline as a liquid at a pressure > 4.5 bar(a)
8. Oxidising fluid conveyed as a liquid
9. Fluid which reacts violently with water
10. Oxidising liquid and toxic or very toxic fluid, or reacts violently with water if it has been, or is liable to be classified, pursuant to regulation 5 of the Chemicals (Hazard Information and Packaging for Supply) Regulations 1994, as the case may be, oxidising, toxic, very toxic or reacts violently with water.

CCUS Policy Perspectives

- HSE published guidance on CO_2 pipelines: http://www.hse.gov.uk/pipelines/co2conveying-full.htm
- CO_2 is not currently classified as a "dangerous fluid" under PSR (1996)
  - Therefore CO_2 pipelines not treated as MAH pipelines
  - Not subject to controls under land-use planning
- However…
  - Previous HSE work has argued that CO_2 pipelines should be treated as MAH pipelines
  - Status remains under review
  - There are other relevant provisions in existing regulations (see next slide)

CCUS Policy Perspectives

- Health & Safety at Work etc. Act 1974, Sections 2 and 3
  - Employers are required to ensure the heath and safety of their employees and others so far as is reasonably practicable
  - CO_2 pipeline operators required to take a proportionate approach to managing the risks from conveying CO_2 at every stage of the pipeline's lifetime
  - Demonstrated through a comprehensive risk assessment which takes account of the range of risks that arise from the design, commissioning, operation (including maintenance and inspection) and decommissioning of the CO_2 pipeline

CCUS Policy Perspectives

- ALARP
  - Operators of CO_2 pipelines can demonstrate compliance with PSR and HSWA by making sure that the risks from their pipelines are reduced as low as is reasonably practicable (ALARP)
  - Application of good practice at the design stage is an essential part of this demonstration

CCUS Policy Perspectives

- Further guidance on HSE website on the topics of:
  - Corrosion
  - Ductile and brittle fracture propagation
  - Saturation pressure
  - CO_2 stream composition and flow assurance
  - Modelling loss of containment
  - Non-metallic components
  - Fluid classification
  - Guidance and Standards

http://www.hse.gov.uk/pipelines/co2conveying-full.htm

Outline

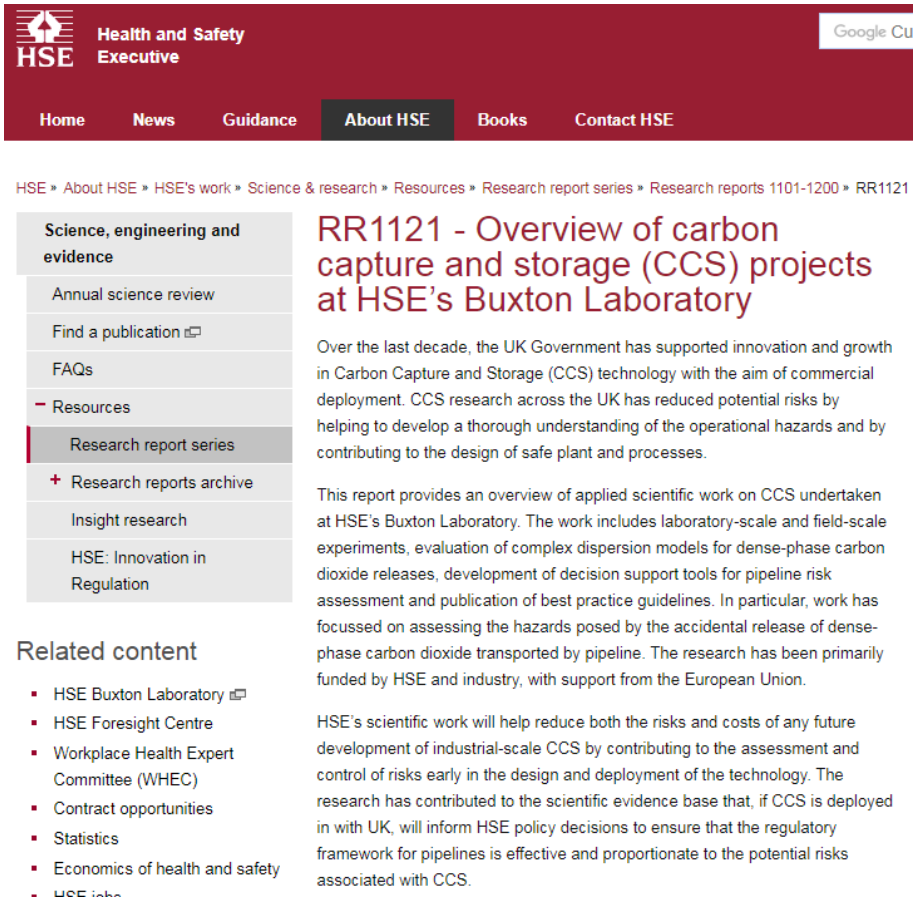
- Pipeline Safety Regulations (PSR) 1996
- Policy perspectives on CO_2 pipelines
- Previous scientific work on CCUS at HSL
- Future directions

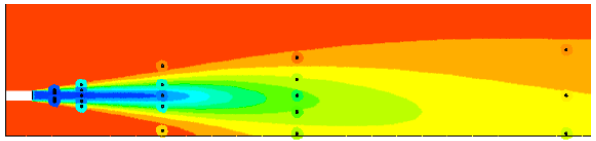
Previous Scientific Work at HSL

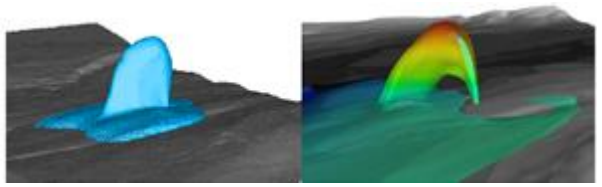
Several large EU, UK Government and industry-funded projects:

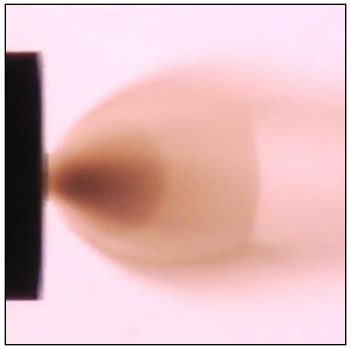
- CO2PipeHaz
  - http://co2pipehaz.eu/
- MATTRAN
  - https://gow.epsrc.ukri.org/NGBOViewGrant.aspx?GrantRef=EP/G061955/1
- COOLTRANS
  - Cosham *et al*. (2016) "Analysis of a dense phase carbon dioxide full-scale fracture propagation test in 24 inch diameter pipeline" http://dx.doi.org/10.1115/IPC2016-64456
  - Cooper R. and Barnett J. (2014) "Pipelines for transporting CO_2 in the UK" https://doi.org/10.1016/j.egypro.2014.11.264
- COSHER
  - Ahmad et al. (2015) "COSHER joint industry project: Large scale pipeline rupture tests to study CO_2 release and dispersion" https://doi.org/10.1016/j.ijggc.2015.04.001
- CO2PIPETRANS
  - https://www.dnvgl.com/oilgas/joint-industry-projects/ongoing-jips/co2pipetrans.html

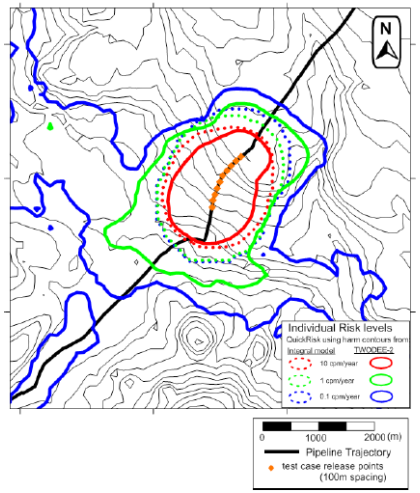
Previous Scientific Work at HSL











http://www.hse.gov.uk/research/rrhtm/rr1121.htm

Previous Scientific Work at HSL

HSE

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http://www.hse.gov.uk/research/rrhtm/rr1121.htm

Future directions?

- What are the main scientific research questions and knowledge gaps that need to be addressed to enable the safe adoption of CCUS ?
  - e.g. Ship transport – poor understanding of CO_2 releases onto water, no experimental data available?
  - e.g. Running ductile fractures in dense-phase CO_2 pipelines – experimental data shows models are non-conservative/unreliable
  - e.g. What lessons have been learnt from recent operational experience with CCUS, e.g. Boundary Dam, Sleipner
  - e.g. What is the current status of academic research in CCUS safety?

Thank you

The contents, including any opinions and/or conclusions expressed, are those of the authors alone and do not necessarily reflect HSE policy

CO_2 Phase Diagram