Well Integrity Performance Assessment in a CO2 Geological Storage Project

V. Meyer[1], E. Giry[2,*], E. Houdu[1], O. Poupard[1]
[1]OXAND S.A., Avon, France
[2]OXAND Canada Ltd., Calgary, AB, Canada
*Corresponding author: emmanuel.giry@oxand.com

Greenhouse Gases (GHG) emissions are a major contributing factor to global climate change. In the context of the Kyoto protocol (1997) and deadlines of 2008-2012 for reducing GHG emissions, CO2 capture and storage (CCS) projects constitute a promising solution to control and reduce these emissions among the portfolio of available options. It is now commonly accepted that risk assessment and management is instrumental for a successful development of CCS, as far as they are directly associated to impacts evaluation on health, safety and environment (HSE), but also to efficiency in terms of GHG emission reduction.

Wellbore integrity is of major importance to prove the reliability and safety of CO2 geological storage (saline aquifers, depleted reservoir, coal seams …) over long term and constitutes a key issue for public acceptance and environmental impact. Well integrity assessment describes the capabilities of a well to contain CO2 (i.e. to confine the injected gas within the storage reservoir, or at least it does not reach shallow formation (i.e. potable aquifers seepage) or surface (leakage)).

A quantitative risk-based methodology is proposed to evaluate the Performance and Risk (P&R™) associated to well integrity within a CO2 storage project. The major steps of the methodology consist in (1) collecting the available data, identifying the system limits and the associated degradation processes to take into account; (2) quantifying the risk levels of specific scenarios through CO2 migration and system ageing modelling, (3) and building efficient and operational risk mitigation plans adapted to the risk sources identified.

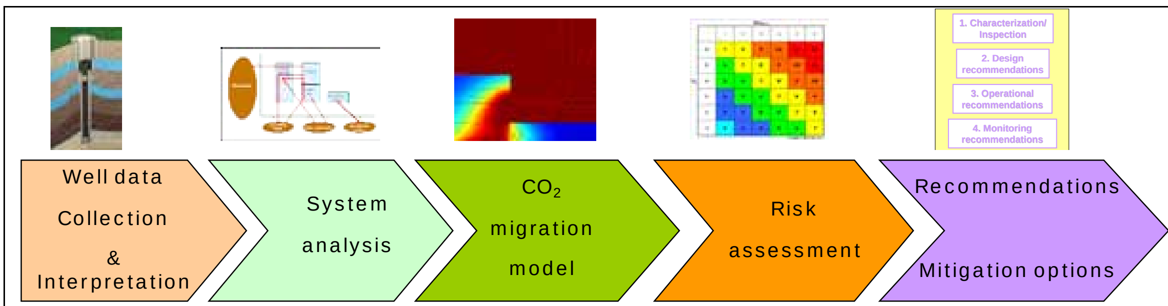

Figure 1. Workflow for well integrity performance and risk analysis methodology

Among others, the modelling step is one of the most important of the P&R™ analysis. Well materials ageing (cement leaching by fluids formation, cement leaching/carbonation by acid fluid, casing corrosion, thermo-mechanical effect …) and uncertainties related to the system characteristics are fully integrated and coupled to a CO2 flow model in porous media in order to assess CO2 migration along the wellbore over long term. Tools like Design of Experiments are efficiently used to identify the main parameters that could impact the well behaviour and focus simulations efforts on relevant scenarios likely to happen.

The numerical simulations allow to assess CO2 migration along the wellbore and to quantify the possible leakage towards targets (fresh water aquifer, surface …) for different well integrity conditions (i.e. scenarios built from uncertainties ranges associated to the system (geometry, cement quality, ageing kinetics …)).

The fluids flows through the various components of the well completion and along the wellbore are simulated for each CO2 migration scenario identified. By considering the balance between the two fluids (water and CO2) flows as shown on Figure 2 below, CO2 migration pathways can be obtained and each point of interest (shallower aquifer, surface…) informed in terms of potentiality to be reached by CO2 and of leakage amount.

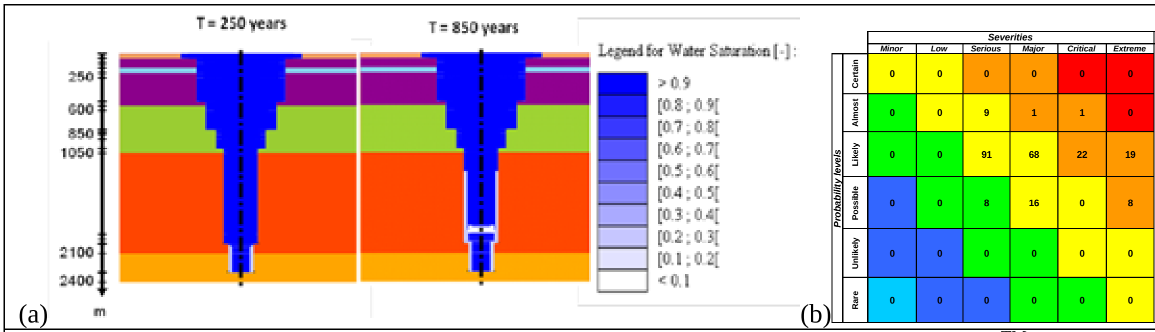

Figure 2. (a) CO2 migration flow up along wellbore over long term (snapshots from Simeo™ Stor) for a scenario; (b) risk mapping

A computation of all the scenarios' results is performed to assess risk levels (i.e. frequency level and severity level) associated to the well integrity. Information is then gathered into a risk mapping tool and an acceptable risk level can be established for each stake (environment, health & safety, economics ...) involved in the project according to specific levels of acceptability.

Based on these objective elements and identified risk sources, recommendations are proposed as orientations in order to treat/mitigate the risks that are above/close to the unacceptable level. Those recommendations are made of characterization/inspection and/or design actions that would ensure such risks to remain above the risk acceptance threshold.

As a conclusion, this structured approach provides: an objective and compelling support to a sound decision-making process, information sharing among stakeholders of a project, and safety demonstration to authorities and/or public from CO2 containment issue. Moreover, this quantitative well integrity risk assessment enables to lay the groundwork for the implementation of a targeted MMV protocol. Recommendations for an appropriate data collection plan can be established through the definition of the most risky areas deserved with poor monitoring. It also yields recommendations for immediate mitigation actions when necessary, in order to secure the injection process with respect to CO2 leakage risks.