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CO_2 Pipelines – Dangerous and Under-Regulated

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The Pipeline Safety Trust (PST) commissioned a report on the regulatory shortfalls of CO_2 pipelines. We have prepared this backgrounder to accompany the report to provide context and highlight its major findings. This report points to large, glaring regulatory shortfalls and analyzes a regulatory framework that does not address the significant safety risks CO_2 pipelines pose to the public.

PST commissioned the report in response to the flurry of multibillion-dollar CO_2 pipeline proposals put forward, driven by expanded tax credit incentives provided by the 2021 bipartisan infrastructure bill.

The Pipeline Safety Trust believes existing federal regulations do not allow for the safe transportation of CO_2 via pipelines and calls on the U.S. Department of Transportation and its pipeline safety agency PHMSA[1] to update its regulations of CO_2 pipelines as quickly as possible.

Carbon dioxide has different physical properties from products typically moved in hazardous hydrocarbon liquid or natural gas transmission pipelines. Those differences pose unique safety hazards and greatly increase the possible affected area or potential impact radius upon a pipeline release that would endanger the public. CO_2 pipeline ruptures can impact areas measured in miles, not feet. The way regulations currently consider and mitigate for the risks posed by hydrocarbon pipelines in communities are neither appropriate nor sufficient for CO_2 pipelines.

[1] Pipeline and Hazardous Materials Safety Administration

CO_2 is a potentially lethal asphyxiant. When released from a pipeline, CO_2 will be heavier than air and high-rate releases will form clouds of cold dense gas fog. Upon warming, CO_2 plumes flow considerable distances from the pipeline unobserved, traveling over terrain, displacing oxygen while settling or filling in low areas. Oxygen displacement by CO_2 gas can cause asphyxiation and lead to death. Oxygen displacement also starves equipment that burns fuel causing it to shut off, potentially including first responder equipment, evacuating cars caught in the expanding release plume, and pilot lights on gas fired equipment.

The Pipeline and Hazardous Materials Safety Administration (PHMSA) currently exercises no jurisdiction over pipelines transporting CO_2 as a gas or liquid, and only regulates CO_2 pipelines with a concentration of more than 90% carbon dioxide compressed to a supercritical state, rendering any pipeline moving CO_2 in any other state or with less than 90% purity entirely unregulated by the federal pipeline safety agency. There are other large regulatory gaps around siting, fracture mitigation, determining potential impact areas, use of odorant, emergency response, and contaminants.

Federal pipeline safety regulations do not adequately address the risk a major CO_2 pipeline buildout poses to the public.

A Brief History of CO_2 Pipelines in the United States

CO_2 Pipelines – A Significant Safety Hazard

- In 1988, Congress required the Department of Transportation to regulate carbon dioxide transported by pipeline facilities. The impetus for this directive was a 1986 natural carbon dioxide release event in Lake Nyos, Cameroon. The release spanned many miles and killed over 1,700 people**.**

- On July 12, 1992, a final rule was promulgated that, rather than create new standards, simply added CO_2 to existing federal minimum hazardous liquid pipeline safety regulations and narrowly defined CO_2 as follows: “Carbon Dioxide means a fluid consisting of more than 90% carbon dioxide molecules compressed to a supercritical state.”

The U.S. has the most CO_2 Pipelines in the world

- There are approximately 5,150 miles of CO_2 pipelines operating in the U.S. These pipelines are regulated and reported to PHMSA.

- The vast majority, if not all, of these existing CO_2 pipelines are driven by the use of CO_2 for enhanced oil recovery (EOR) – increasing oil production utilizing CO_2 in a supercritical state. The nature of CO_2 utilization for EOR requires pipeline injection into oil fields as a supercritical fluid.

- Carbon Capture and Sequestration (CCS) efforts are driven by an entirely different purpose and the transmission by pipeline of CO_2 for CCS can take different forms. Current federal safety regulations for CO_2 pipelines are incomplete, inadequate and place the public at great risk.

Three States of Transmission (Supercritical, Liquid, Gas)

Supercritical

- A supercritical fluid is a state with some properties of a gas and some properties of a liquid.

- A CO_2 pipeline carrying a supercritical state fluid can be more prone to running ductile fractures than hazardous liquid hydrocarbons pipelines or natural gas pipelines.

- **A ductile fracture can destroy very long sections of pipeline. Think of it as a zipper opening up and running down a significant length of the pipe following a rupture.** Along with releasing massive amounts of CO_2 upon failure, these extreme ruptures can also hurl large sections of pipe, expel pipe shrapnel, and generate enormous craters.

- Federal regulations addressing supercritical CO_2 pipelines must be amended to require operators to prevent and mitigate the effects of fracture propagation.

Liquid

- Transporting CO_2 as a liquid usually requires cooling to slightly below ambient temperatures to assure the pipeline operates in one phase, a liquid. However, it is important that the pipeline stay well above the carbon steel brittle temperature transition point of approximately - 20 °F to avoid the threat of a catastrophic rupture**.**

- However, the liquid operation and lower temperature and pressure work to reduce the potential for pipeline fracture propagation inherent with super critical or gas pipelines.

Gas

- Situations may exist where existing liquid or larger diameter natural gas pipelines could be “repurposed” into CO_2 gas service.

- Such pipeline conversions would be at much greater risk of failure from CO_2 service than conventional hydrocarbons or new construction CO_2 pipelines due to unique and increased potential for ruptures.

Impurities in CO_2 Pipelines

- While regulations need to be updated to include standards for all typical impurities in CO_2 pipelines, the report highlights two that could pose significant dangers to pipelines and the public: water and hydrogen sulfide (H_2S).

- **The settlement of free water encourages the formation of carbonic acid in the pipeline, an acid that is incredibly corrosive to carbon steel.** Given the rapidity and unpredictability with which carbonic acid can attack pipelines, it is critical that U.S. DOT's PHMSA enact regulations prescribing limits on water quantities in CO_2 pipelines.

- Hydrogen sulfide, or H_2S, is mentioned here because of a supercritical state CO_2 pipeline rupture failure in Satartia, Mississippi in early 2020. First responders reported seeing a "green cloud" from the pipeline release, which is a possible indication of high levels of H_2S. The Center for Disease Control has stated that H_2S levels of 300 ppm or higher are "immediately dangerous to life or health."

Solutions for Advancing Safety in Federal Regulation of CO_2 Pipelines

In order to keep people safe, the Pipeline Safety Trust calls on the U.S. Department of Transportation and its pipeline safety agency PHMSA to adopt the following:

PHMSA needs to update the definition of carbon dioxide in the regulations

- Federal regulations need to be modified to assure federal standards apply to all CO_2 transmission pipelines that transport CO_2, including all supercritical, gas, and liquid CO_2 transmission pipelines.

PHMSA needs to identify the potential impact areas for CO_2 pipeline ruptures

- The unique, and potentially very large impact areas for CO_2 pipeline ruptures need to be developed, defined, and promulgated into pipeline regulations. These areas are likely to be substantially larger than for hydrocarbon pipelines of similar diameter. Once we know how to determine the potential impact areas, that information must be used to inform regulations on routing and siting, emergency response requirements, and more.

Specific CO_2 pipeline federal regulations should not be based solely on industry Recommended Practices

- Changes in the CO_2 pipeline safety regulation are needed and should be prescribed to avoid misinterpretation or misuse. Recent efforts by many in the industry to rely on more performance-based standards, even those incorporated by reference, have proven ineffective.

PHMSA needs to specifically identify how to incorporate fracture propagation protection on CO_2 transmission pipelines

- Regulations should specifically prescribe pipeline design methods to prevent and arrest CO_2 fracture propagation.

PHMSA needs to mandate the use of odorant injection into CO_2 transmission pipelines

- Given the inability to detect or observe a CO_2 pipeline release, it is time to require the use of odorant injection in such pipelines to assist the public, first responders, and pipeline operator employees in identifying dangerous releases.

PHMSA needs to require CO_2 pipeline operators to update their procedural manuals related to local emergency response coordination

- The major differences and unique properties of CO_2 compared to hydrocarbons require that pipeline operators improve the sections of their federally mandated operation, maintenance, and emergencies procedural manuals for emergency response to CO_2 pipeline ruptures.

PHMSA needs to establish regulations setting specific maximum contaminant impurities for CO_2 pipelines

- PHMSA needs to prescribe the maximum concentration of water, H_2S, and other impurities allowed in CO_2 pipelines.

PHMSA needs to strengthen federal regulations for conversion of existing pipelines to CO_2 pipeline service

- The general guidance of PHMSA's 2014 advisory bulletin is not adequate for mitigating the risks posed by conversion of existing hydrocarbon pipelines to CO_2 pipelines. PHMSA needs to issue regulations appropriate to the serious risks that could result from repurposing a pipeline for CO_2 service.

Resources – (Experts & Important Media)

- **Rick Kuprewicz**, president, Accufacts Inc. – Pipeline Engineering – kuprewicz@comcast.net
- **Paul Blackburn**, attorney, Bold Alliance – Pipeline Permitting – paul@boldalliance.org
- **Bill Caram**, executive director, Pipeline Safety Trust – Safety Regulations – bill@pstrust.org

- Affected Landowners – Mark Hefflinger, Bold Alliance – mark@boldalliance.org – Mark has worked with many potentially-affected landowners who can speak to the Press

- Full Report
- Article – The Gassing of Satartia
- Video – 8" CO_2 Pipeline Test Rupture
- Report - Congressional Research Service Report on CO_2 Pipeline Policy Issues 2009
- Research Paper – CO_2 Pipeline Material and Safety Considerations