SECURe
Subsurface Evaluation of CCS and Unconventional Risks

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GOOD PRACTICE AND RISK MITIGATION
FACTSHEET #5

Unconventional hydrocarbons exploration:

Release of natural gas from well during exploration, production and after closure

SECURe employed the Bow Tie risk assessment approach, which identifies a series of barriers that prevent a principal hazard ("top event") from occurring. This factsheet outlines recommendations that address a single top event that can occur if control of a hazard is lost: the release of natural gas from a well during exploration, production and/or after closure. It should be read in conjunction with the Participatory Monitoring Factsheet, which provides overall guidance on project construction.

The issue

Although unlikely, the unplanned release of natural gas from wells must be fully assessed. Research has identified wells as the most probable leakage pathway during and following extraction, and once wells have been abandoned. Such releases could result in the emission of hydrocarbons to the atmosphere and/or impacts to ecosystems and people. Release via the well annulus could arise through poor-quality and/or degradation of well-engineering barriers. A range of well-engineering assessments, appropriate material selection and monitoring provide effective barriers to prevent the release of hydrocarbons. If an unplanned release were to occur, then remediation options include monitoring, operational responses, well engineering interventions, and the use of natural geological properties to slow the release. These barriers, and preventive and remedial actions, are discussed in detail in SECURe report BGS-01-R-11.

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This report is part of a project that has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement number 764531. The content of this report reflects only the authors' view. The Innovation and Networks Executive Agency (INEA) is not responsible for any use that may be made of the information it contains.

For more information about the project, contact info@securegeoenergy.eu

Risk mitigation recommendations

Maintaining borehole integrity

- **A probabilistic approach to assessing well integrity should be taken, with the goal of minimising the probability of failure**. Assessments should also provide information, which will aid the communication of uncertainty in forward modelling. Research reported in D2.6 suggests uncertainty in parameters relating to reservoir and cement characteristics can be reduced via laboratory experiments. These can test cement integrity for realistic stress states and well materials, and assess operating limits for well pressure to prevent fracturing of the cement sheath.
- Operators should use **cement formulations that minimise shrinkage**, when possible. Cement shrinkage can significantly increase the probability of failure for the unconventional hydrocarbons extraction (UHE) well. Using the modelling and relationships demonstrated in D2.6, appropriate cement properties and operating conditions can be selected to reduce well failure risks. Cement formulations that lead to a softer, more flexible (i.e. more ductile) cement are recommended.
- Microannuli, or small gaps, along the well, and radial fractures emanating from the casing through the cement should be considered in **leakage mitigation strategies.** Any individual fracture may dramatically increase the leakage risk, but fracture networks do not necessarily lead to a continuous, high-permeability path along the wells (D2.6).
- Relationships between cement properties and the impact on (1) shear cracking and (2) cement debonding (for both the formation-cement and casing-cement interfaces) and caprock leakage can help with the **design of appropriate leakage management scenarios** (D2.6).

Monitoring approach

- **Thresholds should be set** for hydrochemical parameters that could indicate contamination in the future (D3.6). Thresholds should be established using environmental baseline data to calculate concentrations of parameters, which would indicate excessive natural temporal variation.
- There is a strong need for **close cooperation of industry and researchers** in planning and conducting both baseline studies and further monitoring activities (as recommended in D3.7 and D3.8). The possibility of connecting observation results with an industrial process is crucial for the interpretation of phenomena observed in the environment. Results obtained from all observation systems should be reported both to the site operator and to regulators. This will ensure that any adverse changes and causes are identified and appropriate actions undertaken to minimise an impact and further risk.
- For production wells in operation and decommissioned multi-well clusters, a **tiered monitoring programme should be established to localise point sources of methane emissions on the ground**. Using data collected with unmanned aerial vehicle (UAV) based systems (D4.1), modelling can be undertaken to localise the source of emissions on the ground. This modelling helps to focus ground investigations to pinpoint the gas source and determine the flux, and can be used within a tiered monitoring programme:
    - UAVs deployed initially to cover large or poor-access areas to highlight key areas of interest (or at the very least, rule out the vast majority of land).
    - Follow-up ground surveys directed by UAV-based data, to pinpoint individual vents or vent clusters.
    - Gas sampling at individual vents for specialised gas analysis (e.g. for tracers or noble gases), and/or deployment of automated equipment at fixed sites/vents to gather time-series data (e.g. to quantify how gas fluxes change seasonally or under different meteorological conditions).

Risk mitigation recommendations (cont.)

Use of models

- **Effective modelling of the containment system**, with model forecasts of well integrity based on a thorough understanding of controlling processes associated with UHE operations (D2.6). Numerical geomechanical well leakage modelling can be used to quantify the probability of well failure for a range of scenarios that are applicable to well re-use and new well applications.

Development of technology

- **Technology development** for both monitoring measurements and interpreting of results needs to be foreseen. All changes in monitoring scope and schedule should be introduced gradually and in parallel to ensure that new and previous results are comparable, if not directly then by means of recounting techniques. (D3.8)
- **We recommend the use of vegetation carbon isotopes as proxies for present and past gas emanations** (D4.6). Vegetation around a gas seep has the potential to act as an integrator of gas emanation over time and, if tree rings are used, as an archive of gas fluxes. This offers opportunities for using vegetation carbon isotopes as proxies for present and past gas emanations, including anthropogenic-induced gas leaks, e.g. from gas storage or natural gas exploitation facilities.
- **The combination of microbial techniques with established geochemical (isotope) methods allows for assessment of the source of leaking gas**. From the work conducted in The Netherlands and France as part of D4.6, we concluded that microbial communities have the potential to be used as a monitoring tool. For specific gene types, it was demonstrated that the relative abundance of these genes is correlated to the gas isotopic composition with a higher relative abundance of both genes in biogenic gas (compared to a thermogenic origin).

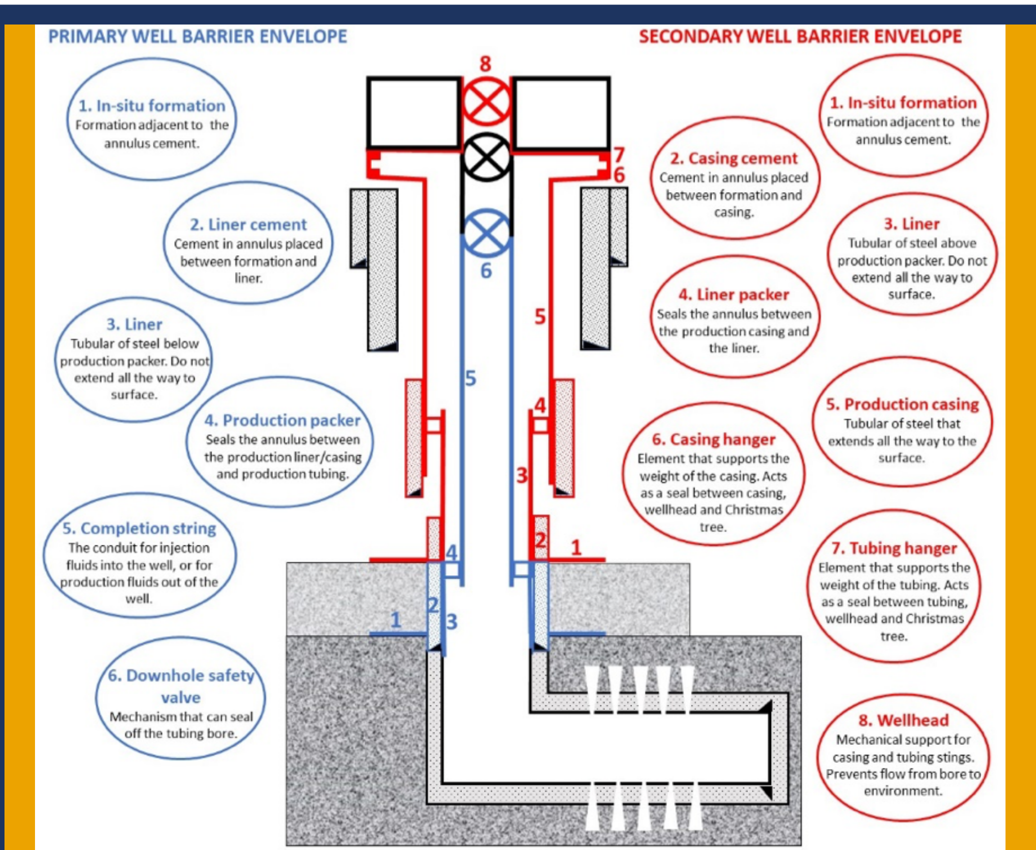

Figure 1: Simplified illustration of well barriers for a typical active shale gas well. Primary well barrier envelope in blue and secondary well barrier envelope in red (from D5.3).