UK CCS workshop – Environmental Impacts (*including Health and Safety*)
Web meeting hosted by UKCCSRC
Date 1st February 2022, 10 am - 12 pm
Chaired by John Henderson, Environment Agency
Presenters: Simon Gant, HSE; Jenny Sutcliffe, Humber Zero; David Graham, Uniper Technologies Ltd & JEP

Key UK research needs highlighted through workshop

Research needs identified in the January/February 2022 workshop:

- Health and Safety
  - Capture plant: Do we understand the risks from toxic amines, nitrosamines etc.?
  - Pipeline design: Is there a validated model for predicting running ductile crack propagation along CO_2 pipelines that can be used to specify material toughness and/or crack arrester requirements? Do we understand corrosion regimes (e.g. non-dry CO_2 streams from different sources, process-upset conditions)? – lessons from Gorgon project
  - Pipeline risk assessment: Pipeline failure rates: need for modifications to fracture mechanics model in pipeline risk assessment models? Need to develop a fast method for CO_2 dispersion modelling incorporating terrain effects on along pipeline route (as a screening tool)? Need to develop a toxic risk methodology that considers sublimating solids (only for dense phase pipelines, but just being used offshore)?
  - Ship transport and subsea CO_2 pipelines: For transport of UK CO_2 to Norwegian "Northern Lights" project? Do we understand impact of CO_2 releases onto water no freely available data (recent DNV Sub- CO_2 JIP study but no data) and potential for rapid phase transitions (RPTs) following release from ship or failure of loading arms?
  - Review of recent operation experience from CCS and CO_2 for EOR applications, e.g. USA pipelines, Sleipner, Snøhvit, learning lessons from near misses, good practice etc.
- Emissions
  - Amines and amine degradation products to atmosphere: impacts of solvents and monitoring of air quality for amines
  - Assessing dangerous toxic load (DTL), release frequencies and CO_2 release modelling, how is this regulated?
  - Air quality assessment: Need to consider all species with a potential impact on human health or sensitive ecosystems, consider direct emissions and atmospheric conversion processes, key species of concern: amines, nitramines and nitrosamines and validation to ensure assessments are robust
  - ADMS module review: simplified chemical scheme, reaction rate data for different amines, techniques to estimate reaction rates based on chemical/structural similarities and which amines are most likely to be used (joined up approach)
  - How novel sorbents can reduce amine emissions
- BAT (Best Available Technology) for post-combustion capture
- Metering/monitoring/measurements
  - Monitoring of cold flue gas
  - How will metering/monitoring work in practice on a carbon capture plant? What are the practical accuracy levels?

- Measurement of emitted CO_2 mass release: Standards/guidance development for CO_2 measurement with low uncertainty and further consideration of background CO_2 in combustion air
- Monitoring of geological storage: underwater acoustics, reservoir modelling, geological sequestration & well head capping
- Method development and validation for measurement of amines in flue gas: types of amines, and ambient monitoring considered
- CO_2 monitoring for accounting purposes

- Storage and Transportation
  - Long-term environmental impact of storing CO_2 in geological storage.
  - Assessment/development of models for running ductile crack propagation in dense phase CO_2 pipelines, to determine material toughness requirements
  - 4D marine seismic monitoring.
- Other
  - Utility demand: water and energy
  - Public perception of major accident risk of CO_2

Research needs identified in the March 2021 workshop that were categorised as high priority in 2022:

- Cross media effects of acid wash on amine PCC
  - Life cycle analysis of sulphuric acid from production, application to disposal
  - Alternative acid washes to sulphuric
  - Water wash vs acid wash
- What is the ultimate environmental fate of species released from carbon capture processes
  - In ground and water
  - Longevity in the environment
  - Macro-environment effects of multiple CCS plants within a cluster
- Emissions from non-amine based capture solutions
- Establish robust measurement methods
  - Stacks monitoring: establish certified monitoring methods for emissions to air
  - Ambient measurements: establish certified monitoring methods
  - Using the above - model validation exercises and confidence about risk

Research needs identified in the March 2021 workshop that were categorised as medium priority in 2022:

- A review of ADMS modelling
  - Improve the ADMS amines module to consider a mix of directly-emitted amines and/or nitrosamines
  - Development of an alternative tool
  - Other parameters that ADMS Chem module uses (hydroxyl radicals, multiple degradation reactions and interactions, NOx etc)
  - Model validation – real world data to compare with the ADMS model
- Amines chemistry and N-amines EALs
  - A refined approach for N-amines instead of assuming every species is NDMA
  - Phase partitioning of N-amines
  - Toxicity of nitramines compared to nitrosamines (sources not consistent)
  - Improved chemistry data for amines

Research needs identified in the March 2021 workshop that were categorised as lower priority in 2022:

- Develop sound risk-based approaches/step-by-step methodology/guidance – possible use of Monte Carlo analysis