HB170 Class VI Well Primacy Comments

Steven G. Jansto Ph.D., MBA
Materials Science and Engineering
May 6, 2025

CCS is still far from being safely commercialized. Fossil fuel and other polluting industries are marketing CCS as safe and effective without sharing the actual chemistry of the waste stream, the technical and financial risks, long-term costs. There is a very high failure rate with many CCS projects. As a materials scientist with extensive steelmaking experience, I am well aware of the many technical issues related to steel corrosion of the valves, fittings, pipelines and injection casings. There are additional concerns I recognize that are outside my area of expertise, such as challenges of the corrosion and thermal stresses to the current cement design in the annular space and other questions about the process that do not appear to be adequately resolved. There is not much proven research over time, like there is in the steel industry. Like injection wells for frack waste that are leaking, this new industry of waste gas CO2 sequestration is far from being developed enough to be a safe and effective disposal method for hazardous material forever. It is doubtful it would ever be economical – there is no profit in disposing of waste product, especially forever. Short-term government incentives will not make up for the long term cost especially if this industry is falsely propped up without assurances of success. The rush to profit by taking advantage of generous incentives often lead to long-term externalized costs to the public. From the beginning of my research on CO2 waste gas sequestration over two years ago, it is obvious to me that the technological, economic and safety concerns have not been inadequately considered and need more research and investment before moving forward. It would be much better to carry out the necessary corrosion studies which have yet to be done. It actually appears that the waste stream is not even adequately characterized. The ounce of prevention will be worth tons of cure. Otherwise, like with fracking when the wells run dry and the injection wells leak, there is no revenue to pay for the maintenance and needed remediation.

To assume primacy without an adequate understanding of all that would be involved in the injection well permit process and Class VI regulation and oversight will cause detrimental impacts to the environment, create safety and public health problems over time, and potentially cause Ohio taxpayers to foot the bill for another new industry that is not adequately regulated. Carbon

sequestration is not yet proven to work, so how can Ohio seek primacy over a novel technology that has not been adequately studied or specified to ensure the hazardous waste product will remain in place forever? If it were not for the 45Q tax credits and other incentives, it is doubtful that anyone would want to engage in carbon sequestration. How long will taxpayers want to fund worthless waste disposal once the federal government decides it won't?

This report details the risks as well as several case examples where the CCS projects have failed. It is apparent in the root cause materials engineering analysis, in many cases, the injection well corrosion is the heart of the problem. The Archer Daniels incident described below exemplifies the problem. It is apparent that even with the deep involvement of the EPA, PHMSA and other regulatory and research bodies that there is no consensus of best practices to safely process, transport and sequester waste CO2, resulting in numerous accidents and the cancellation of CCS projects because of problems globally.

There is an important opportunity to develop new materials and/or upgrade many of the current CO2 pipelines, injection wells and facility components to higher value-added alloys and improved corrosion resistant behavior. From a corrosion point of view, the materials-of-choice must perform over a wide range of environments due to the different CCS processes. High CO2 levels mean that wet process environments tend to be acidic and unprotected carbon steel should not be used. In some cases, an upgrade to stainless steel may not meet the corrosion resistant requirements. Therefore, government funding in this materials engineering research initiative is needed to both develop materials to construct safer and more economical pipelines and CCUS facilities as well as perform corrosion experiments on existing materials based on the blended CC gas chemistry including impurities. There is a huge scientific knowledge gap in this sector of materials and corrosion engineering.

Introduction

Drilling wells for carbon sequestration, especially Class VI wells, requires a special and disciplined procedure approach focusing on secure and stable CO2 injection pathways. This approach involves carefully selecting the injection zone, which is often deep saline aquifers or depleted oil and gas fields. Care must be taken regarding pH control and possible saline corrosion issues affecting the injection well integrity. Operating pressures in these wells are higher than in Class II wells, and proper well construction and appropriate monitoring practices are critical in order to ensure safe injection and containment of CO2 hazardous liquid material leakage. Approval of this House Bill 170 inherits Class VI well regulations and sections of this regulation are changing in the moment because of recent CO2 risks, failures and materials engineering challenges and concerns.

Background Information

Carbon capture and sequestration (CCS) and carbon capture utilization and storage (CCUS) projects continue to develop as a possible method to reduce anthropogenic CO2 emissions. Injection wells are often required to retain integrity over long operational lives, sometimes 50 years or in some permits “forever.”. The injection well operational process conditions vary from well to well. Consequently, if free water is present, either condensing from the CO2 injectate itself or due to injection into a water-bearing formation, the threat of carbonic acid corrosion exists. In the past, the need for a corrosion resistant alloy (CRA) was obvious and typically defined as a 13Cr alloy casing material. However, the recent Archer Daniels 13Cr injection well failure now pressures well designers and operators into the materials engineering challenge for the selection of a more suitable corrosion resistant alloys (CRAs). Casing and cement failures due to stress and corrosion phenomena is not thoroughly understood and requires more global study and international collaboration.

With the exception of 13Cr stainless steel, there is a lack of research data on the performance of CRAs in Super Critical CO2 (SC-CO2) streams containing impurities. Considerations include stream composition, reservoir fluids, flowing and static wellbore conditions, wellhead and surface equipment, downhole completion equipment, service life, etc. Thus, in the absence of water saturation, 13Cr is a possible candidate alloy for SC-CO2. However, the presence of water even at under-saturation concentrations, coupled with chlorides and impurities, such as H2S, O2, and SO2, cause measurable corrosion of this alloy and would not be suitable for long term service. In summary, the results for 13Cr in SC-CO2 with impurities are conflicting/inconclusive and more work is needed to better define the limits. In the meantime, it is well known that O2 causes severe pitting of 13Cr in seawater, so conservatively 13Cr should not be used for SC-CO2 environments containing O2. [1]

Other work on 13Cr materials by Pfennig et. al. [2] and Luo et al. [3] in SC-CO2 conditions indicated that 13Cr may be prone to pitting in saline brine, both with and without oxygen. Hua et al. [4] showed that when the SC-CO2 is undersaturated at 35 °C and 80 bar for water content less than about 600 ppm, the corrosion rate of 13Cr is essentially zero. Zhang et al. [5] evaluated 13Cr in CO2 at 135 bar and 80 °C for 96 hours and recorded corrosion rates as a function of impurity contents. In summary the results for 13Cr in SC-CO2 with impurities are conflicting/inconclusive and more work is needed to better define the limits. In the meantime, it is well known that O2 causes severe pitting of 13Cr in seawater, so conservatively 13Cr should not be used for SC-CO2 environments containing O2. [1]

As a result of several CO2 accidents globally, the materials engineering aspects and standard operating maintenance practices for a CCS facility incorporating Class VI permits is still under development and continuous evaluation. For example, the EPA-Chicago is investigating the recent CO2 leak incident at the CO2 injection well in the Archer Daniels facility in Decatur, Illinois.

Archer Daniels On-going Investigation

Archer Daniels in Decatur, Illinois had recent failures at the monitoring wells and the investigation is ongoing (June 2024). The USEPA regulations require that the CO2 waste stream contents be analyzed and reported, so we sent a FOIA request for the actual composition of waste gas but the USEPA redacted much of the information we needed to understand the components of the CO2 waste stream from ethanol production. Until the results of a thorough investigation are known, we will not know the cause and full extent of the failures but we know enough to be concerned about risks to groundwater over time at Archer Daniels. Even the EPA admitted there are design flaws that need to be addressed before carbon sequestration is done on a larger scale. [6]

A leak at the country's first commercial carbon dioxide sequestration project was likely caused by corrosion of the steel used in the well, a finding by federal regulators that "poses a significant risk to dozens other projects around the country planning to use the same type of metal." The EPA concluded that dozens of other planned CO2 projects have similar dangerous design flaws and risks similar to Archer Daniels injection well. The upgraded steel material (13 Chrome) is still vulnerable to corrosion when exposed to the liquids. A leak at the country's first commercial carbon dioxide sequestration project was likely caused by corrosion of the steel used in the well.

The compelling conclusion in Illinois by the EPA is carbon injection well permits that specify 13 Chrome and a type of cement commonly used by the industry to secure those pipes "are NOT suitable for construction of these wells in most instances, particularly under potentially corrosive conditions when both water and CO2 are present." [6]

Simultaneously in October 2024, more than 150 advocacy groups signed a letter sent to Environmental Protection Agency (EPA) Administrator Michael Regan today, calling on the agency to halt the injection of carbon dioxide into existing underground well sites and reject approval of new injection wells. The letter comes on the heels of multiple leaks discovered at the country's first commercial underground carbon capture and storage (CCS) facility. The letter was facilitated by the environmental group Food & Water Watch along with the Illinois-based Eco-Justice Collaborative. [7] The referenced letter pdf to M. Regan of the EPA is below:

Org-Letter_CO2-Inject
ion-Wells.pdf

PHMSA Class VI Well Safety Regulations Amendments' Status

PHMSA has recently published proposed final rules amending the regulations in these parts, including updates to leak detection and repair requirements. PHMSA issued this Notice of Proposed Rulemaking on January 10, 2025, and it has been submitted to the Office of the Federal Register for publication. [8] They are also actively working on incorporating updated industry standards into the regulations. In summary, PHMSA is constantly updating and refining its pipeline

safety regulations (49 CFR Parts 190-199), including Parts 190, 195, 196, and 198, to ensure public safety and environmental protection.

PHMSA has proposed new regulations to further strengthen safety requirements for CO2 pipelines as a result of such incidents as Archer Daniels, Kemper, Satartia and Sulfur Springs to name a few domestic failures. These regulations aim to improve the safety of pipelines transporting CO2 in all phases, including gaseous, liquid, and supercritical. However, it now appears the draft proposal is now embargoed by the current administration. Shown below is a pdf copy of the CO2 proposal:

PHMSA Notice of
Proposed Rulemaking

Other CCS Project Case Histories

Gorgon CO2 facility Australia

Expensive failure: Flagship Gorgon CCS collects less CO2 in worst year [9]

The "Gorgon disaster" refers to the ongoing Gorgon natural gas project on Barrow Island, Australia, which has been plagued by delays and safety concerns regarding carbon capture and storage (CCS). The project, led by Chevron [10], faces scrutiny due to potential environmental risks and safety issues, including the potential for leaks in the CCS system and the risk of releasing large amounts of CO2 into the atmosphere. The Gorgon LNG project, managed by Chevron, is a large-scale liquefied natural gas (LNG) facility located on Barrow Island in Western Australia.

The Gorgon project's CCS system was designed to inject 3.3 to 4 million tonnes of CO2 per year into the Dupuy Formation. The CCS project has faced significant delays and setbacks, including issues with the pipeline and valve leaks. These delays have resulted in the release of substantial amounts of CO2 into the atmosphere, reports said. One report indicated that the Gorgon CCS project is potentially unsafe due to the presence of over 700 wells drilled in the area, some of which reach the injection zone. Former firefighters working on the Gorgon project have voiced concerns about safety standards and the potential for a disaster. These concerns highlight the potential for an inadequate safety response in case of a major incident, such as a fire or explosion.

The delays in the CCS project have resulted in the release of millions of tonnes of CO2 into the atmosphere, contributing to climate change. The project's potential environmental impact on Barrow Island, a protected nature reserve of global importance, is also a major concern.

This project, one of the world's largest, has faced ongoing operational issues, including sand buildup in the injection wells, leading to reduced capacity and delayed operations, according to a Medium article by Tim Baxter. [11]

Other Case Study Failure CCS Project Examples

A more detailed look at some of the highlighted failed or problematic CCS projects with embedded web link:

- **American Electric Power's Mountaineer project [12]**

  AEP withdrew from the project after receiving significant funding from the Department of Energy (DOE), primarily due to uncertainty in U.S. climate policy and the weak economy.

  https://www.gem.wiki/Mountaineer_Plant

- **Southern Company's Kemper project [13]**

  This project received substantial federal grants and tax credits, but faced numerous challenges including construction delays, cost overruns, and ultimately, was abandoned. Half of a multibillion-dollar power plant that was supposed to gasify lignite coal and store most of its carbon emissions in Mississippi recently demolished.

  https://www.eenews.net/articles/the-kemper-project-just-collapsed-what-it-signifies-for-ccs/

- **CEMEX CCS project [14]**

Despite allocating US$1.1 million to the project, CEMEX and its partners concluded that commercial-scale CCS in the cement industry was not yet ready for deployment and canceled the project.

https://www.geoengineeringmonitor.org/the-current-state-of-ccs-in-the-u-s-resume-after-100-years-of-co2-capture-and-25-years-of-extensive-federal-funding

- **Petra Nova project [15]**

This was the only large-scale U.S. carbon capture project at a coal plant, but it was idled in 2020 due to low oil prices, making it economically unviable.

[15] "Lessons Learned From the Closure of Petra Nova," IDTechEx Reports, March 22, 2021. https://www.prnewswire.com/news-releases/lessons-learned-from-the-closure-of-petra-nova-idtechex-reports-301252906.html

- **Boundary Dam CCS project [16]**

This project in Saskatchewan has missed its carbon capture targets by approximately 50%, according to a report from the Institute for Energy Economics and Financial Analysis.

https://ieefa.org/resources/carbon-capture-crux-lessons-learned

In summary, the majority of major carbon capture and storage projects have not met targets financially and operationally. The majority of 13 flagship CCS schemes worldwide, representing 55 per cent of captured carbon dioxide, have either failed entirely or captured much less CO2 than expected. [17]

References

[1] Craig, B., Rowe, A., Warmack, M., Doll, T., Stevens, C. and Connors, K, "Guidelines for the selection of corrosion resistant alloys for CCS and CCUS injection wells," International Journal of Greenhouse Gas Control, Volume 129, October 2023, 103988.

[2] Pfennig, A. et al., 2021. "Corrosion and Corrosion Fatigue of Steels in Downhole CCS Environment – A Summary, Processes, vol. 9, p. 594-627.

[3] Luo, B-W et al., 2017. "Comparative study on the corrosion behavior of X52, 391 3Cr and 13Cr steel in an O2-H2O-CO2 system: products, reaction kinetics and pitting sensitivity", Int. J. Minerals, Met. And Mater., v. 24, p. 646-656.

[4] Hua, Y. et al., 2016. "Comparison of corrosion behavior of X65, 1Cr, 5Cr and 13Cr steels in water containing supercritical CO2 environments with SO2/O2", Corrosion 2016, Paper No. 7681, NACE.

[5] Zhang, Y. et al., 2019. "Steel Corrosion Under Supercritical Carbon Dioxide with Impurities" , Mat. Perform, vol. 58, p. 40-43.

[6] By Annie Snider and Ben Lefevbre 10/08/2024 02:52 PM EDT | UPDATED 10/09/2024 03:28 PM EDT [https://subscriber.politicopro.com/article/2024/10/carbon-storage-projects-hit-a-hurdle-corroding-steel-00182889]

[7] EPA Must Immediately Stop CO2 Injection Wells to Protect Public Safety and Drinking Water, October 22, 2024. https://www.foodandwaterwatch.org/2024/10/22/150-groups-to-epa-halt-permitting-of-carbon-injection-wells-after-dangerous-leaks-at-nations-first-ccs-facility/

[8] PHMSA - DEPARTMENT OF TRANSPORTATION, Pipeline and Hazardous Materials Safety Administration, 49 CFR Parts 190, 195, 196, and 198, [Docket No. PHMSA-2022-0125], RIN 2137-AF60, Pipeline Safety: Safety of Carbon Dioxide and Hazardous Liquid Pipelines, January 10, 2025.

[9] Renew Economy, Expensive failure: Flagship Gorgon CCS collects less CO2 in worst year, May 6, 2025.

https://reneweconomy.com.au/expensive-failure-flagship-gorgon-ccs-collects-less-co2-in-worst-year/#:~:text=%E2%80%9CThe%20key%20reason%20behind%20Gorgon's,has%20had%20to%20be%20constrained.

[10] Chevron Australia Pty Ltd, "Gorgon Project-Low Emission Technology Demonstration Project, Annual Report, 5 Oct, 2017 [released under the FOIact-DISER 67758].

[11] Baxter, T., Gorgon carbon capture and storage project: The failure of the world's largest CCS facility, Medium, November 29, 2024. https://timinclimate.medium.com/gorgon-carbon-capture-and-storage-project-the-failure-of-the-worlds-largest-ccs-facility-d517de0ee176

[12] https://www.gem.wiki/Mountaineer_Plant

[13] https://www.eenews.net/articles/the-kemper-project-just-collapsed-what-it-signifies-for-ccs/

[14]https://www.geoengineeringmonitor.org/the-current-state-of-ccs-in-the-u-s-resume-after-100-years-of-co2-capture-and-25-years-of-extensive-federal-funding

[15] "Lessons Learned From the Closure of Petra Nova," IDTechEx Reports, March 22, 2021. https://www.prnewswire.com/news-releases/lessons-learned-from-the-closure-of-petra-nova-idtechex-reports-301252906.html

[16] https://ieefa.org/resources/carbon-capture-crux-lessons-learned

[17] Vaughn, A., "Most major carbon capture and storage projects haven't met targets," Scientist, 1 September, 2022. https://www.newscientist.com/article/2336018-most-major-carbon-capture-and-storage-projects-havent-met-targets/