CCSA Health & Safety Working Group

01/05/2025
10:00 (GMT)

CCSA

Agenda

	Time	Topic	Speaker
1.	10:00	**Introductions & CCSA Competition Law Policy Notice**	Toby St Leger (Co-chair)
2.	10:05	**UK HSE Updates**	Rachel McCann & Simon Gant (HSE)
3.	10:35	**Industry Initiatives / JIP Updates**	Sebastien Cochet (DNV)
4.	10:50	**Presentation / discussion of health & safety areas of current interest**	John Entwistle (ENI) & Toby St Leger (Harbour Energy)
5.	11:20	**Action Plan & New CCSA Working Group Structure**	CCSA Secretariat / All
6.	11:25	**AOB and next meeting date**	Toby St Leger (Co-chair) / CCSA Secretariat

House keeping & Introductions

- Slides & Recording will be available for members after the meeting.
- CCSA Competition Law Policy notice is attached to the meeting invite and available on the CCSA website.
- If you are not speaking, please mute your microphone.
- Please **raise your hand** if you wish to comment, you will be invited to come off of mute, if you can also turn on your camera.
- Please also pose any **comments in the chat** and these will be picked up by the secretariat.
- **Introductions** of any new members joining the call.

UK HSE Updates

- Policy and Regulation developments and updates (SCR, PSR, COMAH, Other)
- Technical updates and areas of emerging interest

Health and Safety Executive (HSE)

CCSA

Industry Initiatives / JIP Updates

- Update on the Skylark JIP
- Proposed JIP/test program on CO_2 cryogenic releases
- Other JIPs

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Skylark: Addressing the Challenges in CO_2 Pipeline Transportation Safety

Challenge: Firstly; there is a knowledge gap associated with the prediction of hazard distances from CO_2 pipeline incidents. Secondly; there is a lack of operational and emergency experience for CO_2 pipelines. This means that operators, regulators and emergency services are not fully equipped to plan for such incidents. This can have a serious impact on project planning, consent and public perception.

Solution: DNV has pulled together a world-leading delivery team of researchers, regulators and emergency response experts. Together, this team will deliver both small, high fidelity wind tunnel experiments and large realistic release experiments. Such experiments will be analysed for their dense gas dispersion characteristics, compared with predictive tools and emergency response plans developed.

DNV's role and impact

- International ability to build JIPs: pulling together regulators, operators and researchers from across the world
- Large-scale experimental facilities and experience at Spadeadam
- Modelling and analysis capability in Energy Systems, Digital Solutions
- Industry accepted RPs continually being updated

Project details

Customer: JIP: APA, BP, EBN, Equinor, GasUnie, Natran (GRTGaz), Shell, TotalEnergies, Uniper. Grant from DESNZ.

Delivery Partners: DNV, HSE, Ricardo, University of Arkansas, NCAS

Country: Most delivery in UK, small WP in US (University of Arkansas)
Date: Start April 2025 for 3 years
DNV solution: Multi-disciplinary JIP

a Joint Industry Project
ADDRESSING THE CHALLENGES IN CO_2 TRANSPORTATION SAFETY
SKYLARK

Project Skylark

Transportation of carbon dioxide forms an important element of any accelerated decarbonisation initiative. Repurposed and new-build capture, transportation and storage infrastructure will be required and **must** be delivered safely.

Identify the Challenges

Challenge 1: Source characteristics from CO_2 pipeline craters

Challenge 2: Terrain effects on dense clouds

Challenge 3: Emergency Response

Challenge 4: Operational Issues (venting)

Address the Challenges

WP0 - Project Management
Coordination of the JIP throughout its ~3 year duration.

WP1 - CO_2 Pipeline Craters and Source Terms
Large scale experiments involving gaseous and dense-phase buried pipeline ruptures to assess crater formation and generation of different source terms.

WP2 - Wind Tunnel Experiments
Reduced-scale experiments at University of Arkansas to investigate crater sources and complex terrain effects for a wide range of precisely controlled atmospheric conditions.

WP3 - Simple Terrain Dispersion Experiments
Well-defined large-scale releases of CO_2 onto simple slopes of varying inclination in one plane with dispersion measurements.

WP4 - Complex Terrain Dispersion Experiments
Large, dense phase releases of CO_2 onto complex terrain including multi-planar slopes (valleys, hills, obstacles) with dispersion measurements.

WP5 - Model Evaluation
HSE SD will coordinate a series of model validation exercises using the experimental data generated in this project. The aim is to encourage the development of a variety of tools of differing complexity to enable robust pipeline risk assessment, permitting studies and emergency planning and response.

WP6 - Emergency Response
Led by Ricardo's NCEC, this work package will engage with emergency responders to make best use of the CO_2 dispersion trials. Development of training materials and best-practices for emergency response will be developed with the learning from the experiments and critical pieces of equipment will be tested for their operability in emergency scenarios.

WP7 - Venting
Near full-scale venting experiments will be conducted alongside other work packages to assess the dispersion behaviour and measure temperatures.

Status Update:

April 2025 – Multi-party agreement signed with 9 partners plus DNV. Grant with UK Gov signed. Project KO planned for early May! KO budget is £7.5M and some work-packs still require funding.

Other Planned JIPs

- Subsea CO_2 Phase 3

SubCO$_2$ – Next Phase

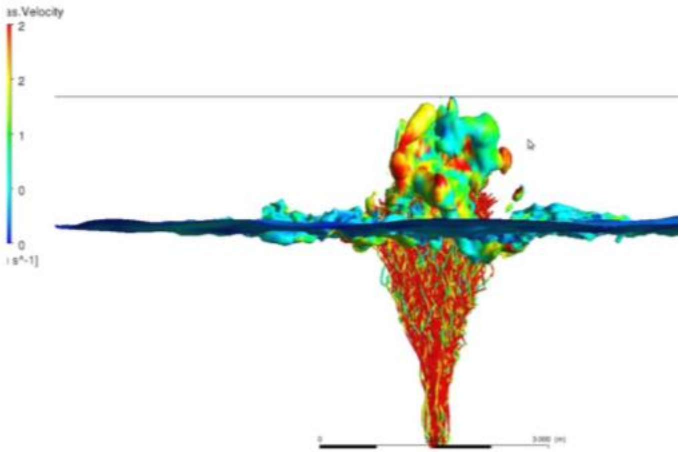
Underwater CO$_2$ Releases at 40m Water Depths

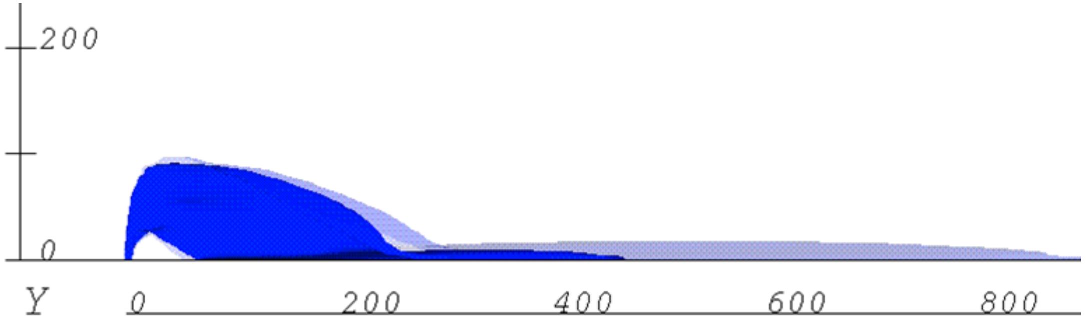
Aim and Objectives – Phase 3

The aim of this project is to study the subsurface and atmospheric dispersion and dynamics of underwater CO_2 pipe leaks.

The objectives are:

- To establish safety guidelines and standards for offshore CO_2 pipelines
- To validate numerical models and techniques for subsea and atmospheric CO_2 plume dynamics
- To establish a scientific understanding of the behaviour of CO_2 leakage from underwater high pressure pipelines





Approach

Phase 3: Subsea CO_2 releases at 40 m deep in an open water testing environment

The tank and pond tests were bounded systems; water rapidly saturated with CO_2

Approach

- A limited number of larger (real) scale experiments will be conducted.
- Scaling-up depth and release rates from previous Phases 1 and 2.
- Exploring the effect of higher downstream pressure due to increased depth.
- Experimental data will be compared with dedicated CFD model predictions

Approach

WS 1, Experiments:

- CO_2 release at a depth of 40 m performed at the Underwater Centre in Fort William Scotland. The effect of different release diameters, wind speed and water current on the propagation and solubility of the CO_2 plume is investigated.

WS 2, Subsea model:

- Subsea release and dispersion modelling before and after the experiments. Comparisons, uncertainty estimates and discussion of effects.

WS 3, Interface model:

- Interface between subsea and atmospheric dispersion models. This involves some technical model development.

WS 4, Atmospheric model:

- Release from the surface and atmospheric dispersion modelling before and after the experiments. Comparisons, uncertainty estimates and discussion of effects.

WS 5, Application of models:

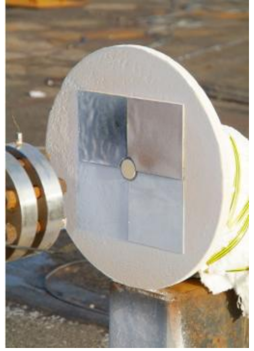
- Safety and environmental example on the impact of the atmospheric and subsea CO_2 release.
- In close cooperation between the project partners a **3x3x3 matrix of cases** will be defined and run to exemplify the use of the tools for developing safety zones and QRAs.

WS 6, Project management:

Other Planned JIPs

- CO_2 Valves and CO2 Jets – Low Temperature Impact
- Preliminary Results for LCO_2 releases conducted at Spadeadam

Introduction



- Two knowledge gaps have been identified which require similar experimental facilities:
  - 1a: The heat transfer and erosion characteristics of CO_2 jets when impinging on objects (in particular adjacent infrastructure with the potential for escalation).
  - 1b: The performance of protective materials and systems to mitigate the cooling effects of impinging CO_2 jets.
  - 2: The performance of valves and systems under high flow, dense-phase CO_2 conditions

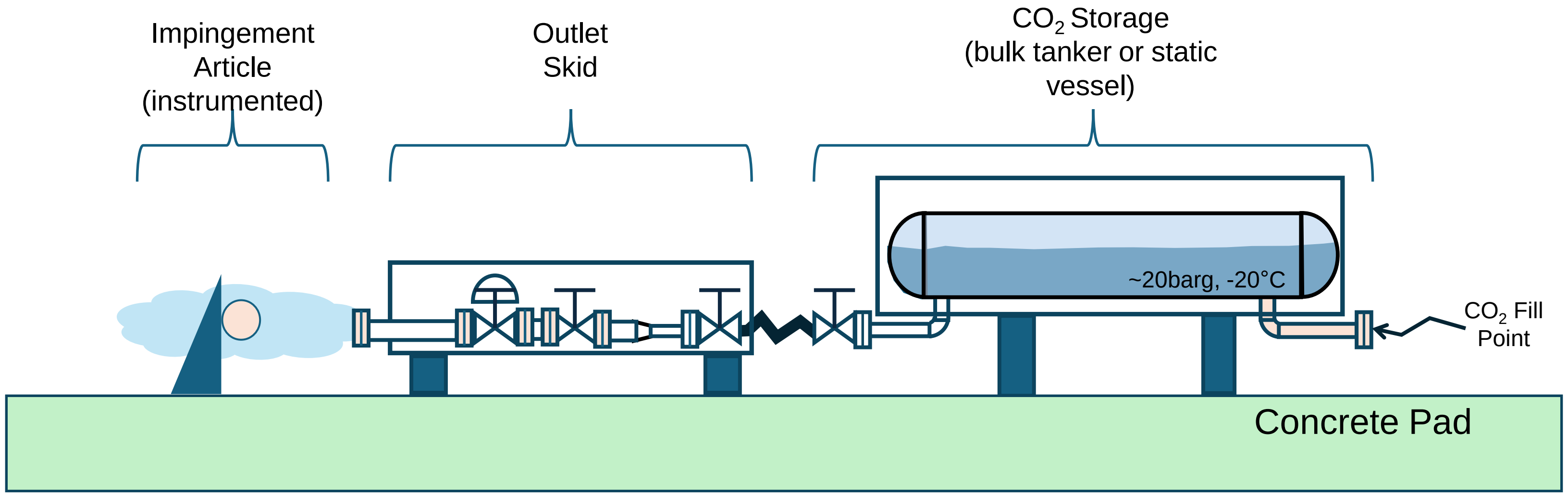
- This slide-deck attempts to illustrate a programme of works to satisfy 1a above with 1b and 2 being left as follow on works in the same facilities.

Programme

- Phase 1: Simple high volume saturated CO_2 releases
  - Provide quick, preliminary information on the heat transfer in CO_2 jets in non-real but known conditions
  - Releases will be close to road transportation and storage conditions (i.e. 20barg, -20°C, saturated liquid)
  - Very little equipment is required and comparisons can be drawn to other cryogenic fuels (LiN, LNG)
  - Perhaps some parallels with CO2 cleaning applications: https://www.boconline.co.uk/en/images/CRYOCLEAN-Dry-Ice-Blasting_tcm410-171681.pdf

- Phase 2: High pressure, high flow, dense phase CO_2 releases.
  - To replicate the real properties of a dense phase CO_2 application, flows of CO_2 at up to 150 barg, ambient temperature and up to 200 kg/s are required (up to 2" diameter).
  - The heat transfer properties can be studied with the addition of the high velocities, higher solid CO_2 content and erosive properties.
  - These flows are useful for testing the performance of valves, components and systems at realistic conditions.

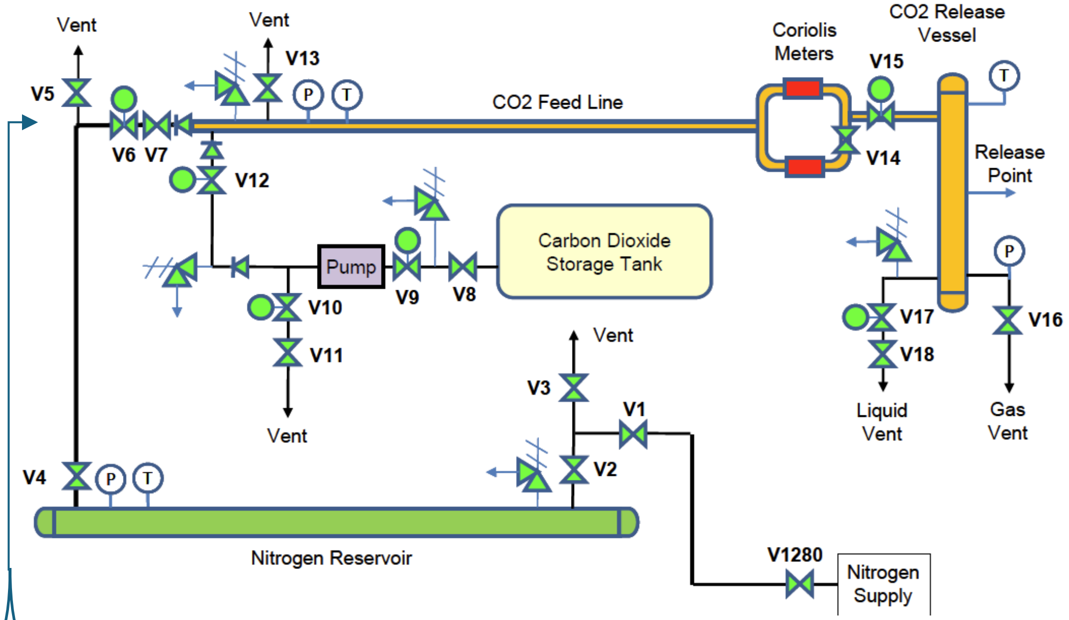
Phase 1 Equipment

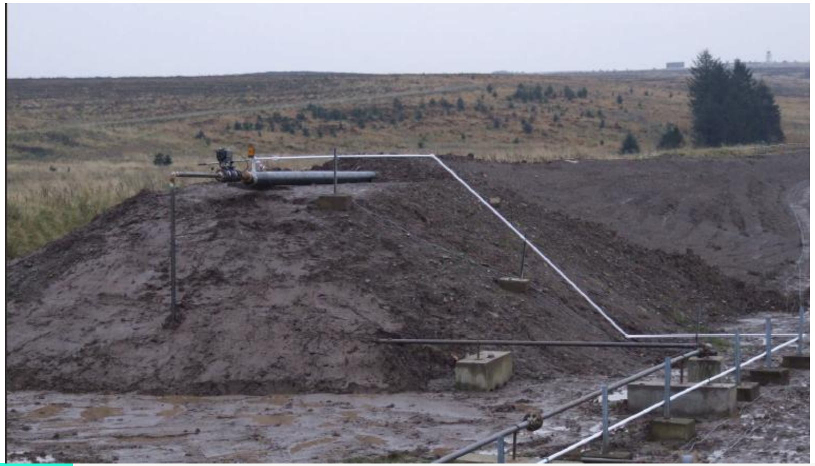


Notes:

- CO_2 could be from bulk tank or from road tanker
  - Road tanker would have outlet pump for small elevated pressure
- Mass flow might be difficult (two-phase flow). Level gauge on store might be enough.
- Most equipment exists already. Needs:
  - MOC
  - Test Procedure

Phase 2 Equipment





- "CO_2 Release Vessel" can be replaced with nozzle for jets or 'valve' for flow testing.

Notes:

- Rebuild (or similar) previous HP, dense phase injection rig:
  - 240m 12" NB inclined pipe
  - Up to 165 barg N2 injection to maintain pressure and flow
  - Up to 200kg/s dense phase CO_2 (2" @ 150barg)
  - Nominal inventory is 15 Te:
    - ¼" 3 kg/s for >1hour
    - 1" 50kg/s for 5min
    - 2" 200kg/s for 1min

Example Programme: Phase 1

Nozzle Size	Impingement Article	Stand-off	Supply Condition	Duration
1/4”	Pipe	1.0m	Saturated, ~20barg	10 min
	Pipe	1.5m	Saturated, ~20barg	10 min
	I-Section Para	1.0m	Saturated, ~20barg	10 min
	I-Section Para	1.5m	Saturated, ~20barg	10 min
	I-Section Ortho	1.0m	Saturated, ~20barg	10 min
	I-Section Ortho	1.5m	Saturated, ~20barg	10 min
1/2”	Pipe	1.0m	Saturated, ~20barg	10 min
	Pipe	1.5m	Saturated, ~20barg	10 min
	I-Section Para	1.0m	Saturated, ~20barg	10 min
	I-Section Para	1.5m	Saturated, ~20barg	10 min
	I-Section Ortho	1.0m	Saturated, ~20barg	10 min
	I-Section Ortho	1.5m	Saturated, ~20barg	10 min
1”	Pipe	1.0m	Saturated, ~20barg	10 min
	Pipe	1.5m	Saturated, ~20barg	10 min
	I-Section Para	1.0m	Saturated, ~20barg	10 min
	I-Section Para	1.5m	Saturated, ~20barg	10 min
	I-Section Ortho	1.0m	Saturated, ~20barg	10 min
	I-Section Ortho	1.5m	Saturated, ~20barg	10 min

Example Programme: Phase 2

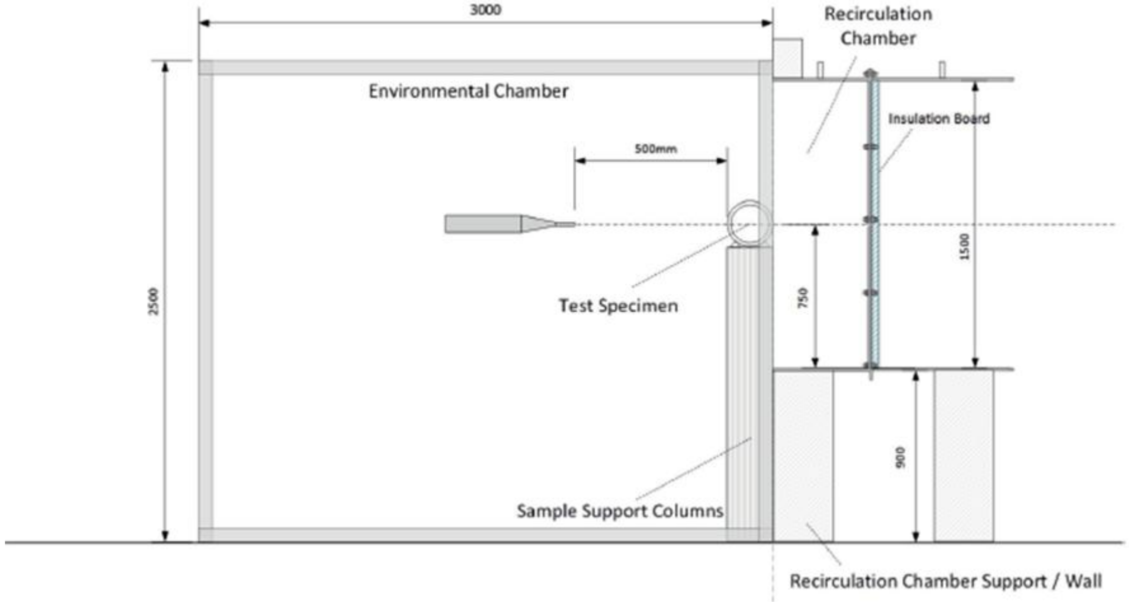
Nozzle Size	Impingement Article	Stand-off	Supply Condition	Duration
1/4”	Pipe	1.0m	150barg, dense phase	1 hour
	Pipe	1.5m	150barg, dense phase	1 hour
	I-Section Para	1.0m	150barg, dense phase	1 hour
	I-Section Para	1.5m	150barg, dense phase	1 hour
	I-Section Ortho	1.0m	150barg, dense phase	1 hour
	I-Section Ortho	1.5m	150barg, dense phase	1 hour
1/2”	Pipe	1.0m	150barg, dense phase	15 mins
	Pipe	1.5m	150barg, dense phase	15 mins
	I-Section Para	1.0m	150barg, dense phase	15 mins
	I-Section Para	1.5m	150barg, dense phase	15 mins
	I-Section Ortho	1.0m	150barg, dense phase	15 mins
	I-Section Ortho	1.5m	150barg, dense phase	15 mins
1”	Pipe	1.0m	150barg, dense phase	5 mins
	Pipe	1.5m	150barg, dense phase	5 mins
	I-Section Para	1.0m	150barg, dense phase	5 mins
	I-Section Para	1.5m	150barg, dense phase	5 mins
	I-Section Ortho	1.0m	150barg, dense phase	5 mins
	I-Section Ortho	1.5m	150barg, dense phase	5 mins

Summary

- Two phase project (pardon the pun!)
- Phase 1 build and test: Quick and relatively inexpensive
  - Can do coatings tests in parallel for coating manufacturers
- Phase 2 build and test: More complex and costly to achieve high flow, high pressure realistic releases.
  - Same facility can accommodate performance testing of valves and equipment within the parameters detailed earlier

LCO2 Releases conducted at Spadeadam

- Work paid for by PPG
  - Representatives from HSE, Oil & Gas producers, EPC's
- Investigated cooling effect of LCO2 releases
- Address concerns about risk of brittle fractures caused by releases of LCO2
- Test programme based on ISO 20088-3:2018 test standard



Pipe Configuration (Side View – Including Environmental Chamber)

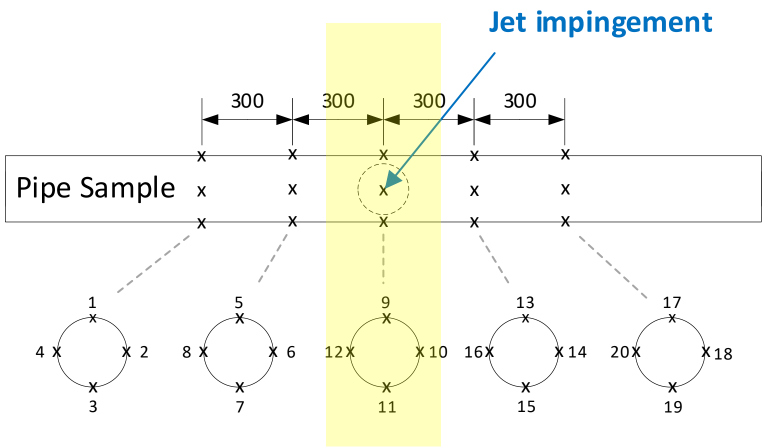
Deviations

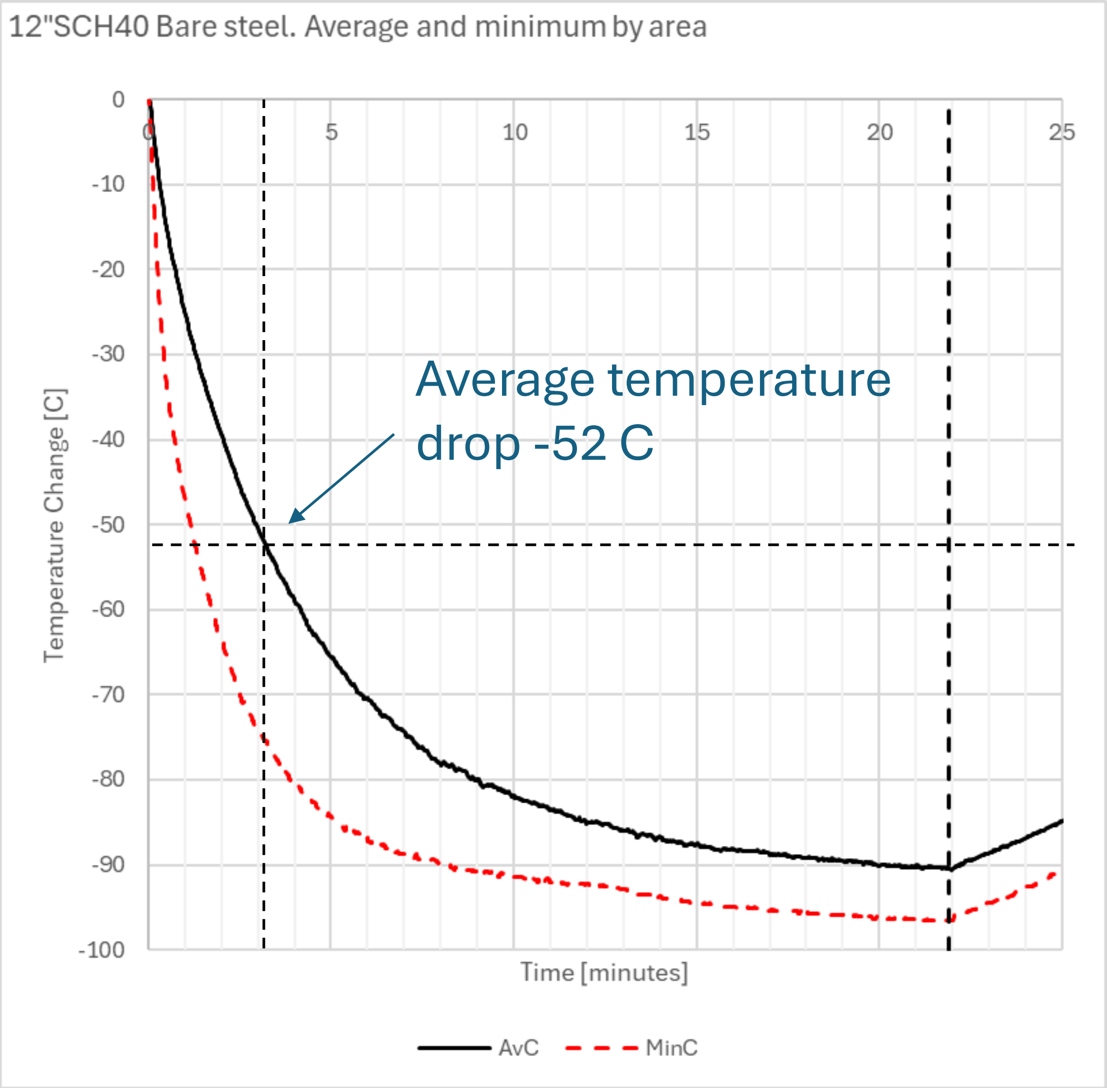
- LCO_2 (from a commercial road tanker)
- Nominal onboard pressure and temperature of 16 barg, and -25 °C
- LCO_2 driven using the head space pressure
- Nozzle was 8 mm hole in a blank flange.

LCO2 testing

Initial Findings

- 12"SCH20 bare steel pipe
- 12"SCH40 bare steel pipe
- Time required to reach -52C
  - Temperature drop from 23C to -29C
- Temperature drop with 5 minutes at the central location
  - (Based on average temperature drop around section)



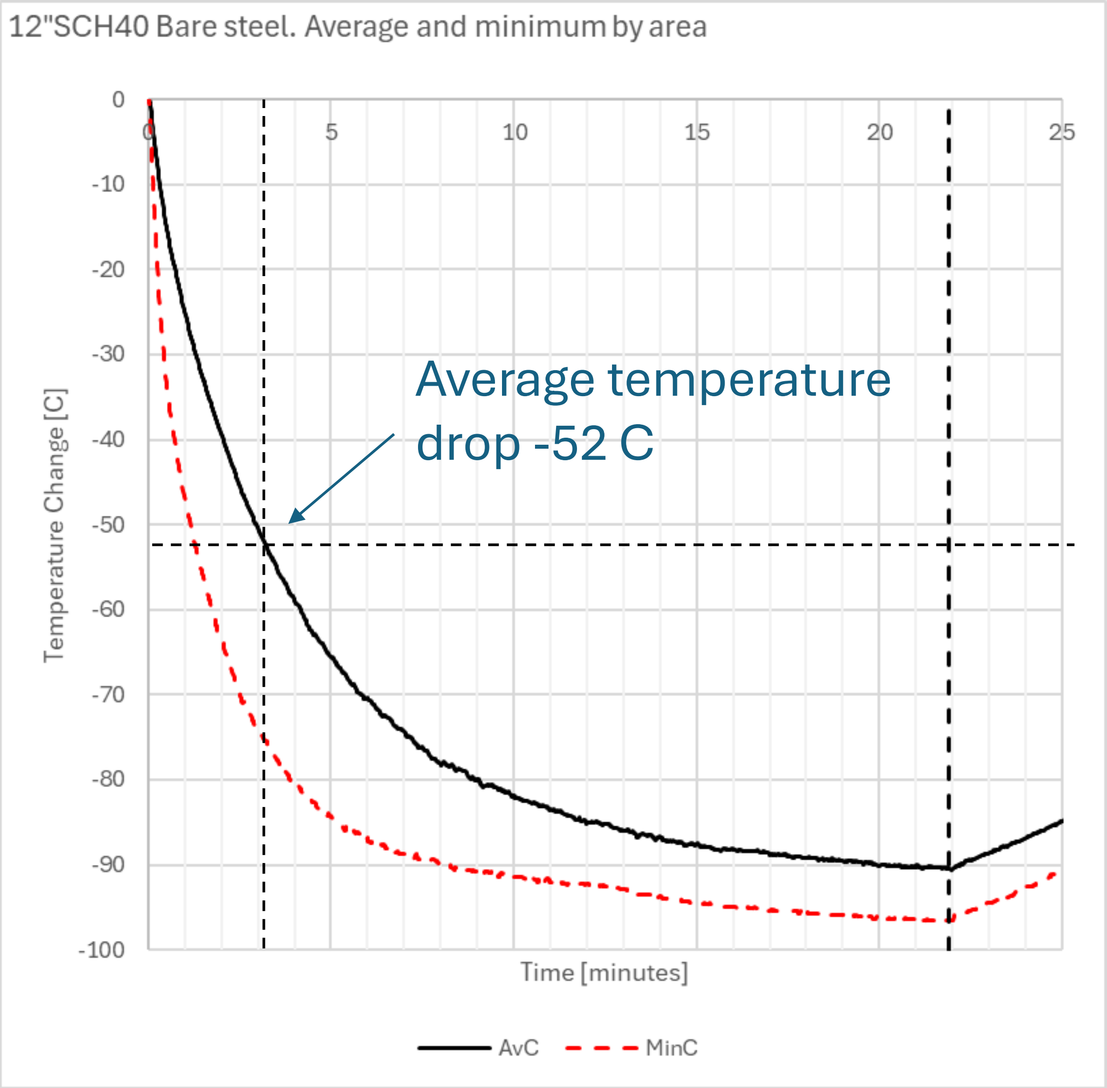


Initial Findings

- Lowest temperature achieved, approx. -88C
- Fastest cooling location, impingement point
- Coldest location, top of test specimen
- Temperature roughly stable in about 15 minutes

- **Temperature drop was prevented by a typical PFP coating thickness**
- **Coating thickness would have been greater if LN2 would have been used**

- **Contact Richard Holliday (Holliday@ppg.com)**



JIPs / Industry Initiatives

- Any interest in these JIPs – please contact CCSA! (despoina.tsimprikidou@ccsassociation.org)

- Are you aware of other Safety related JIPs or initiatives? E.g.
  - EI's CO_2 Hazard Analysis Guidance update
  - EI's CO_2 Hazard Analysis Training Course plans

Presentation/discussion

Health & safety areas of current interest

All

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Overview

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Infrastructure

- Capture Plants
- Pipelines
  - On / Offshore
- AGIs / Compression facilities
- Offshore Installations
  - Surface
    - NUI / NPA / PAI
  - Sub Surface
    - Wells / Manifolds

Operating Conditions / Model

- Pressures, Temperature, Flow etc
- Gas / Dense phase

Which developers/ operators are doing what ?

Common / unique areas of interest for safety and level of interest

Identified H&S priorities for discussion and information sharing between CCSA technical members

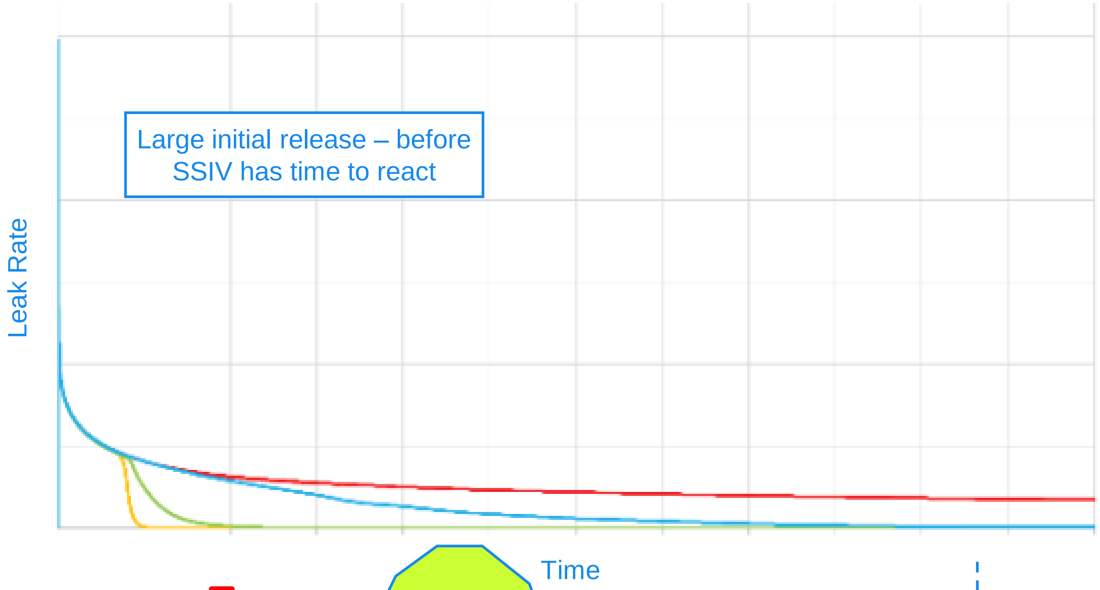
- Offshore and nearshore SSIVs
- Acceptable ESDV leakage rates and how to test for them
- Emergency responses – Onshore & Offshore
- CO_2 Hazard and Effects Criteria
  - Effect on people (workers onshore and offshore, members of public), on Escape and Evacuation functions
  - Effect on assets / equipment, escalation – e.g. Low temperature impact thresholds, structural response
- ALARP Decisions, Good Practice Guidance
- Supply Chain & 3rd party assets (ability to work in CO_2 risk environment)
- CO_2 Gas Alarm Set points (High / Low etc)
- Subsea releases, including
  - effect on vessel buoyancy (CO_2 vs 'typical' high pressure NG),
  - hazard ranges for surface plume toxic concentrations

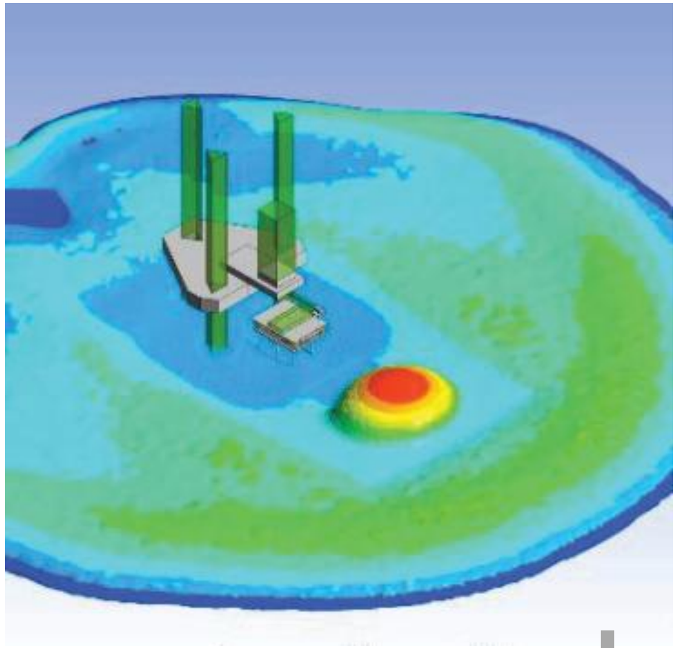
Identified H&S priorities for discussion and information sharing between CCSA technical members

<u>Suggestions for topics/inputs/regular updates from HSE:</u>

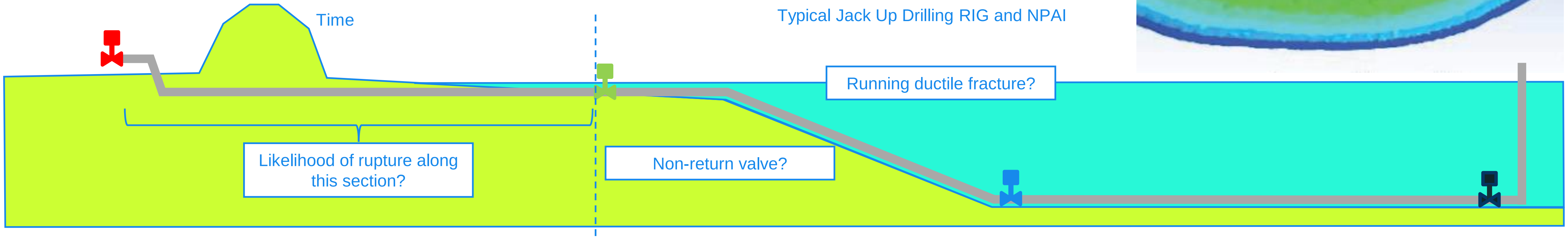
- PSR/Regulatory Policy Update / Consultation (onshore and offshore)
- SCR15 & PFEER 95 for CO_2 as MAH
- Agreement of hazard criteria for CO_2 (e.g DTL, WEL LTEL, IDLH, other guidance of effects
- CO_2 Risk Evaluation and ALARP – good practice
- Release and Dispersion Modelling (Software, Methods, Validation etc)
- Effect of wave action on dispersion of CO_2
- Interim/on-site CO_2 storage

Offshore & Nearshore SSIVs





Typical Jack Up Drilling RIG and NPAI

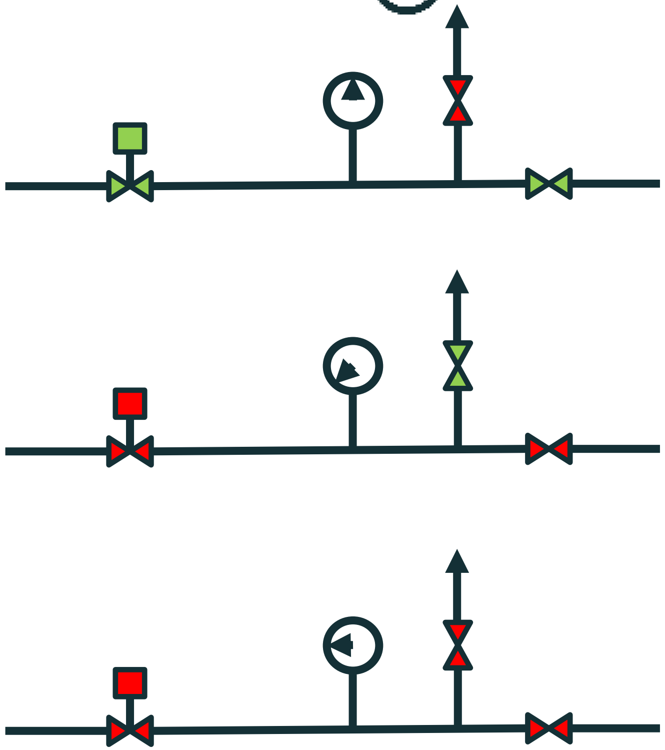


Max hazard distance to onshore receptor

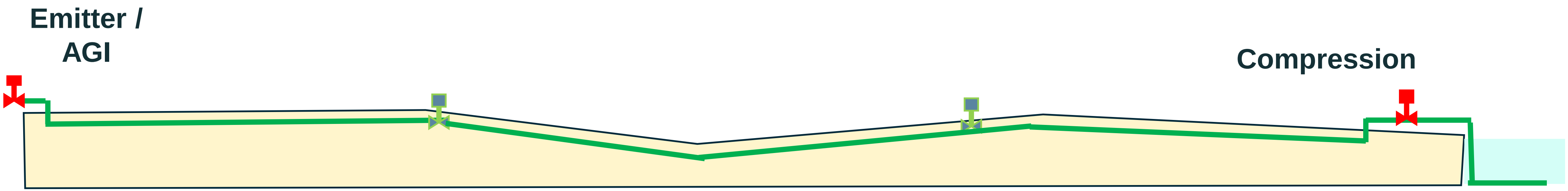
Installing SSIV “reasonably practicable”?

ESDV Leakage Rates

- *"The operator should make an assessment of the maximum internal [leakage] rate that can be tolerated. The rate of leakage should be based on the installation's ability to control safely the hazards produced by such a leak."*
  ACOP to PSR Schedule 3 (offshore installations)
- Annex D of PD 8010-4 alludes to similar testing of ESDV in onshore pipelines.
- Traditional method measures rate of repressurisation downstream of valve
- Does downstream section need to be flattened?
- Time consuming to vent dense phase CO_2
- What is an acceptable leakage rate? IDLH at site boundary?
- Are other technologies available?
- Does anyone have any experience using them?
- Are they proven for use with CO_2?



Cross Country Pipelines – BVS



Is installing BVS "reasonably practicable"?

What are the relevant advantages and disadvantages?

CO_2 Hazard and Effects Criteria

TOXIC

- DTL / SLOT & SLOT
- COSHH & STEL/LTEL
- UK HSE CO_2 Hazard Guidance
- General Guidance on physiological effects
- DNV RISKMAN Guidelines
- EI Guidelines
- IOGP Guidelines
- **OTHERS ???**

Low Temperature / Cryogenic

- Vulnerability of people - IOGP/DNV and Company criteria
- Eni Company damage / impairment criteria
- DNV RISKMAN & EI Guidelines
- **OTHERS ???**

Basis and methodologies for Evaluation & Risk Management

- **QRA / Toxic Gas Dispersion**
  - **Failure mechanisms and data DFP etc**
- **Low Temperature Assessments**
- **Others ?**

Emergency Responses

Onshore

- Operator's Emergency Response Plans
  - Emitter Interfaces
  - Leak detection
  - Shut down and Isolation
  - etc
- Offsite / Local Authority
- Nearby Industries, Populated areas, Crossings / Proximity etc

Offshore

- Detection, Isolation, Depressurisation
- Escape Sets
- Safe Refuges
  - Safe breathing duration / cold jet impingement etc
- Means of Escape (TEMPSC, direct to sea)
  - Breathing air, ICE, electric
- ERRV
  - Ability to function within CO_2
- MCA

Supply Chain and 3rd Party Assets

Capability to Design for CO_2 Safety Operate in a CO_2 Risk Environment

General Considerations

- Expertise and established standards / specifications etc for CO_2 infrastructure design, engineering and integrity
  - In pipe hazards (e.g. corrosion, multiphase, degradation etc)
- Well Services & Vendors

Offshore

- Jack Up Barge in Combined Operations
  - Safety Case, CO_2 MAH related SECEs for Detection & Emergency etc
- MODU for well interventions, workover, drilling etc (Sub Sea or Platform Wells)
  - Safety Case and CO_2 related SECEs + Rig systems for CO_2 fluids (e.g. diverters)
- Attendant Vessels
- Helicopters

Onshore ??

Potential Workstreams & Outputs

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CCSA Position Paper

- Set out identified health & safety priorities.
- Lay out any challenges industry is facing.
- Use position paper to engage with government and regulators.

Industry & Regulator Workshop

- Follow similar structure as CCSA/Environment Agency Pathway to Permitting Workshops.
- Identify common ground and key challenges and priorities.
- Agree ways of working.

Roadmap for Policy Development

- Set out industry, government and regulator health & safety actions to support project deployment in the UK.
- Engage with external organisations on Good Practice Guidance.

Resource Library

- Collate industry expertise and useful existing resources.

H&S Action Plan &

New CCSA Working Group Structure

CCSA Secretariat

CCSA

Summary of CCSA Health and Safety Subgroup Action Plan 2025

Key aspects and steps

- Review and finalise the list of priority topic items and the basis to identify interested / work group members [May 2025]
- Deep dive into H&S priority topics via targeted groups [Q2 2025]
- Collate discussion outcomes (if any) [Q3 2025]
- Hold an in-person meeting/workshop with the HSE [Q3/Q4 2025]

Proposed outcomes

- Open and flexible structure for targeted H&S meetings
- Operator-focused discussions for each identified H&S priority
- Openly discuss any issues relating to the Health and Safety legislation and guidance for CCUS
- Enable knowledge exchange and explore challenges of projects, discuss appropriate solutions
- Finalised with close HSE engagement via convening a joint forum and agree on next steps
- Feedback to wider CCSA Technical Forum

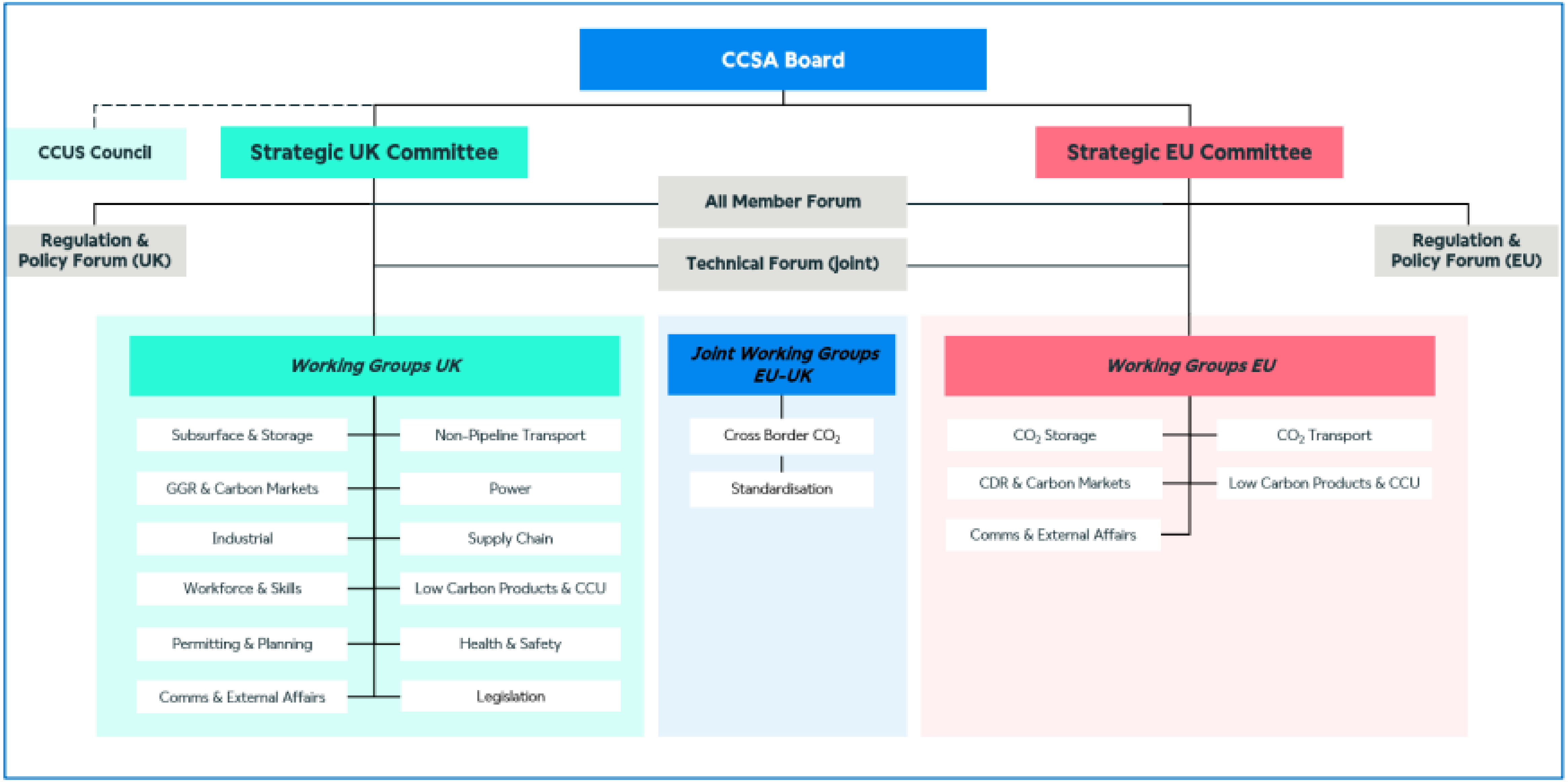
New CCSA Working Group Structure

Based on member feedback, we are implementing a revised working group structure to better cover key topics, enhance input, and provide timely, relevant information.

- As of 1st April 2025, this *"Health & Safety Task Subgroup"* has been renamed as the "**Health & Safety Working Group"**
  - This will be a UK focussed Working Group.
  - Terms of Reference will be shared with members in due course.
  - The group will convene 3-4 times per year to reflect the growing work in this area.
  - In the meantime, if you have any questions, please contact Despoina Tsimprikidou (UK Senior Policy Officer).

- You can find the full update on the CCSA's working group structure here

New CCSA Working Group Structure



AOB & Conclusions

- Review actions arising from the meeting
- Next Health & Safety Working Group Meetings:
  - **End of May/Beginning of June 2025**
  - **17 July**
  - **18 September**
  - **20 November**
- AOB