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The Honorable Rick Crawford
Ranking Member
Subcommittee on Railroads, Pipelines, and Hazardous Materials
Committee on Transportation and Infrastructure
House of Representatives

The Honorable Tammy Duckworth
United States Senate

# Pipeline Safety: Manufacturing Defects in Pipeline Components Rarely Contribute to Accidents

The U.S. pipeline network includes almost 350,000 miles of interstate gas and hazardous liquid transmission pipelines that operate at high pressures and transport products across the country.[1] The integrity of individual components used in constructing these pipelines is critical to the safe and efficient operation of the network. These components include fittings to accommodate changes in terrain or direction of the pipe; flanges to connect pipe and other equipment together; and valves to help control the flow and pressure of product in the pipe. While pipelines are among the safest modes to transport energy products and other hazardous materials, failure of the components due to issues such as incorrect installation, corrosion, or manufacturing defects could cause significant damage to life, property, and the environment.

Within the U.S. Department of Transportation, the Pipeline and Hazardous Materials Safety Administration (PHMSA) oversees the safety of the pipeline network.[2] As part of this oversight, PHMSA sets the federal minimum safety standards for pipelines and pipeline facilities, including requirements and specifications relating to the design and manufacture of pipeline components.[3] The minimum safety standards apply to owners and operators of pipeline facilities rather than the manufacturers of pipeline components.

Citing potential concerns about the manufacturing process for pipeline components, you asked us to review the quality of fittings, flanges, and valves on interstate transmission pipelines. This report describes: (1) the extent to which manufacturing defects in pipeline components have contributed to accidents from 2016 through 2020, and (2) the actions selected pipeline operators have taken to ensure the quality of components manufactured for their pipelines.

[1] In this report, we use the term gas to include natural gas, flammable gas, or gas that is toxic or corrosive. We also use the term transmission pipeline throughout to refer to both gas and hazardous liquid pipelines carrying products over long distances to users.
[2] PHMSA's general authority is under the Pipeline Safety Laws codified at 49 U.S.C. § 60101 et seq.
[3] While PHMSA has primary authority over interstate pipeline safety, states may assume authority over the safety of intrastate pipelines, provided they certify to PHMSA that they have adopted and are enforcing the federal minimum safety standards.

Our review covers manufacturing defects in fittings, flanges, and valves on onshore interstate gas and hazardous liquid transmission pipelines from 2016 through 2020, the most recent 5-year period for which data were available at the time of our review.[4] For the first objective, we analyzed PHMSA's accident data—including number, cause, item involved, related fatalities, injuries requiring in-patient hospitalization (injuries), and amount of product released—on interstate transmission pipelines for gas and hazardous liquids.[5] PHMSA requires that operators report information on all accidents that, among other things, result in fatalities, or injuries, or that meet or exceed specific thresholds for the release of gas (three million cubic feet) or hazardous liquid (5 gallons), subject to certain exemptions. To identify the number of accidents related to manufacturing defects involving components, we filtered the data to accidents: (1) caused by equipment failure, (2) in which the item involved was a fitting, flange, or valve, and (3) where "manufacturing defect" was selected as a contributing cause.[6] We compared these to all accidents with respect to the number of fatalities and injuries and amount of product released. We assessed the reliability of the data by reviewing PHMSA reports, analyzing the data to identify any outliers, and interviewing PHMSA officials. We found the data sufficiently reliable to describe the frequency in which manufacturing defects contributed to reportable pipeline accidents.

For both objectives, we reviewed relevant pipeline safety statutes and regulations, including those governing the safety of pipeline components. We also reviewed publications from the National Transportation Safety Board (NTSB), industry, and non-industry groups on topics related to pipeline component manufacturing. We interviewed officials from PHMSA and NTSB, as well as representatives from 10 pipeline operators, six industry associations, four pipeline manufacturers (located in the U.S. and other countries), three standards-setting organizations, and one safety group.[7] We selected operators that manage interstate transmission pipelines, but vary in size (number of pipeline miles managed), commodity transported (gas or hazardous liquid), accident history, and geographic location.[8] We selected pipeline manufacturers of fittings, flanges, and valves based on recommendations from pipeline operators; for valves, we also reviewed PHMSA's accident data, which list manufacturers whose components were involved in accidents.[9] We selected the remaining stakeholders based on inclusion in prior GAO reports, recommendations from stakeholders, or references to standards-setting organizations in PHMSA's regulations. In this report, we refer to a "few" if representatives from two to three entities expressed the view, "some" if representatives from four to five entities expressed the

[4] Our review of manufacturing defects did not examine cybersecurity risks from fittings, flanges, and valves because these are not computerized components that connect to a network.

[5] PHMSA's regulations refer to the release of gas from a pipeline as an incident and a spill from a hazardous liquid pipeline as an accident. 49 C.F.R. §§ 191.3, 195.50. We will refer to both as accidents. Our analysis of accidents on gas pipelines excluded pipelines made from plastic because our review focused on the larger transmission pipelines, which are generally not constructed from plastic.

[6] PHMSA collects data across 11 causal categories, but we limited our review to accidents categorized as equipment failure because that is the only category where an operator can select manufacturing defect as a contributing factor. Specifically, "manufacturing defect" is one of numerous optional sub-cause fields that operators can select when describing the root cause of an accident. Pipeline operators are responsible for assuring the accuracy and completeness of the reported data, so operators must complete even optional fields if the information is applicable or known.

[7] We reached out to 19 out of 339 relevant interstate transmission gas and hazardous liquid pipeline operators identified in PHMSA's 2020 Annual Reports. Of these operators, 10 agreed to be interviewed. One standards-setting organization provided written responses in lieu of an interview.

[8] We used PHMSA's 2020 Annual Reports to describe the U.S. pipeline system, including number of pipeline miles, type of pipeline, and the number of operators that submitted these reports to PHMSA.

[9] PHMSA collects the manufacturer's name for valves involved in accidents (if known). PHMSA officials said they began collecting this information at stakeholders' requests. Specifically, stakeholders wanted to know how frequently valves from specific companies were involved in accidents.

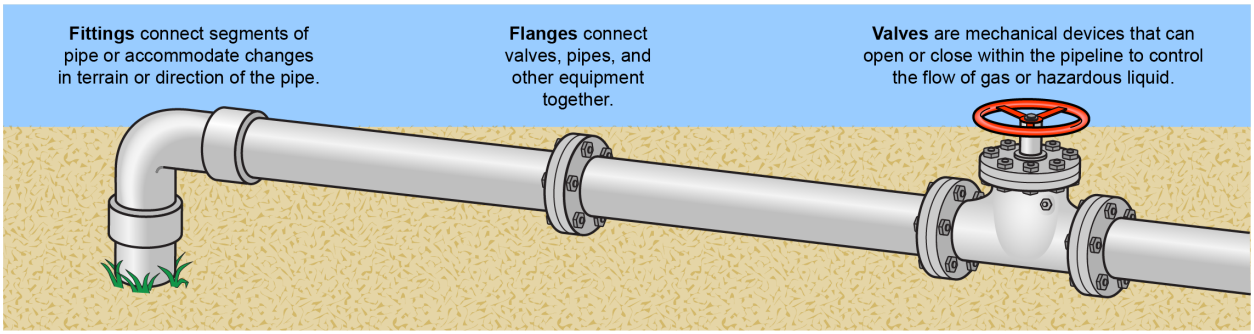
view, and “many” if representatives from six or more entities expressed the view. We used these same counts when only providing pipeline operators’ perspectives. While the views presented in our report provide perspectives from a range of knowledgeable stakeholders, they are not generalizable.

We conducted this performance audit from April 2021 to January 2022 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

## Background

As illustrated in figure 1 below, fittings, flanges, and valves help connect pipe segments together or control the flow of materials, among other things.

**Figure 1: A Fitting, Flange, and Valve on a Pipeline**




Source: GAO. | GAO-22-105140

PHMSA, pipeline operators, and manufacturers all help ensure the integrity of pipeline components on interstate gas and hazardous liquid pipelines. For example:

- PHMSA sets the federal minimum safety standards for the design, construction, operation, and maintenance of components. These standards include technical requirements developed by standards-setting organizations and incorporated by reference into PHMSA’s regulations.[10] PHMSA officials also periodically inspect interstate pipelines to help ensure operators’ compliance with federal minimum safety standards and may issue enforcement actions against an operator for failing to meet them.[11]

- Pipeline operators are responsible for ensuring that the components they purchase from pipeline component manufacturers and install on their pipelines meet federal safety requirements. For example, pipeline operators must follow design specifications, such as those that prescribe the thickness and quality of materials used. In addition, operators must

[10] PHMSA’s natural gas pipeline safety regulations are located in 49 C.F.R. parts 191-192; its hazardous liquid pipeline safety regulations are located in 49 C.F.R. part 195.

[11] PHMSA’s regulations governing its enforcement of pipeline safety are located at 49 C.F.R. part 190. Under its regulations, PHSMA has broad discretion to determine what enforcement action to take against an operator. For example, Warning Letters notify operators of less serious violations and direct the operator to correct the issues or be subject to potential, future enforcement actions. In contrast, Notices of Probable Violation allege the existence of one or more probable violations of the Pipeline Safety Laws or regulations and include a proposed compliance order identifying the remedial actions the operator is required to take, proposed civil monetary penalties, or both.

visually inspect components immediately prior to installation. PHMSA also generally requires that operators conduct a hydrostatic test to ensure the integrity of the pipeline and components prior to placing the pipeline in service.[12]

- Manufacturers are responsible for ensuring that the components they produce meet the quality and safety standards specified by the operator.

**PHMSA Data and Selected Stakeholders Indicate Manufacturing Defects Involving Fittings, Flanges, and Valves Rarely Contributed to Accidents**

Manufacturing defects involving pipeline components—fittings, flanges, and valves—accounted for less than 2 percent of all accidents on interstate transmission pipelines from 2016 through 2020, according to PHMSA data. Of the 1,529 accidents on interstate transmission pipelines reported to PHMSA, 23 accidents included manufacturing defects in these components as a contributing factor.[13] Eighteen of the accidents involved valves on hazardous liquid pipelines. The remaining five accidents involved flanges on three hazardous liquid pipelines and valves on two gas pipelines. According to representatives from one industry association, valves are more complex than fittings or flanges because they may have multiple mechanical parts and are generally more customized, putting them at a greater risk for manufacturing defects.

We found that none of the 23 accidents on interstate transmission pipelines from 2016 through 2020 resulted in fatalities or injuries, and the average amount of product released was also generally lower than for all pipeline accidents. Specifically, none of the 10 fatalities and 24 injuries reported by operators from all accidents were related to accidents involving manufacturing defects of fittings, flanges, or valves. We also found that the amount of gas unintentionally released for accidents involving manufacturing defects of pipeline components was less than the average for all accidents. According to PHMSA data, gas pipeline operators unintentionally released an average of 14.2 million cubic feet of gas during accidents involving manufacturing defects in pipeline components. This amount is about 7 percent less than the average of 15.2 million cubic feet during all gas pipeline accidents. Hazardous liquid pipeline operators spilled an average of almost 69 barrels of hazardous liquid during accidents involving manufacturing defects in pipeline components, compared to almost 242 barrels during all hazardous liquid pipeline accidents.

Our review of pipeline operators' narrative summaries describing the causes of each of the 23 accidents identified a number of issues related to manufacturing defects, including welding flaws, errors in the manufacturing process that caused the components to become brittle and crack, missing parts, and a failure of the manufacturer to meet an operator's specifications. For example, one operator reported that a valve was missing a seal. The operator attributed the missing part to an oversight during the manufacturer's assembly process. Another operator reported that the O-ring—which prevents the escape of product—was out of position, likely because the manufacturer used an O-ring made of material that was incompatible with the valve and that did not meet the operator's specifications.

[12] See, e.g., 49 C.F.R. § 195.116(d). In a hydrostatic test, the pipeline is filled with water and pressurized to a level above the normal operating pressure for a number of hours to ensure there are no leaks in the pipeline.

[13] Equipment failure was listed as the primary cause for 730 of the 1,529 accidents. When limiting these 730 accidents to those involving fittings, flanges, or valves there were 277 accidents. Of those 277 accidents, 23 also listed "manufacturing defect" as a sub-cause.

Many selected stakeholders said that manufacturing defects in pipeline components rarely contribute to accidents. For example, NTSB officials who investigate pipeline accidents said they rarely see manufacturing defects in pipeline components lead to accidents. As a result, many pipeline operators said that manufacturing defects in components pose a minor risk to the safety of the interstate transmission pipeline network. Moreover, our interviews with stakeholders did not identify any common factors across accidents. For example, according to many stakeholders, there is generally no difference in the quality of components between domestic and foreign manufacturers.

### Selected Operators Described Taking Steps to Design, Inspect, and Test Pipeline Components to Ensure Quality

All pipeline operators we interviewed described taking various steps related to the design, inspection, and testing of components. In particular, many of the operators described actions they have taken beyond those needed to meet PHMSA's minimum safety standards to design and inspect pipeline components to ensure quality prior to placing the components into service.

#### Design

Many selected pipeline operators said they take steps in addition to those needed to comply with PHMSA's minimum safety standards to help ensure that manufacturers have the skills and expertise to design high-quality components, including:

- **Maintain an approved manufacturer list**. Many pipeline operators said they maintain approved manufacturer lists, which some said they developed from reviews of manufacturers' quality assurance processes and past performance, as well as other operators' recommendations.

- **Require additional certifications from manufacturers**. Some pipeline operators said they may require that manufacturers supplying their components obtain voluntary certifications related to, for example, management and leading industry design practices for pipeline components.

- **Inspect manufacturers' processes**. A few pipeline operators told us they—or a third party they hire—inspect manufacturers' processes and quality assurance practices for producing pipeline components. According to one operator, this inspection can be done before adding a manufacturer to an approved manufacturer list or prior to purchasing or accepting specific components.

#### Inspection

Some operators also take steps to inspect and verify the quality of components in addition to the required inspection at installation:

- **Visual inspection on receipt**. Some pipeline operators told us they conduct a physical inspection of the component immediately after it is received. According to one pipeline operator, conducting multiple inspections increases the likelihood that any manufacturing defects are identified prior to placing the component in service.

- **Review of material test reports**. A few operators said they review material test reports provided by manufacturers for batches of components upon receipt. This report verifies,

among other things, that the chemical composition and mechanical properties comply with the design specifications set forth by the operator in the request order.

Testing

While selected operators generally did not describe taking additional testing steps above PHMSA's minimum requirements, many of these operators and other stakeholders agreed that the hydrostatic test is when defects are often identified. Moreover, according to some stakeholders, it is one of the most important requirements for ensuring that pipeline components meet federal safety standards.

## Agency Comments

We provided a draft of this report to the Department of Transportation for review and comment. The Department of Transportation told us that it had no comments on the draft report.

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We are sending copies of this report to the appropriate congressional committees, the Secretary of Transportation, and other interested parties. In addition, the report is available at no charge on the GAO website at https://www.gao.gov.

If you and your staff have any questions, please contact me at (202) 512-2834 or repkoe@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are Sara Vermillion (Assistant Director); Melissa Swearingen (Analyst-in-Charge); Antoine Clark; Gina Hoover; Joshua Ormond, Mary-Catherine P. Overcash; and Amy Rosewarne.

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