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Regulatory and Knowledge Gaps in the Safe Transportation of Carbon Dioxide by Pipeline

This document is intended to provide an overview of federal regulatory and knowledge gaps related to the safe transport of carbon dioxide by pipeline. Following the CO_2 pipeline rupture in Satartia, MS in 2020 which sent 45 people to the hospital, the Pipeline Safety Trust (PST) commissioned a report to examine various aspects of carbon dioxide transmission pipeline safety and federal pipeline safety regulations related to CO_2. The report identified numerous **regulatory gaps** outlined below.

1. The current definition of “carbon dioxide” in the federal pipeline safety regulation does not apply to all CO_2 pipelines that may be developed for CCS projects.
    a. Currently, only CO_2 that is moved in a supercritical state is regulated under the current definition.
    b. Federal regulations need to be modified to assure that federal standards apply to all CO_2 transmission pipelines that transport CO_2 in all phases, including supercritical, gas, and liquid CO_2.
2. There is currently no defined safe distance or plume dispersion model for developing a potential impact area (PIR) along CO_2 pipelines.
    a. CO_2 has unique physical properties which warrant the development of a unique PIR zone to be promulgated into federal pipeline regulation.
3. There is currently no requirement to add an odorant to transported CO_2.
    a. Carbon dioxide is odorless, colorless, doesn’t burn, and is heavier than air meaning that releases are harder to observe and therefore avoid.
    b. Adding an odorant would help alert the public of a CO_2 pipeline rupture.
4. The unique physical properties of CO_2 moved at high pressures through pipelines can cause running ductile fractures upon rupturing.
    a. This essentially means that a pipe has a higher likelihood of opening up like a zipper when a rupture occurs, leading to more product being released over a shorter period of time and potentially violent and dangerous pipe shrapnel.
    b. Fracture propagation protection, or fracture arresters, and steel thickness requirements should be carefully examined and incorporated into federal CO_2 pipeline design regulations.
5. Contaminants within CO_2 products being transported can jeopardize the integrity of the pipeline.
    a. Water, when mixed with carbon dioxide, can form carbonic acid which has the ability to rapidly erode carbon steel.
    b. Different industries can produce numerous other contaminants which can be toxic to public health and/or affect the temperature and pressure of the product, potentially impacting the safe operation of the pipeline.
    c. Standards for maximum contaminant levels within different CO_2 producing industries should be reviewed and set by PHMSA in the federal pipeline safety regulations.
6. The risks associated with the conversion of existing transmission pipelines to CO_2 service have not been fully investigated.

a. Given the unique properties of CO_2 mentioned previously, pipeline conversions have the potential to be at higher risk of failure from CO_2 service than conventional hydrocarbon or even new construction CO_2 pipelines.
b. PHMSA needs to develop detailed safety standards for the conversion of existing lines to CO_2 service.

The incident in Satartia also prompted the Pipeline and Hazardous Materials Safety Administration (PHMSA) to initiate the funding of [new research and development (R&D) projects] related to the safe transportation of carbon dioxide through pipelines. These projects, titled *"Developing Design and Welding Requirements Including Material Testing and Qualification of New and Existing Pipelines for Transporting CO_2"* will attempt to address many of the elements needing more research mentioned in the above regulatory gaps. The projects are intended to cover the following **knowledge gaps**:

1. The appropriate fracture toughness and steel pipe quality is currently unknown to prevent CO_2 pipeline leak or ruptures.
    a. R&D project findings may be used to develop pipe quality standards and strategies for the correct placement of fracture mitigation measures along these pipelines.
2. The effects of corrosion, dents, cracks, or gouges have yet to be determined on a wide range of steel grades regarding CO_2 operation.
3. Odorization strategies have yet to be identified.
    a. Odorization of CO_2 is likely one of the simplest ways to ensure effective leak detection as well as public safety and emergency response.
4. There is currently no defined safe distance or plume dispersion model for developing a potential impact area (PIR) along CO_2 pipelines.
    a. Without a PIR, it is impossible to establish accurate emergency response safe distances. Due to the asphyxiation potential for CO_2 pipelines, this could have deadly consequences.
    b. Only once an appropriate PIR for CO_2 pipelines has been established can PHMSA assess the effectiveness of integrity management procedures.
5. Results from these projects will not be available for two years and the funding provided to study these complex issues is relatively small.

In addition to these issues, PHMSA has directed the researchers of this project to "identify safety gaps and requirements to support best practices for both gaseous and supercritical liquid systems, beyond the requirements of 49 CFR Part 195 for CO_2 pipeline transportation."

Considering the scope of this project, and the directive to look at CO_2 as both a gas and a liquid, it is clear that PHMSA is concerned not only with the under-regulation of CO_2 pipelines, but also with the current lack of technical knowledge which is needed to create appropriate minimum safety standards.

With a focus on reducing the impacts of climate change, the expansion of the 45Q tax credits, and now with the Inflation Reduction Act being signed into law, there has been a massive push for Carbon Capture Sequestration and Storage projects across the country. However, the regulatory and knowledge gaps outlined above make clear the need for caution moving forward.