



# **USE OF SUBSTANDARD STEEL BY THE U.S. PIPELINE INDUSTRY 2007 TO 2009**

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**Plains Justice  
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**310 North 27th Street  
Billings, MT 59102  
406-696-8700**

**100 First Street SW  
Cedar Rapids, IA 52404  
319-362-2120**

**100 East Main Street  
Vermillion, SD 57069  
605-659-0298**

**Fax: 866-484-2373    [info@plainsjustice.org](mailto:info@plainsjustice.org)    <http://plainsjustice.org>  
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## SUMMARY

**Between 2007 and 2009 a number of pipe mills produced substandard steel pipe for U.S. pipeline companies.** This pipe failed to comply with the American Petroleum Institute Grade 5L X70 standard (API 5L X70 Standard). In response to this discovery of defective pipe, on May 21, 2009, the Pipeline and Hazardous Materials Safety Administration (PHMSA) issued Advisory Bulletin ABD-09-01, entitled “Potential Low and Variable Yield and Tensile Strength and Chemical Composition Properties in High Strength Line Pipe” (Advisory Bulletin). The Advisory Bulletin described the low strength steel pipe issue and recommended an industry response to it in very general terms.

To learn more about this problem, a number of groups submitted a Freedom of Information Act Request to PHMSA on September 2, 2009, which requested documents related to PHMSA’s investigation of and response to this problem. In response, in March and May of 2010, PHMSA sent 3,710 pages of information, including test results and reports, emails, letters, presentations, and other documents. This report is intended to summarize the material disclosed by PHMSA, discuss its implications, and identify a number of concerns that may not have been fully addressed by PHMSA and the industry.

The documents provided show that PHMSA investigated a total of seven pipelines, four constructed by Boardwalk Partners, LP (Boardwalk), and three by Kinder Morgan, Inc. (Kinder Morgan). PHMSA confirmed that five of these pipelines contained significant amounts of defective pipe. Specifically, the documents show that the pipe stretched under pressure, creating “expansion anomalies” that indicate use of low-strength steel. To repair their pipelines, the affected companies removed and replaced hundreds of pipe joints.

A number of companies are implicated in producing defective pipe, but it appears that Welspun Corp. Ltd (Welspun), an Indian steel pipe manufacturer, produced most of it. For example, according to released documents, Welspun was responsible for 88% of pipe with expansion anomalies provided to Boardwalk. This being said, other pipe mills also provided defective pipe, some in significant amounts. **Globalization of steel pipe supply chains has made quality control more challenging and increased the need for greater domestic measures to ensure discovery of defective pipe.**

Even though the documents released show that certain pipe mills provided most of the defective pipe, none of the documents describe any systematic approach to defining the scope of this problem or identify the final disposition of pipe provided by these mills during this time period. Thus, it is not clear that PHMSA has tracked down all of the potentially defective pipe joints and confirmed that they have been tested and, where necessary, replaced. Accordingly, this report provides recommended actions, accomplishment of which would assure the public that PHMSA has responded fully to the threat created by low-strength steel.

**New natural gas and hazardous liquid pipelines are larger, higher pressure, and more dangerous than earlier generations of pipelines.** It is critical that PHMSA fully investigate the root cause of the industry’s failure to comply with pipe steel standards so that appropriate solutions are implemented. **It is also critical that large high-pressure pipelines be regulated more stringently than smaller lower pressure pipelines, including measures that increase certainty of the industry’s compliance with written standards.**

Public confidence in pipeline safety will be increased only through greater regulatory transparency, increased opportunities for public participation, and a demonstration that PHMSA will respond aggressively to the increasing need to update and improve pipeline safety standards.

## INDUSTRY USE OF SUBSTANDARD STEEL PIPE

Between the third quarter of 2007 and the fourth quarter of 2009, Kinder Morgan Inc. and Boardwalk Pipeline Partners, L.P., constructed a number of new large, high-pressure natural gas pipelines. The approximate construction schedules for these pipelines are shown below.

Pipeline Construction Schedules	Defective Pipe Steel Investigation Period										
	3Q 07	4Q 07	1Q 08	2Q 08	3Q 08	4Q 08	1Q 09	2Q 09	3Q 09	4Q 09	
Kinder Morgan Louisiana Pipeline			■								
Kinder Morgan Midcontinent Express Pipeline						■					
Kinder Morgan Rockies East Pipeline				■							
Boardwalk East Texas Pipeline	■										
Boardwalk Gulf Crossing/MS Loop Pipeline				■							
Boardwalk Southeast Pipeline			■								
Boardwalk Fayetteville/Greenville Pipelines				■							

Upon completion, each of these pipelines was “hydrotested,” meaning that each new pipeline was filled with water and pressurized to find out if it had any leaks. Five of these pipelines failed their hydrotests, including the Louisiana Pipeline, the East Texas Pipeline, the Mississippi Loop portion of the Gulf Crossing Pipeline, and the Fayetteville Pipeline. As described below, these tests triggered an investigation by PHMSA, which ultimately determined that these companies had incorporated significant amounts of defective steel pipe into their pipelines.

### Kinder Morgan Investigation

PHMSA investigated three Kinder Morgan pipelines:

- Kinder Morgan Louisiana Pipeline (Louisiana Pipeline) – 137 mile 42 inch diameter natural gas pipeline constructed between January 2008 and December 2008;<sup>1</sup>
- Midcontinent Express Pipeline – approximately 500 mile long natural gas pipeline with 40 miles of 30 inch pipe, 197 miles of 36 inch pipe, and 257 miles of 42 inch pipe, constructed between September 2008 and August 2009;<sup>2</sup> and
- Rockies Express Pipeline – East Project (REX East) – a 639 mile 42 inch diameter natural gas pipeline constructed between June 2008 and November 2009.<sup>3</sup>

Investigation of each of these pipelines is discussed below.

<sup>1</sup> Kinder Morgan, Presentation, *Kinder Morgan Louisiana Pipeline (KMLP) – Pipe Issues*, December 15, 2008 (KMLP December 15 Presentation) at 2; *Kinder Morgan 10-K*, February 23, 2009. Given the danger of natural gas leaks and ruptures, initial pressure tests are conducted with water rather than natural gas.

<sup>2</sup> U.S. Dept. of Transportation, *Special Permit for the Midcontinent Express Pipeline*, April 4, 2007; *Kinder Morgan 10-K*, February 23, 2009.

<sup>3</sup> *Kinder Morgan 10-K*, February 23, 2009.

## **Kinder Morgan Louisiana Pipeline**

Sometime in late 2008 the Louisiana Pipeline failed a hydrotest.<sup>4</sup> This failure triggered PHMSA's investigation. Little is known about this hydrotest failure because PHMSA did not release documentation disclosing the location, time, or circumstances of this failure.

In its initial investigation of what caused this failure, Kinder Morgan determined that some of the pipe joints in the Louisiana Pipeline had expanded beyond specification.<sup>5</sup> Expansion was of concern because it indicated that the steel pipe might not have been strong enough to withstand the very high pressures under which this pipeline would operate. Accordingly, Kinder Morgan conducted a high resolution caliper survey of the entire pipeline to identify all expanded substandard pipe joints.<sup>6</sup> PHMSA did not supply the data collected by these high resolution caliper surveys in response to the FOIA Request, nor did it identify the pipe and steel mills that supplied the expanded pipe joints.

Once Kinder Morgan identified specific pipe joints that had expanded, it tested 30 of these joints for chemical composition and strength.<sup>7</sup> It also tested 30 random pipe joints that had not been subject to pressures sufficient to expand them.<sup>8</sup> It found that 43% of the samples from expanded pipe failed to meet strength specifications contained in the API 5L X70 Standard. The data table containing these results describes the pipe as "NPS 42 x 0.864" WT API Grade X70 Welspun LMLP Linepipe."<sup>9</sup> It also found that 13% of the samples from non-expanded Welspun pipe did not meet specification.<sup>10</sup>

Kinder Morgan concluded that "[t]he variability in the pipe yield properties is a result of deviation from plate controlled rolling parameters,"<sup>11</sup> meaning that the steel had been formed improperly. PHMSA provided us with no data or information supporting this conclusion.

To ensure pipeline integrity, Kinder Morgan ultimately removed approximately 7,100 feet (19.7%) of installed pipe due to "diameter variability."<sup>12</sup> Kinder Morgan also requested that Welspun investigate this matter and recertify substandard steel pipe joints based on its records.<sup>13</sup> Welspun recertified an undisclosed number of pipe joints as API 5L X56, X60, and X65 pipe, meaning that it downgraded different segments of pipe from the API 5L X70 Standard to lower standards.<sup>14</sup>

Even though PHMSA did not provide data beyond that contained in generalized Kinder Morgan presentations, it is clear that a substantial number of pipe joints expanded to a degree that caused Kinder Morgan and/or PHMSA to remove and replace these joints. Also, Welspun is the only one of Kinder Morgan's pipe suppliers implicated by the released documents.

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<sup>4</sup> Email, S. Nanney, PHMSA to A. Mayberry, PHMSA, transmitting undated Kinder Morgan presentation on KMLP use of defective steel.

<sup>5</sup> Id. at 5.

<sup>6</sup> Kinder Morgan, *KMLP Presentation*, December 15, 2009, at 8. A high resolution caliper survey is performed by sending a device through the pipeline that measures the diameter of the steel pipe. Such test can determine with precision if and where the pipeline has stretched under the pressure of a hydrotest.

<sup>7</sup> Id. at 5.

<sup>8</sup> Id. at 6.

<sup>9</sup> Id. at 11.

<sup>10</sup> Id. at 7.

<sup>11</sup> Id. at 12.

<sup>12</sup> Id. at 5.

<sup>13</sup> Id. at 13.

<sup>14</sup> Id. at 13. The "X" classifications in the API 5L Standard are based on pressure ratings. X70 steel pipe is designed to withstand a pressure of 70,000 psi, X65 steel pipe is designed to withstand 65,000 psi, etc.

## **Kinder Morgan Midcontinent Express Pipeline**

Due apparently to the failure of the Louisiana Pipeline, PHMSA investigated whether or not Kinder Morgan also used substandard pipe in its Midcontinent Express Pipeline.<sup>15</sup> Specifically, it tested 30 samples of steel from API 5L X70 42-inch pipe manufactured by Man Industries in India.<sup>16</sup> Man Industries contracted to supply 257 miles of 42-inch pipe to Midcontinent Express Pipeline, which is the length of the entire 42-inch segment of this pipeline.<sup>17</sup> Kinder Morgan found that all 30 steel samples complied with strength standards.<sup>18</sup> It appears that Kinder Morgan did not test the steel from pipe manufactured for the Midcontinent Express Pipeline by other companies. These companies included Welspun, which provided a majority of the 197 miles of 36-inch pipe,<sup>19</sup> and JSW, IVLA, and Evra OSM Portland, which provided smaller amounts of pipe.<sup>20</sup>

Even though Kinder Morgan ran a “construction type” caliper tool immediately after construction of the Midcontinent Express Pipeline,<sup>21</sup> apparently this tool was not considered adequate to test for pipe expansions, because Kinder Morgan also tested this pipeline with a high resolution caliper tool owned by TDW Magpie.<sup>22</sup> This high resolution tool discovered one 42-inch pipe joint that expanded 2.08%, which was removed and replaced. Kinder Morgan also reported that 1,906 feet of 42-inch pipe joints had expanded between 0.6% and 1.32%, but it deemed these pipe joints to be safe.<sup>23</sup> None of the documents we received indicate that Kinder Morgan tested the 36-inch diameter Welspun pipe with the high resolution tool.

Kinder Morgan’s detailed test results for the Midcontinent Express Pipeline have not been disclosed. Further, Kinder Morgan may not have tested the 36-inch Welspun pipe in this pipeline with a high resolution caliper tool. Therefore it is not possible to compare these test results to test results from other pipelines. Nonetheless, it is clear that PHMSA required the removal of at least one defective pipe joint. I also appears that the pipe produced by Man Industries did not suffer a large number of significant expansions because perhaps only a few dozen pipe joints expanded modestly.

## **Kinder Morgan Rockies Express Pipeline – East Project**

PHMSA also investigated whether Kinder Morgan had used substandard steel in the construction of its Rockies Express Pipeline (REX). As it did for other pipelines, PHMSA required that Kinder Morgan test the pipeline with high resolution deformation tool.<sup>24</sup> Kinder Morgan reported inconsistently that one pipe joint had expanded 1.07%<sup>25</sup> but also found that that no pipe joints showed an expansion of greater than 0.79% of pipeline diameter.<sup>26</sup> Otherwise, PHMSA provided no detailed documentation related to investigation of the steel in this pipeline or the source of this steel. However, press reports indicate that Kinder Morgan contracted with Oregon Steel Mills, Inc. to supply all or most of the 42 inch

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<sup>15</sup> Email, J. Torres, Kinder Morgan, to J. Mendoza, PHMSA, January 5, 2009; Email, J. Mendoza, Project Manager, PHMSA, to T. Binns, PHMSA, June 3, 2009.

<sup>16</sup> Kinder Morgan Metallurgical Investigation Report NGI-09-01, January 8, 2009.

<sup>17</sup> Business Line, Man Ind. Bags Rs 1,000-cr Order from Midcontinent of US, March 30, 2007.

<sup>18</sup> Kinder Morgan Metallurgical Investigation Report NGI-09-01, January 8, 2009.

<sup>19</sup> Email, J. Mendoza, PHMSA, to J. Torres and K. Kahncke, PHMSA, May 4, 2009.

<sup>20</sup> Id.; Kinder Morgan Metallurgical Investigation Report NGI-09-01, January 8, 2009 at 11.

<sup>21</sup> Email, J. Mendoza, PHMSA, to J. Torres and K. Kahncke, PHMSA, May 4, 2009.

<sup>22</sup> Email, D. Burton, VP Kinder Morgan, to A. Mayberry, PHMSA, October 1, 2009.

<sup>23</sup> Letter, D. Burton, VP Kinder Morgan, to A. Mayberry, PHMSA, August 25, 2009 (Appendix A, Technical Discussion for Pipe Diameters in Excess of 0.6% of Pipe Body Diameter For Midcontinent Express Pipeline at 3-4).

<sup>24</sup> Letter, D. Burton, VP Kinder Morgan, to I. Huntoon, PHMSA, August 27, 2009.

<sup>25</sup> Email, D. Burton, VP Kinder Morgan, to I. Huntoon, PHMSA, August 17, 2009.

<sup>26</sup> Letter, D. Burton, VP Kinder Morgan, to I. Huntoon, PHMSA, August 27, 2009. There may be a reasonable explanation for this inconsistent reporting, but the information received did not provide it.

pipe used in REX.<sup>27</sup> Despite a lack of detailed data, the documents provided do indicate that the steel pipe provided by Oregon Steel Mills showed little expansion.

### **Kinder Morgan Investigation Summary**

Kinder Morgan constructed the Louisiana, Midcontinent Express, and REX pipelines between mid-2008 and the end of 2009. One of these, the Louisiana Pipeline, suffered a rupture during a hydrotest. In response, PHMSA ordered Kinder Morgan to investigate each of these pipelines to determine if they contained substandard steel, and Kinder Morgan used a high resolution caliper tool to test each pipeline for excessive expansion. Kinder Morgan determined that Welspun provided defective steel pipe for construction of this pipeline, and after testing the pipe for strength, removed 7,100 feet of defective pipe joints and left others in place but with down-graded ratings. With regard to the Midcontinent Express and REX pipelines, Kinder Morgan discovered limited expansions in pipe provided by Man Industries and Oregon Steel Mills and ordered the removal of only one pipe joint. It does not appear that PHMSA required Kinder Morgan to inspect the 36-inch Welspun pipe used in the Midcontinent Express Pipeline, such that it is not possible to evaluate the performance of this pipe.

### **Boardwalk Pipeline Partners Investigation**

From 2007 to 2009 Boardwalk Pipeline Partners (Boardwalk) constructed a number of natural gas pipelines in the south central U.S. including:

- East Texas Pipeline – a 238 mile long 42-inch diameter natural gas pipeline constructed between July 2007 and June 2008;
- Gulf Crossing/Mississippi Loop Pipeline – 355 miles of 42-inch diameter natural gas pipeline constructed between June 2008 and February 2009;
- Southeast Pipeline – a 111 mile 42-inch natural gas pipeline constructed between December 2007 and February 2009; and
- Fayetteville/Greenville Pipelines – two 36-inch natural gas lateral pipelines<sup>28</sup> with a combined length of 263 miles constructed between March 2008 and January 2009.

The East Texas, Gulf Crossing, and Southeast pipelines were mostly constructed with 42-inch diameter pipe, although some 36-inch pipe was used in these projects. The Fayetteville/Greenville Pipelines were comprised of 36-inch diameter pipe, although some 20-inch pipe was used as well. All of these pipelines were to be constructed using steel in conformance with the API 5L X70 Standard.

PHMSA's investigation of Boardwalk's use of defective steel appears to have been triggered by a series of failed hydrotests in Boardwalk's pipelines.<sup>29</sup> Three of these failures were caused by defective end welds.<sup>30</sup> The fourth failure, in the Mississippi Loop Pipeline on December 5, 2008, was caused by use of substandard steel in pipe number 07388793.<sup>31</sup> In response to these failed hydrotests, PHMSA

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<sup>27</sup> Press Release, Oregon Steel Mills, Inc., *Oregon Steel Announces Receipt of 510,000 Ton Large Diameter Pipe Order*, March 1, 2006.

<sup>28</sup> The Fayetteville and Greenville Pipelines are in fact separate pipelines, but since much of the Boardwalk data for these pipelines is reported together, this report treats them as one project.

<sup>29</sup> The East Texas Pipeline failed a hydrotest in February 2008, the Southeast Pipeline failed on April 24, 2008, the Mississippi Loop Pipeline failed on December 5, 2008, and the Fayetteville Pipeline failed on March 11, 2009.

<sup>30</sup> Pipelines are constructed by welding joints of pipe end-to-end. Here three of these types of welds failed.

<sup>31</sup> Boardwalk Partners Update, November 6, 2009, Deformation Lab Results for Mississippi Loop Pipeline.

ordered Boardwalk to conduct a high resolution caliper test for each pipeline, similar to the tests performed by Kinder Morgan. This investigation produced surprising results.

First, Boardwalk determined that a mill owned by the Mittal Steel Company in Mexico (Mittal) accidentally substituted three slabs of API 5L X70 steel with three slabs of low grade steel, thereby mistakenly providing steel that did not conform to the API 5L X70 Standard to the JSW pipe mill owned by Jindal Pipes Limited.<sup>32</sup> One of these pipe joints, number 07388793, burst during the Mississippi Loop hydrotest.<sup>33</sup> The other two pipes containing switched slabs expanded but did not burst.<sup>34</sup>

The high resolution caliper testing also determined that an Essar steel mill in India accidentally switched one slab provided to Welspun (pipe number D08132667).<sup>35</sup> This slab ultimately ended up in the Gulf Crossing Pipeline.<sup>36</sup>

The fact that only one switched slab burst when hydrotested suggests that hydrotests alone cannot be relied upon as the only means to discover even grossly substandard steel, and that high resolution caliper testing is also necessary.

Second, the high resolution caliper tests identified 550 expansion “anomalies” in Boardwalk’s pipelines.<sup>37</sup> The following chart<sup>38</sup> summarizes the numbers and severity of these expansion anomalies for each Boardwalk pipeline.

<b>Pipeline</b>	<b>Total Miles</b>	<b>% of Total Miles</b>	<b>Expansions /mile</b>	<b>Expansions &gt; 2%</b>	<b>Expansions &gt;1%&lt;2%</b>	<b>Expansions 0.25"-1%</b>	<b>Expansions &lt;0.25"</b>	<b>Total Exp's - All Sizes</b>	<b>% of Total Exp's</b>
<b>East Texas</b>	238	25%	0.55	9	48	56	18	<b>131</b>	24%
<b>Gulf Crossing/ MS Loop</b>	355	37%	0.08	2	9	16	3	<b>30</b>	5%
<b>Southeast</b>	111	11%	0.04	0	2	2	0	<b>4</b>	1%
<b>Fayetteville/ Greenville</b>	263	27%	1.46	53	150	173	9	<b>385</b>	70%
<b>Total</b>	<b>967</b>	<b>100%</b>	<b>0.57</b>	<b>64</b>	<b>209</b>	<b>247</b>	<b>30</b>	<b>550</b>	<b>100%</b>

This data shows that the expansion anomalies were not evenly distributed among the pipelines, as would be expected if the cause of the expansions was based on random variability in steel quality. In fact, the East Texas and Fayetteville/Greenville Pipelines together accounted for 94% of the excessive expansion anomalies. Further, a full 70% of the expansion anomalies were in the Fayetteville/Greenville Pipelines even though they accounted for only 27% of total pipeline length.

The number of expansions per mile ranged from a high of about one and one-half expansions per mile in the Fayetteville/Greenville Pipeline, to a low of one expansion every 25 miles in the Southeast

<sup>32</sup> Id.

<sup>33</sup> Id.

<sup>34</sup> Id.

<sup>35</sup> Id. Deformation Lab Results for Gulf Crossing, Paris to Mira Segment.

<sup>36</sup> Id.

<sup>37</sup> Boardwalk Pipeline Partners Update, November 6, 2009.

<sup>38</sup> Id. Expansion anomaly data provided herein are based on Boardwalk’s November 6, 2009, Update, which is the most recent Boardwalk Update provided by PHMSA in response the FOIA request.

Pipeline, making the anomaly rate in the Fayetteville/Greenville lines over 36 times higher than that in the Southeast Pipeline.

Boardwalk also identified the pipe manufacturers and steel mills that provided plate steel to the pipe manufacturers for each of the investigated pipelines,<sup>39</sup> and this information is summarized in the following table. Small amounts of pipe were also provided by Durabond and IPSCO.

Pipe Supplier	Steel Mills Supplying Slab Steel to Pipe Supplier	Total Miles of Pipe Installed	Percent of Pipe Installed
<b>Jindal/JSW (India)</b>	Azovstral (Ukraine)	536	55%
	Mittal (Mexico)		
	Essar (India)		
	Jindal (India)		
<b>Welspun (India)</b>	Essar (India)	363	38%
	POSCO (Korea)		
	BAOSTEEL (China)		
	TISCO (China)		
<b>Camrose (US)</b>	Mittal (Mexico)	68	7%

Jindal and Welspun provided 93% of the pipe for these pipelines. Jindal sourced its steel from the Ukraine, Mexico, and India. Welspun sourced its steel from China, Korea, and India. The only steel mill that provided steel to both Jindal and Welspun was the Essar steel mill.

Boardwalk also identified the pipe manufacturers that provided expanded pipe for each pipeline.<sup>40</sup>

Pipeline	Camrose Total Expansions	Camrose % of Total Expansions	Welspun Total Expansions	Welspun % of Total Expansions	Jindal Total Expansions	Jindal % of Total Expansions
<b>East Texas</b>	0	0%	93	71%	38	29%
<b>Gulf Crossing/ MS Loop</b>	0	0%	7	23%	23	77%
<b>Southeast</b>	0	0%	0	0%	4	100%
<b>Fayetteville/ Greenville</b>	0	0%	385	100%	0	0%
<b>Total</b>	<b>0</b>	<b>0%</b>	<b>485</b>	<b>88%</b>	<b>65</b>	<b>12%</b>

Thus, 88% of the recorded expansion anomalies were in pipe provided by Welspun. Moreover, as shown below, it appears that the Welspun pipe stretched more than the Jindal pipe.<sup>41</sup>

Pipe Supplier	Expansion >2%	Expansion >1% <2%	Expansion 0.25" - 1%	Expansion <0.25"	Total Expansions
<b>Jindal/JSW</b>	2	17	35	11	65
<b>Welspun</b>	62	192	212	19	485

This data shows that 13% of the Welspun anomalies exhibited expansion greater than 2%, whereas only 3% of the Jindal anomalies exhibited expansions of this amount. Further, 40% of the Welspun anomalies

<sup>39</sup> Boardwalk, Summary of Pipe and Slab/Coil Sources Used on Boardwalk Expansion Projects, March 2, 2009.

<sup>40</sup> Boardwalk Pipeline Partners Update, November 6, 2009.

<sup>41</sup> Id.



exhibited expansion of between 1% and 2%, whereas only 26% of the Jindal expansions were in this range. This data shows that Welspun pipe varies more in quality than Jindal pipe.

Even though PHMSA did not provide any systematic analysis showing which steel mills provided the steel used in each defective pipe joint,<sup>42</sup> it did provide some test data indicating that Boardwalk and PHMSA focused their testing efforts on steel provided by certain steel mills.<sup>43</sup> The following table summarizes the number of tests performed on expanded pipe joints by pipe manufacturer and steel mill.

Pipe Mill	Tests on Welspun Pipe							Tests on Jindal Pipe					
	Steel Mill	Anshan	Baosteel	Essar	Mittal	POSCO	TISCO	Welspun Total	Azovstal	Mittal	Essar	JSW	Jindal Total
<b>Pipelines</b>													
<b>East Texas</b>													
Carthage to Hall Summit									2	2			4
Hall Summit to Vixen									2	4			6
Tullulah to Harrisville		2		69	2			73	1	6			7
Vixen to Tallulah									4	2			6
<b>Gulf Crossing</b>													
Bennington to Paris										1			1
Mira to Sterlington									1	2			3
Paris to Mira										4	1	5	10
Sterlington to Tallulah						1	6	7					
<b>Mississippi Loop</b>									3	3			6
<b>Southeast</b>									2	2	1		5
<b>Fayetteville</b>													
Bald Knob to Lula								23					23
Grandville to Bald Knob								2	2				4
<b>Greenville</b>								7	5				12
<b>Total Tests</b>		<b>2</b>	<b>9</b>	<b>99</b>	<b>2</b>	<b>1</b>	<b>6</b>	<b>119</b>	<b>15</b>	<b>26</b>	<b>2</b>	<b>5</b>	<b>48</b>

For Welspun, 119 pipe joints were tested; for Jindal 48 pipe joints were tested.

<sup>42</sup> It appears that PHMSA and Boardwalk determined that the defective steel could be traced to certain steel mills, because Boardwalk requested a variance from its Special Permit Modification Agreement for Welspun pipe manufactured with POSCO steel since only one pipe joint manufactured with POSCO steel had expanded. Letter, D. Goodwin, VP Boardwalk Pipeline Partners, to A. Mayberry, PHMSA, July 22, 2009.

<sup>43</sup> Boardwalk Pipeline Partners Update, November 6, 2009.

The following table shows Boardwalk tested pipe made with Essar steel almost four times more than pipe made with steel from any other mill.

<b>Steel Mill</b>	<b># Tests</b>	<b>% of Tests</b>
Anshan	2	1%
Azovstal	15	9%
Baosteel	9	5%
Essar	101	60%
JSW	5	3%
Mittal	28	17%
POSCO	1	1%
TISCO	6	4%
<b>Total</b>	<b>167</b>	<b>100%</b>

This data shows that PHMSA and Boardwalk focused most of the strength testing on pipe produced by the Welspun-Essar combination.

That there is a correlation between pipe expansions and pipe strength is shown by metallurgical test data for the Fayetteville/Greenville Pipelines provided by Boardwalk to PHMSA on October 7, 2009.<sup>44</sup> This test data shows results for strength tests of 46 Welspun pipe joints, all of which were fabricated using steel from the Essar steel mill.<sup>45</sup> Boardwalk strength tested 28 joints that had expanded more than 1.5%, 10 joints that had expanded approximately 1%, and eight joints that were “control joints” that showed no expansion. Each joint was subjected to nine separate tests.<sup>46</sup> Almost all of the joints that had expanded more than 1.5% failed most of the strength tests.<sup>47</sup> The joints that expanded approximately 1% also failed most of the strength tests.<sup>48</sup> In contrast, six of the eight control joints exceeded strength standards by substantial margins.<sup>49</sup> The two control joints that did not pass all of the strength tests failed in only a few sample runs by narrow margins but generally passed almost all of the strength tests.<sup>50</sup> This data shows a clear correlation between pipe expansions and the use of substandard steel.

Even though it appears that PHMSA could order Boardwalk to trace each expansion anomaly to a specific steel mill, PHMSA did not provide such information in response to the FOIA Request. Further, the absence of a root-cause analysis in the information provided in response to the FOIA Request suggests that PHMSA did not conduct, report on, and/or disclose such analysis. Therefore, based on the documents provided by PHMSA it is not possible to determine the full extent of the low-strength steel problem or trace all possible low-strength steel from particular steel and pipe mills to particular pipelines.

Tracing defective steel back to each steel mill is important because other PHMSA data suggests that one of the causes of the substandard steel was mis-formulation during alloying of the steel. In a September 8, 2009, report by the Microalloyed Steel Institute to PHMSA, the Institute determined that the pipe in the Fayetteville Pipeline (provided by Welspun) and Mississippi Loop Pipeline (provided by Jindal) had improper steel chemistry.<sup>51</sup> The report noted low manganese levels and no vanadium,

<sup>44</sup> Email, D. Goodwin, VP Boardwalk Pipeline Partners, to S. Nanney, PHMSA, October 7, 2009.

<sup>45</sup> Id.

<sup>46</sup> Id. Tests applied included flat strap yield, flat strap tensile, flat strap elongation, round bar yield, round bar tensile, round bar elongation, Charpy toughness, Charpy shear, and grain size tests.

<sup>47</sup> Id.

<sup>48</sup> Id.

<sup>49</sup> Id.

<sup>50</sup> Id.

<sup>51</sup> Letter, J.M. Gray, Microalloyed Steel Institute, to S. Nanney, PHMSA, September 8, 2009.

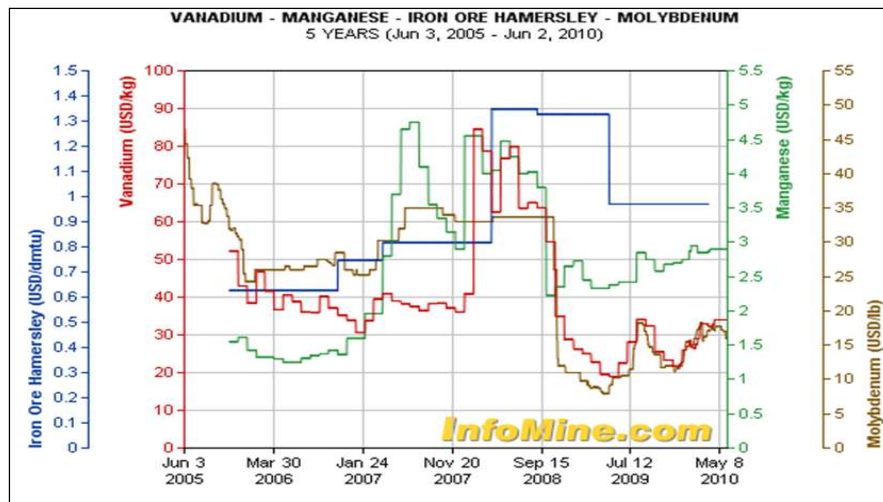
niobium, and molybdenum in steel samples from the Mississippi Loop pipeline, and an absence of vanadium in the Fayetteville Pipeline.<sup>52</sup> The data in Boardwalk’s November 6, 2009, Update also indicates that low strength pipe (including the switched slabs) had low levels of vanadium, niobium, and Titanium.<sup>53</sup>

In summary, it appears that 88% of the pipe that expanded was provided to Boardwalk by a single pipe manufacturer, Welspun, even though in terms of length it provided only 38% of the pipe for all the new Boardwalk pipelines combined. Welspun provided a total of 363 miles of pipe that contained 485 expansion anomalies, for a rate of over one anomaly per mile. In contrast, the Jindal pipe had an expansion anomaly rate of about one anomaly every eight miles, and pipe provided by Camrose exhibited no expansion anomalies at all. Also, the expansion anomalies found in the Welspun pipe were markedly worse than the anomalies in the Jindal pipe. Another difference is that Welspun and Jindal sourced their steel from different steel mills, except that they both acquired steel from the Essar steel mill. That Boardwalk and PHMSA focused their attention on pipes made by Welspun-Essar is also indicated by the fact that 60% of all tested pipe joints were made from steel produced by Essar. Further, it appears that mis-formulation of the steel alloy for this pipe may have been a cause of the weakness of some of the Welspun steel pipe.

Ultimately, Boardwalk agreed to remove 305 pipe joints, including all pipe joints in the East Texas, Southeast, Gulf Crossing Pipelines that expanded more than 0.25” (148 pipe joints), and all pipe joints in the Greenville/Fayetteville Pipelines that expanded more than 1.5% (157 pipe joints).

## Commodity Prices, Pipe Steel Market Growth and Quality Control

During the period when the defective pipe was fabricated, commodity prices soared, including prices for most metals. The following chart shows that the price for manganese more than tripled in 2007 and the price for iron ore and vanadium more than doubled in 2008.



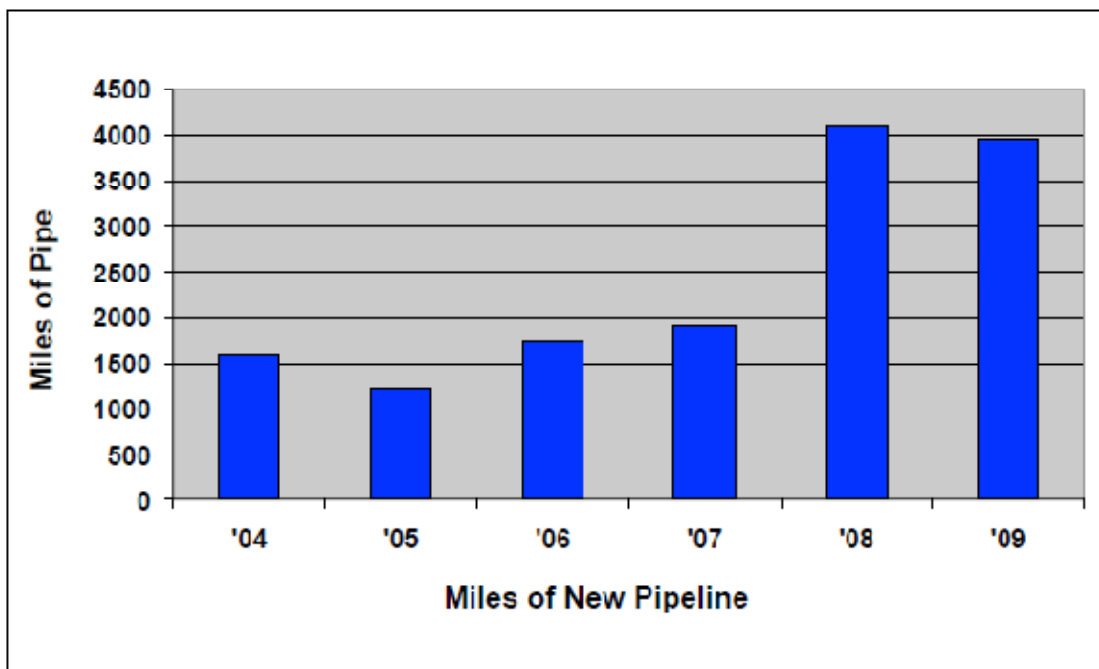
This market evidence indicates that steel mills faced substantially higher prices for raw materials than they likely anticipated. It is reasonable to question whether these dramatic changes in commodity prices shifted steel mill priorities toward meeting production and price goals and away from quality control, including control over the quality of raw materials and steel formulation. However, in the absence of

<sup>52</sup> Id.

<sup>53</sup> Boardwalk Pipeline Partners Update, November 6, 2009.

systematic metallurgical analysis, it is not possible to know with certainty that a pattern of production of mis-alloyed steel existed, and that this was the root cause of the production of substandard pipe by manufacturers.

During this same time period, demand for steel increased dramatically. According to the industry graph below, between 2007 and 2008 the miles of new pipe installed by the industry doubled.<sup>54</sup>



Source: ICF International

This increase in installed miles of pipe is reflected in a corresponding growth in sales of pipe by pipe mills. For example, from 2006 to 2009, Welspun increased its pipe production rapidly, registering nearly 50% increases in sales in fiscal years 2007 and 2008.<sup>55</sup> Its pipe volume production rate increased by 34% in the third quarter of 2008 alone.<sup>56</sup> This rapid growth likely required the retention and training of new employees, pressed steel and pipe mill infrastructure to its limits, and resulted in substantial management pressure on personnel to meet production deadlines. Such production conditions could have adversely impacted quality control.

PHMSA knew about quality control problems at a Jindal pipe mill as early as May 2007.<sup>57</sup> Specifically, PHMSA conducted a visit of a Jindal mill to review quality control problems.<sup>58</sup> PHMSA produced a list of concerns related to pipe rolling and coating, mill hydrotest equipment failures, seam inspection equipment failures, steel plate rejections, pipe end quality, pipe repair quality, pipe tracking, and oil and chloride contamination.<sup>59</sup> Also, in September, 2007, Boardwalk was informed of allegations

<sup>54</sup> Presentation, M. Hereth, INGAA Foundation, *Best Practices in Procurement and Manufacturing Workshop*, June 9, 2010, at 2.

<sup>55</sup> KJMC Institutional Research, *Research Updates, Welspun Gujarat Stahl Rohren Limited*, June 3, 2009 and April 29, 2010.

<sup>56</sup> Hindu Business Line, *Welspun Gujarat Stahl Rohren: Buy*, November 23, 2008.

<sup>57</sup> Email, H. Wang, Boardwalk, to S. Nanney, PHMSA, June 25, 2007.

<sup>58</sup> Id.

<sup>59</sup> Id.

by two former Jindal pipe mill employees that Jindal's production of steel for the East Texas Pipeline could impact the pipeline's integrity.<sup>60</sup> Although PHMSA provided no detail on these allegations, Gulf South, the initial developer of this pipeline, responded to them by conducting:

- a review of current inspection procedures,
- a review of recordkeeping and data storage practices,
- cross-checks on pipe data across multiple independent sources including: Jindal, Gulf South, and third party suppliers for Jindal (double-joint contractors, NDE contractors),
- a physical audit of selected pipe with alleged issues,
- a spot audit of inspection areas in question, and
- immediate implementation of an independent tracking and verification database for pipe procedures beyond the pipe mill to assure an independent check of pipe specification conformance, quality, and disposition through final shipment and receipt at Gulf South's field yards.<sup>61</sup>

Unfortunately, PHMSA provided very limited information about these early reports of pipe mill quality control problems. Nonetheless, the limited information provided indicates that the steel pipe industry was experiencing quality control challenges in 2007.

## Summary of Industry Production and Use of Defective Steel Pipe

The information provided by PHMSA in response to the FOIA Request is not as comprehensive as expected. Nonetheless, it indicates that most pipe mills provide limited numbers of joints of substandard pipe, but in 2007 to 2009 the Welspun-Essar mill combination produced an unusually large amount of defective pipe, and that the Jindal-Mittal-Azovstal mill combinations also produced a significant amount of defective pipe.

Even though PHMSA did not provide data tracing the defective pipe steel to specific steel mills, it appears that PHMSA, Kinder Morgan, and Boardwalk may very well have such data. In any case, the data provided by PHMSA shows that the problem here was not caused by random quality variation within the pipe manufacturing industry but rather the vast majority of the substandard steel provided to Boardwalk and Kinder Morgan can be attributed to the Welspun-Essar and Jindal-Mittal-Azovstal mill combinations.

The information provided by PHMSA also identifies that at least three distinct mechanisms are believed to have caused the low-strength steel pipe provided to Boardwalk and Kinder Morgan: (1) improper steel chemistry; (2) improper rolling of steel plate; and (3) a lack of proper segregation of slabs of different grades of steel at steel mills. Other causes are possible. All of the identified mechanisms can result in violations of the API 5L X70 Standard and would impact the quality of large diameter X70 pipe regardless of the specific size. Also, market conditions during this time period may also have contributed to steel and pipe mill quality control failings.

While the low-strength steel problem was first discovered after investigation of two failed hydrotests caused by low-strength steel pipe, hydrotesting did not identify the full scope of this problem. Only two of hundreds of defective pipe joints burst during the hydrotests. Instead, the scope of this

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<sup>60</sup> Emails, W. Bennett and J. Earley, Boardwalk, to S. Nanney et al., PHMSA, September 10-11, 2007.

<sup>61</sup> Id.; Email, J. Garris, Boardwalk, to S. Nanney, PHMSA, September 24, 2007 (further describing Boardwalk's response).

problem was identified only through high resolution caliper testing. Ultimately, PHMSA and the industry concluded that this problem was of sufficient gravity to require the removal and replacement of hundreds of pipe joints.

Unfortunately, it does not appear that PHMSA has yet conducted a comprehensive root-cause analysis of this problem, given that it provided no such analysis in response to the FOIA Request. It also appears that PHMSA may not have conducted a comprehensive study of the possible flow of defective steel pipe from steel and pipe mills noted herein to new natural gas and hazardous liquid pipelines constructed in the U.S. from 2007 to 2009. Instead it appears that PHMSA limited its investigation to only Kinder Morgan and Boardwalk.

## INDUSTRY TRADE ASSOCIATION RESPONSE

PHMSA's first formal action related to the defective pipe steel problem was to issue the Advisory Bulletin.<sup>62</sup> In response, the industry convened a meeting on or about June 11, 2009, to which PHMSA was not invited.<sup>63</sup> Apparently, one product of this meeting was a September 2009 White Paper by the Interstate Natural Gas Association of America Foundation (INGAA Foundation) entitled, "Identification of Pipe with Low and Variable Mechanical Properties in High Strength, Low Alloy Steels" (INGAA White Paper). By way of background to this issue, the INGAA White Paper states the following:

During 2007 and 2008 there was a significant increase in new pipeline construction in the United States. This construction boom put almost unprecedented demands on both pipe and other material manufacturers and pipeline constructors. To meet the demands for high yield line pipe, both traditional and newer pipe mills, utilizing plate and coil from both established and nontraditional steel suppliers, were used. During post-commissioning test (field hydrostatic test) inspection of some of these lines, a small number of pipe joints were detected that had expanded well beyond the dimensional tolerance limits of the pipe manufacturing specification, API Specification 5L. In most cases, the point at which this expansion occurred has not been definitively determined. As the investigation of this phenomenon progressed, it became apparent that it was not limited to one pipe mill, one steel supplier, or one manufacturing process. Through experience of a limited number of operators, it appeared that this issue was a rarity, affecting an extremely small percentage of pipe joints produced. However because the phenomenon could not be isolated or traced to a single source, PHMSA issued [the] Advisory Bulletin.<sup>64</sup>

Thus, due to a boom in pipeline construction, the industry admits that it acquired pipe from "newer," and presumably less experienced pipe mills, and that some pipe mills acquired steel from "nontraditional" steel mills, which could be less familiar with the exacting quality control standards that regulate the construction of pipelines in the United States. It is reasonable to believe that unprecedented demands for high-strength steel pipe and high commodity costs increased the risk of production of substandard pipe in 2007 and 2008.

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<sup>62</sup> PHMSA Advisory Bulletin ABD-09-01, *Potential Low and Variable Yield and Tensile Strength and Chemical Composition Properties in High Strength Line Pipe*, 74 Fed. Reg. 23930, May 21, 2009. PHMSA also conducted a workshop on pipeline construction issues on April 23, 2009, which addressed a variety of pipeline construction failings.

<sup>63</sup> Emails, P. Lidiak, API, to J. Wiese, PHMSA, May 21, 2009.

<sup>64</sup> INGAA White Paper at 1.

Rather than seek or provide greater clarity about the cause and sources of the pipe joints that “expanded well beyond the dimensional limits of the pipe manufacturing specification, API Specification 5L,” the industry merely stated that the “point” of expansion (presumably this means time and cause of expansion) had not been “definitively determined.” It also stated that the expansions were not limited to one pipe mill, one steel mill, or one manufacturing process, thereby implying that problems linked to only a single supplier should be of concern (which makes no logical sense). It did not support its statements with any data. It also stated that industry operators believe that the quality control problems were a “rarity, affecting an extremely small percentage of pipe joints produced,” but failed to reference or provide any data supporting this statement or discuss the risks created by small amounts of defective pipe. After all, it only takes one bad pipe joint to create an environmental and economic disaster. In short, the INGAA White Paper ignored any detailed discussion of the root causes of the substandard pipe and offered only unfounded generalizations about the problem rather than solid explanations.

The industry attempted to justify a limited response to this problem by discussing historical pipeline failures occurring prior to the events that precipitated the Advisory Bulletin.<sup>65</sup> Historical data is not relevant when current evidence suggests new types of industry failings in “unprecedented” market conditions. Historical data does not justify a lack of robust response by PHMSA or the industry to specifically identified problems.

Finally, the INGAA White Paper contains two flow charts intended to guide an operator of an existing pipeline in its determination of whether it has a “potential issue with pipe quality and if so, what actions should be taken to address those issues.”<sup>66</sup> Figure 1 indicates that existing pipelines intended to operate at an 80% design factor are subject to the review included in process B1.<sup>67</sup> Figure 2 and its accompanying text describe the B1 process as being:

- 1) a determination of whether there is a known history of low mechanical properties or excessive expansion found during normal operations;<sup>68</sup>
- 2) if such history exists, then a company should conduct an in-line inspection (ILI) during its next assessment; and
- 3) if such investigation shows expansions greater than “X%” amount (X% is not specifically defined by the INGAA White Paper, which states only that it may be about 1%) then the company must “evaluate and mitigate” the expansions, apparently within one year of the analysis, however the industry has not identified what “evaluate and mitigate” means, when the one-year period tolls, or what actions might be required based on differing degrees of pipe failings.<sup>69</sup>

Thus, it appears that the industry recommends that operators of existing pipelines, including pipelines constructed between 2007 and 2009, conduct an inspection for expansion anomalies only if their “normal” review of pipe data or information discovered during normal operations indicates that a threat of expanded pipes exists. However, the INGAA White Paper makes no recommendations about the type of

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<sup>65</sup> INGAA White Paper at 2.

<sup>66</sup> Id. at 3.

<sup>67</sup> Id.

<sup>68</sup> Id. The INGAA White Paper describes this history as, “Regardless of the preceding steps, if the company, through its normal review of the pipe data, such as is conducted during pipe production, and any other operational data or field observations, such as during tie-ins, installing taps, making coating repairs or performing pipe replacements, has made a determination that the threat of expanded pipe exists, then it must look further for such deformation during the next in-line inspection of the pipeline. If there is no evidence of low strength or excessively expanded pipe, no further action is required. Examples of such evidence include coating flaws caused by pipe strain and improper tie-in of a repair due to strain. This step does not contemplate extraordinary evaluations or inspections, but rather relies on those normally conducted as operations and maintenance activities.”

<sup>69</sup> Id. at 6-9.

in-line inspection required, and it specifically states, “This step does not contemplate extraordinary evaluations or inspections, but rather relies on those normally conducted as operations and maintenance activities.”<sup>70</sup>

The INGAA Foundation’s recommendation is essentially to allow operators of pipelines constructed between 2007 and 2009 to determine by and for themselves whether or not they need to conduct high resolution deformation testing and how to redress any problems found. Its response provides no assurance of any systematic investigation of or response to the defective steel problem. Thus, it appears that the industry makes no recommendation that such operators do any initial investigation beyond normal operations and also does not recommend particular responses.

## **RECOMMENDED PHMSA ACTIONS**

Since this report is based only on documents released pursuant to the FOIA Request, it is not possible to fully know about all of the actions taken by PHMSA in response to the defective steel problem. With this caveat in mind, we recommend that PHMSA take the following actions, if it has not already done so:

- Investigate and provide a public report on the use of defective steel in U.S. hazardous liquid and natural gas pipelines that:
  - identifies the number of defective pipe joints discovered;
  - provides a description of each defective pipe joint;
  - provides any test results performed on each pipe joint;
  - identifies the pipe and steel mill sources for each defective joint;
  - identifies the root cause or causes of the defective pipe joints; and
  - presents recommended improvements in safety regulations, safety enforcement, pipe steel standards, pipeline testing, quality control surveillance, and other appropriate responses to this problem.
- Order all operators of natural gas and hazardous liquids pipelines constructed between 2007 and 2009 to conduct high-resolution in-line deformation caliper testing and provide the results of such inspections to the public on the PHMSA website;
- Order all operators of natural gas and hazardous liquids pipelines constructed between 2007 and 2009 using API 5L X70 and higher grades of pipe to trace pipe from pipe and steel mills with a history of supplying defective API 5L X70 and higher pipe to all U.S. pipelines that contain such pipe, regardless of pipe diameter, and provide a report to PHMSA and the public describing the use of such pipe in U.S. pipelines.
- Post all hydrotest results provided by pipeline operators on the PHMSA website; and
- Reduce the operating pressure of newly conducted hazardous liquid and natural gas pipelines to a design factor of 72% or lower pending completion of PHMSA investigation of possible use of defective pipe steel, any necessary fitness for service determinations, and opportunity for public review and participation in these activities.

All of the foregoing recommendations include easily accessible information disclosures by PHMSA and greater opportunities for public participation in PHMSA activities. Greater transparency in PHMSA operations is necessary to ensure public participation in and support for PHMSA activities. A lack of transparency will result in a lack of trust and risk greater opposition to pipeline development.

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<sup>70</sup> Id. at 8.



The growing number of high-pressure, large diameter hazardous liquid and natural gas pipelines are putting increasing numbers of citizens at risk. New large pipelines must be built to the highest standards and be fully tested using the best available technology to ensure that they comply with safety requirements. Existing pipelines, especially large diameter pipelines, must be tested with greater frequency as they age.

To avoid further fatalities, injuries, and property damage, PHMSA must adapt its safety standards, regulations, and enforcement activities to protect citizens and their property from the greater risk posed by new large high-pressure pipelines. To gain greater public trust and public support for its activities, PHMSA must allow citizens to easily learn what it is doing and increase opportunities for citizens to participate in PHMSA's efforts to protect them.