UNITED STATES OF AMERICA
BEFORE THE
DEPARTMENT OF TRANSPORTATON

PIPELINE AND HAZARDOUS MATERIALS
SAFETY ADMINISTRATION

Pipeline Safety: Information Collection Activities	**)**	**Docket No. PHMSA-2015-0205**

COMMENTS OF NORTON MCMURRAY MANUFACTURING COMPANY

In accordance with the notice and request for comments established by PHMSA in the above-referenced docket on May 13, 2016, 81 Fed. Reg. 29943 ("Notice"), Norton McMurray Manufacturing Company ("NORMAC") respectfully submits its comments on proposed revisions to the following incident and accident report forms and associated instructions currently under OMB Control No. 2137-0522:

- PHMSA F 7100.1 Incident Report—Gas Distribution System.
- PHMSA F 7100.2 Incident Report—Natural and Other Gas Transmission and Gathering Pipeline Systems.
- PHMSA F 7100.3 Incident Report—Liquefied Natural Gas (LNG) Facilities.

And to proposed revisions to the following accident report form currently under OMB Control No. 2137-0047:

- PHMSA F 7000-1 Accident Report – Hazardous Liquid Pipeline Systems

NORMAC supports PHMSA's efforts to collect accurate fact-based incident data in order that trends related to the root causes of such events may be analytically and transparently identified, and to that end appreciates the opportunity to comment on PHMSA's proposed revisions.

I. IDENTIFICATION OF NORMAC

Norton McMurray Manufacturing Company, known to gas pipeline operators throughout the United States as NORMAC, was founded in 1938 by Francis McMurray, a salesman, and Charles Norton, an engineer. Each of the founders left their successful employ with M.B. Skinner and Dresser, respectively, to form this new company. The product line that they designed, manufactured, and sold included compression fittings of all types, such as adapters, tees, elbows, couplings and later risers. The NORMAC fittings are widely accepted, and, as a result, millions have been sold to pipeline operators across the United States.

As one of the leading manufacturers of compression fittings for over seven decades, NORMAC brings a unique perspective to this effort. NORMAC therefore requests that its comments and recommended revisions to the incident report forms and instructions be incorporated in these important reporting forms.

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II. HISTORICAL PERSPECTIVE

In 1978, PHMSA's predecessor outsourced a study on the causes of leaks in compression joints. The results repeatedly stressed that poor workmanship was the primary cause.[1] This fact unfortunately has been lost to history. In its place, PHMSA has presented as fact to stakeholders, including NORMAC customers, unproven hypotheses and biased publications (*i.e.*, ADB-02-08) against mechanical fittings as a marketable product (*i.e.*, the Mechanical Fitting Failure Report ("MFFR")). In so doing, PHMSA has ignored the **core problem** that has been identified repeatedly in court decisions (*e.g.*, Fremont, Nebraska and Lawrence, Kansas incidents)[2], numerous findings by the National Transportation Safety Board ("NTSB"),[3] and

[1] Transportation of Natural Gas and Other Gas by Pipelines: Joining of Plastic Pipes, 43 Fed. Reg. 49334 (proposed Oct. 23, 1978), http://phmsa.dot.gov/staticfiles/PHMSA/hrmpdfs/1978%20hist%20rulemakings/43%20FR%2049334.pdf (referencing DOT/OPS-75/07, "Pipeline Industry's Practices Using Plastic Pipe in Gas Pipeline Facilities and the Resulting Safety Factors" (Toups Corp.)).

[2] *Strong v. E. I. DuPont de Nemours Co., Inc.*, 667 F.2d 682 (8th Cir. 1981) ("Here, viewing the facts in the light most favorable to the plaintiff, Judge Denney could find that NNG and Mr. Strong knew or should have known of the pull-out hazard"); *Kearney v. Kansas Pub. Serv. Co.*, 233 Kan. 492, 665 P.2d 757 (1983) ("There is also no doubt but that KPS was in violation of the regulations in the instant case as they apply to the requirement for anchoring installations such as the one involved here").

[3] *See*, *e.g.*, "Pipeline Accident Brief: Explosion, Release, and Ignition of natural gas, Rancho Cordova, California, December 24, 2008" (NTSB Report No. PAB-10-01), adopted May 18, 2010; "Kansas Public Service Company, Inc., Explosion and Fire, Lawrence, Kansas, December 15, 1977" (NTSB Report No.PAR-78-04), adopted July 5, 1978; "Nebraska Natural Gas Company, Pathfinder Hotel Explosion and Fire, Fremont, Nebraska, January 10, 1976." (NTSB Report No.PAR-76-06), adopted July 7,1976; NTSB Safety Recommendation, P-85-31, adopted Nov. 27, 1985; "Pipeline Accident Report, National Fuel Gas Company, Natural Gas Explosion and Fire, Sharpsville, Pennsylvania, February 22, 1985" (NTSB/PAR-85/02), adopted Oct. 25, 1985.

ironically by PHMSA itself[4] - **the failure to follow manufacturers' installation instructions, recommendations and warnings.** Unfortunately, other organizations, by citing PHMSA, have only perpetuated these myths.[5] These problems unfortunately continue in the instant Notice. The proposal to "overhaul Mechanical and Compression Fittings" by simply copying the flaws from the MFFR into the Gas Distribution incident report and adding "Contributing Factors" is symptomatic of the broader problem at PHMSA – data quality is accorded too low a priority.

NORMAC has actively participated in numerous venues in an effort to dispel rumors, and replace speculative and unsupported allegations about mechanical fittings and joints with factually accurate information.[6] Despite the significant advantages of mechanical joints over other methods for joining, operators are being misled, in part due to poor quality data published by PHMSA. NORMAC's latest demonstration of the engineering strength of compression joints is set forth in a research paper recently presented at the American Gas Association ("AGA") Operations Conference on April 21, 2016 in Phoenix, Arizona, a copy of which is attached to these comments and incorporated herein by reference. The research,

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[4] Advisory Bulletin ADB-86-02, issued Feb. 26, 1986, properly recognized that incidents had occurred due to improper joint design and recommended that "Each operator of natural gas pipelines review their present procedures for using mechanical couplings on plastic pipe to insure that the design of the coupling used, and the qualifications of the person(s) doing the joining meet the requirements of the Federal pipeline safety regulations contained in CFR Part 192 and in particular Sections 192.273(b), 192.281(e), 192.283(b), 192.285, and 192.287." U.S. Dept. of Transportation, ADB-86-02, Pipeline Safety Advisory Bulletin, at 2 (Feb. 26, 1986), http://www.phmsa.dot.gov/staticfiles/PHMSA/DownloadableFiles/Files/ADB_86_02%20PDF.pdf.

[5] *See, e.g.,* Plastic Pipe Institute, Position Paper: Replacement of Gas Distribution Pipelines, https://plasticpipe.org/pdf/epsd-position-gas-distribution-replacement.pdf (quoting December 2011 letter by PHMSA to NARUC encouraging commissioners to "accelerate the replacement of "… "Mechanical couplings used for joining and pressure sealing pipe, which are prone to failure under certain conditions;"(emphasis added)). Such accusations are both vague and baseless. Improper use of the fitting to make a joint is the only condition to cause leaks that has been shown by any research.

[6] *See* Comments, Recommendations and Request for Immediate Retraction of Norton McMurray Manufacturing Company, Docket No. PHMSA-RSPA-2004-19856 (Apr. 23, 2008). *See also* Renewed Request of Norton McMurray Manufacturing Company For Immediate Retraction and Adoption of Recommendations, Docket No. PHMSA-RSPA-2004-19856 (Feb. 24, 2009).

performed over eight years beginning in 2008, demonstrates a 99.998% success rate for compression joints based on a reasonable estimate of 400 million of these joints installed since about 1890. This engineering research also shows that the sealing power contained in a properly installed NORMAC compression joint is predicted to remain above 100 psi for at least 2,862 years; and includes data clearly showing that, despite earlier claims by PHMSA, age and degradation of the rubber gaskets have not been causing patterns of leaks; and that reports of nuts "loosening" or gaskets "shrinking" are simply myths. There are no studies or tests that support PHMSA's allegations. The true test of success is time in service. So far, properly installed compression joints have remained leak free for as long as 125 years. No other joining method enjoys a longer record of success.

III. NORMAC COMMENTS

A. GENERAL COMMENTS

From their inception in 1970, PHMSA has continually identified the purpose of its incident reporting forms as follows:

> Thus, the primary purpose of this regulation is to provide for the accumulation of factual data that will give the Department a sound statistical base with which to define safety problems, determine their underlying causes, and propose regulatory solutions.[7]

However, PHMSA's proposed revisions in this docket do not serve the "primary purpose" laid out by PHMSA for these data collection forms. This is because there is no

[7] U.S. Department of Transportation, Part 191 – Transportation of Natural and Other Gas By Pipeline: Reports of Leaks, Docket No. OPS-2, 35 Fed. Reg. 317 (Jan. 8, 1970), http://www.phmsa.dot.gov/staticfiles/PHMSA/hrmpdfs/1970%20hist%20rulemakings/35%20FR%20317.pdf.

overarching strategy for meaningful collection and use of the information, critical elements for the development of a "sound statistical base." Likewise, as demonstrated by NORMAC in numerous filings, publications addressing the cause of problems resulting from these forms (such as the MFFR) do not meet OMB-issued standards and guidelines that require Federal agencies to maximize the quality, objectivity, utility and integrity of their disseminated information.[8]

In 2009 PHMSA published a Data Quality Assessment ("Assessment") to evaluate and ensure that the agency's safety data provides a sound basis for risk-based decision making.[9] The agency's self-assessment tellingly concluded that (1) PHMSA does not capture the chain of failures – especially the root causes – that typically are associated with significant incidents; and (2) PHMSA has limited data on risk exposure to help it understand failure rates or trends.

Critical to the instant Notice, the Assessment concluded that: "At the root of all of these issues: *We haven't thought through what we need to know in a systematic way.* As a result, we often don't have the data we need to understand risk, while we don't use much of the data we collect."[10]

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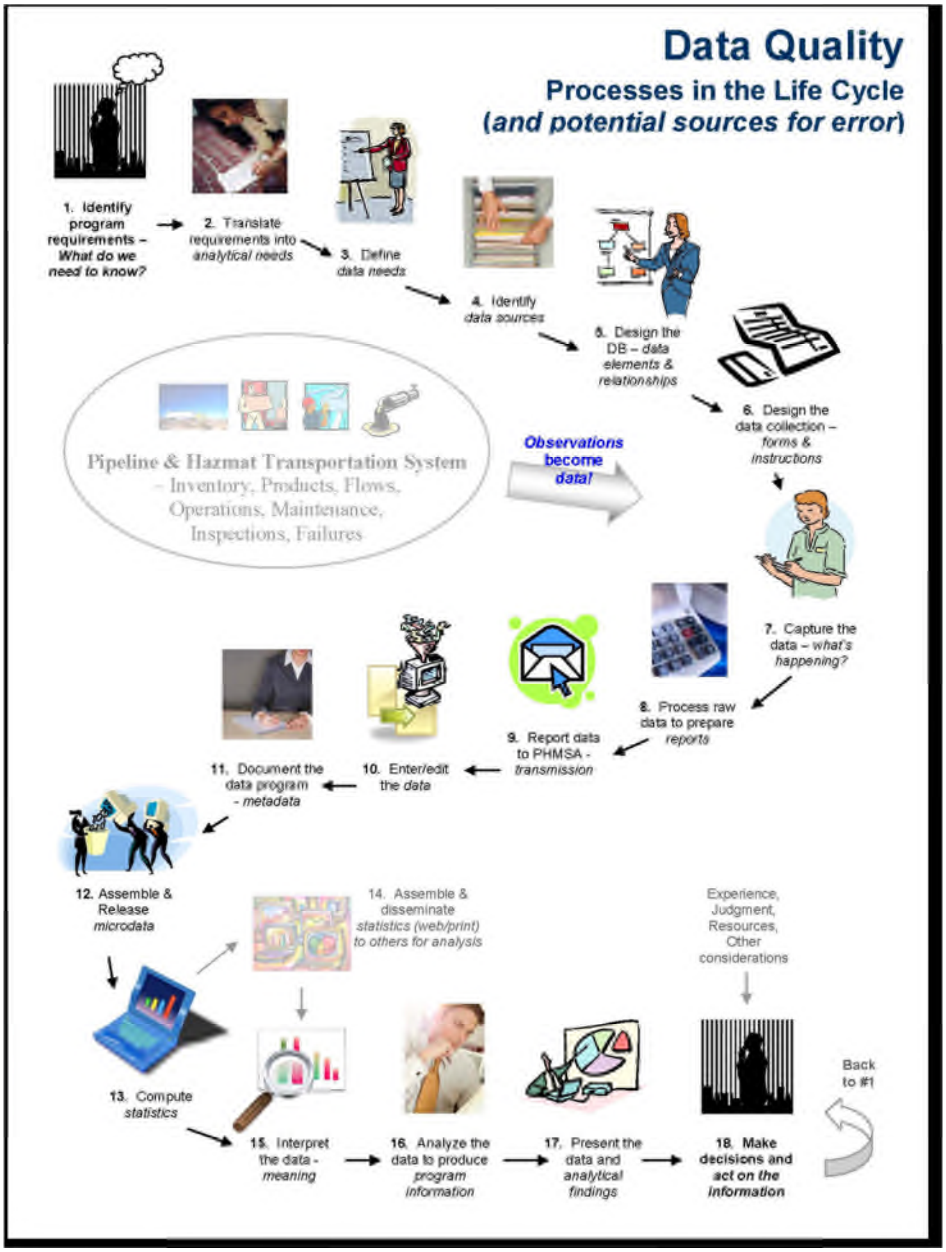
[8] Office of Management and Budget, Guidelines for Ensuring and Maximizing the Quality, Objectivity, Utility, and Integrity of Information Disseminated by Federal Agencies; 67 Fed. Reg. 8452 (Feb. 22, 2002) (2002 OMB Guidelines); *see also* Exec. Order No. 13,563, 76 Fed. Reg. 3821 (Jan. 18, 2011); Exec. Order No. 12,866, 58 Fed. Reg. 51,735 (Oct. 4, 1993); Office of Management and Budget, Standards and Guidelines for Statistical Surveys, 2-4 (Sept. 2006) (2006 OMB Standards);Office Of Management And Budget, Administrator Office Of Information And Regulatory Affairs, Guidance on Agency Survey and Statistical Information Collections (Jan. 20, 2006) (2006 OMB Survey Guidance).

[9] Pipeline and Hazardous Materials Safety Administration, Data Quality Assessment: Evaluating the major safety data programs for pipeline and hazardous materials safety (Nov. 10, 2009), http://www.phmsa.dot.gov/staticfiles/PHMSA/DownloadableFiles/Files/DQA%20Report.pdf ("Assessment").

[10] *Id.* at 1-3 (Emphasis in Original).

As part of their Assessment, PHMSA included the following flow chart that accurately depicts the appropriate processes for developing meaningful data programs:[11]



The author emphasized that each of these steps presents an opportunity for error in the data or its use, and cautioned that "*errors tend to accumulate* through the life cycle."[12] These

[11] *Id.* at Attachment A (Data Quality – Processes in the Life Cycle).

problems are easily prevented in the early stages in which the program requirements are identified and translated into analytical needs; and data sources are identified and captured.[13] However, problems that become embedded are difficult if not impossible to correct after the data is collected. For example, the Assessment pointed to the inherent bias in collected data:[14]

> We rely heavily on the regulated industry to help us acquire information. This is convenient, and goes directly to the source. It also introduces a natural, inherent bias in the data we collect. Our accident investigations have shown some significant differences between what the company reports and an objective view of these events. Our processes do not effectively reconcile these discrepancies. There is a historical understanding that the data we get from industry is "their" data. Even when we know (or believe) their data to be wrong, we don't modify our data until we get revised reports from the companies—which can result in releasing and using bad data for months or years after an incident.[15]

Several additional federal reports have also criticized PHMSA's information gathering programs, and the quality and usefulness of information presented to stakeholders.[16]

In sum, the Assessment and other critiques of PHMSA share a common thread: that data quality is the direct result of the diligence and expertise applied at the outset of the data

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[12] *Id.* at 11.

[13] *Id.* at Attachment C (Findings from the Data Quality Assessment) (Emphasis in Original).

[14] *Id.* at 2.

[15] *Id.*

[16] Notably, a DOT memo issued in 2012 provided similar criticism, namely that "PHMSA has not resolved long-standing data management deficiencies or established meaningful analysis capabilities." U.S. Department of Transportation, Office of Inspector General, Audit Report: Hazardous Liquid Pipeline Operators Integrity Management Programs Need More Rigorous PHMSA Oversight, at 3 (June 18, 2012), https://www.oig.dot.gov/sites/default/files/PHMSA%20Oversight%20of%20Hazardous%20Liquid%20Pipeline%20Operators'%20Integrity%20Managment%20Programs%5E6-18-12.pdf. *See also* National Transportation Safety Board, Safety Report: Transportation Safety Databases, at Abstract (Sept. 11, 2002), http://www.ntsb.gov/safety/safety-studies/Documents/SR0202.pdf ("Most of these databases are sponsored and operated by the modal administrations of the DOT. The Board's ability to study important safety issues is often affected by poor data quality."); U.S. Government Accounting Office, Pipeline Safety and Security: Improved Workforce Planning and Communication Needed, at 30 (Aug. 2002), http://www.gao.gov/products/GAO-02-785 ("In the past, we, the Safety Board, DOT's Office of the Inspector General, and others have identified problems with the completeness and accuracy of OPS's data.").

collection effort. The proposed changes in the instant docket do not follow the guidance of the agency's own Assessment, and as a result should not be implemented by PHMSA.

With data quality already lacking, NORMAC submits that the proposed revisions further degrade rather than enhance the quality, practical utility and clarity of information published to stakeholders. It is essential that stakeholders receive factual information from which regulatory and, more importantly, functional engineering decisions can be made; decisions that will improve on the already outstanding record of safety of natural gas pipelines.

The infirmities of PHMSA's proposed revisions fly in the face of direct recommendations made by the National Transportation Safety Board ("Board") over 35 years ago but never implemented. In 1980 the Board conducted a study evaluating the management and use by DOT of its gas pipeline data system, including the types of data collected, how the data system operates, and how it is being used by the DOT in fulfilling its responsibility for promoting public safety regarding gas pipelines. Among other findings, the Board determined that the pipeline data collected by PHMSA's predecessor, Materials Transportation Bureau ("MTB"), are "often inaccurate" due in part to the MTB's failure to have a pipeline data analysis plan.[17] The Board found that "development of such a plan must precede revision of the data reporting forms and reporting requirements to guide the selection of data collected and to assure that it is requested in a useable form."[18]

[17] National Transportation Safety Board, Safety Recommendations P-80-61 through -65, at 1 (Aug. 20, 1980), http://www.ntsb.gov/safety/safety-recs/RecLetters/P80_61_65.pdf.

[18] *Id.*

PHMSA can enhance the quality and utility of its incident reporting forms by complying with the following NTSB safety recommendations:[19]

> Develop and publish for public comment a formal data analysis plan for the pipeline data system. (Class II, Priority Action) (P-80-61)
>
> Postpone promulgation of proposed, revised pipeline data forms until development of a data analysis plan and coordination of the forms with the plan. (Class II, Priority Action) (P-80 -63)

By taking action today to implement these recommendations, PHMSA has the opportunity to take a powerful step forward to improve data management analysis capabilities that are necessary to address the safety problems that are the focus of the instant forms.

B. SPECIFIC RESPONSES TO ISSUES RAISED BY PHMSA

1. **Issue:** The need for the renewal and revision of these collections of information for the proper performance of the functions of the agency, including whether the information will have practical utility.

   Response: As discussed above, without an overarching plan for actually using the data, it is impossible to ensure that the data is of sufficient quality, rendering their practical utility nil. Further, it is impossible for the public to comment intelligently without knowing how PHMSA is going to use the information and whether the instant proposals are aligned with that plan.

2. **Issue:** The accuracy of the agency's estimate of the burden of the proposed collection of information, including the validity of the methodology and assumptions used.

   Response: Any burden associated with data collection that is not purposeful and meaningful is excessive. The instant Notice is a perfect example of PHMSA over-

[19] National Transportation Safety Board, Safety Recommendation P-80-061, http://www.ntsb.gov/safety/_layouts/ntsb.recsearch/Recommendation.aspx?Rec=P-80-061; National Transportation Safety Board, Safety Recommendation P-80-063, http://www.ntsb.gov/safety/_layouts/ntsb.recsearch/Recommendation.aspx?Rec=P-80-063. Though both P-80-61 and -63 were marked "Closed – Unacceptable Action" by NTSB in 1986 and 1990, respectively, it remains unclear as to why these significant recommendations were not implemented.

investing in report-level topics and under-investing in more important areas of concern, a problem identified in the Assessment:[20]

> We don't regularly monitor data quality indicators. We invest substantial resources in improving the accuracy of our data. But we do not track error rates or how much our efforts *change* the quality of our data. We could be over-investing in report-level accuracy compared to the more general problems with data gaps, concepts, and analysis of the data.

3. **Issue:** Ways to enhance the quality, utility, and clarity of the information to be collected.

   Response: To enhance quality, utility and clarity, PHMSA must follow NTSB's recommendation to defer any modifications to existing data collection forms until a data analysis plan that meets OMB criteria and DOT Information Dissemination Quality Guidelines[21] is completed through the public comment process. Further, quality, clarity and usefulness of information will be improved by increasing the minimum financial limit for a reportable incident to $500,000 so that operators can focus their talent and resources on root cause analysis of fewer, more devastating incidents rather than on filling out forms for multiple incidents. To reach these goals, NORMAC supports a collaborative Total Quality Management approach bringing together subject matter experts. This approach would be consistent with AGA's admonition to PHMSA "…to utilize the Gas Data Quality & Analysis Team on subsequent revisions to report forms and analysis of the information submitted."[22]

4. **Issue:** Ways to minimize the burden of the collection of information on those who are to respond, including the use of appropriate automated, electronic, mechanical, or other technological collection techniques.

   Response: PHMSA can minimize the burden on stakeholders by collecting and publishing only observations, not conclusions or opinions or findings that are not independently verifiable.

C. ADDITIONAL RECOMMENDATIONS

1. <u>The Proposed "Contributing Factors" Category Should Be Eliminated</u>

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[20] Assessment at 2.

[21] *See* U.S. Department of Transportation, Secretary's Policy Statement On Information Quality (Aug. 2002), https://cms.dot.gov/sites/dot.gov/files/docs/DOT%20Information%20Dissemination%20Quality%20Guidelines.pdf.

[22] American Gas Association, Comments on PHMSA's Proposed Revisions to Annual and Incident Reports, PHMSA-2013-0084 (Dec. 27, 2013).

a) Consistent with the above-discussed recommendations by NTSB, OMB and the Assessment, the proposed "Contributing Factors" category should not be added unless and until a plan for analyzing and using the new data in a way that develops a sound statistical base to define safety systems is developed and first made available for public comment.

b) According to the Assessment's flow chart detailing essential steps to maximize data quality, there are 5 processes that must be fulfilled prior to designing any data collection forms and instructions.[23] To the best of NORMAC's knowledge and belief, none of these 5 processes have been implemented or, if they have, publicly shared by PHMSA to support or provide context for the addition of a Contributing Factors category or any other changes proposed in this Notice.

c) Responses to a query for "Contributing Factors" are not factual observations. They merely are subjective opinions of individuals who likely are not subject matter experts. Therefore any publications based on such responses do not present facts and as a result cannot meet OMB requirements that federal agencies maximize quality, integrity and utility of information disseminated.

d) The current databases include innumerable errors of fact. Rather than add new opportunities for additional errors using a format already shown to be deficient, PHMSA should improve the effectiveness of validation of incoming incident reports consistent with their commitment to NTSB in response to recommendation P-80-065, which advised PHMSA that its incident reports have not resulted in a sufficient level of accuracy and usefulness. PHMSA responded as follows:

> Beginning with the pipeline operator annual reports for 1985 and the pipeline operator incident reports for 1986 the appropriate staff of the state regulatory agency or ops regional offices will validate the data reported. A validation procedure has been developed and provided to each regional office with further instructions to be distributed to each state agent. The procedures will also be included in the pipeline safety data analysis plan.[24]

e) In sum, NORMAC believes that validation of "Contributing Factors" is not possible because the information gathered is not factual. Further, because it would require a completely independent analysis to substantiate the opinions recorded as "Contributing Factors", such analysis likely would be unduly burdensome and in the end still would not result in factual information. Consistent with recommendations

[23] Assessment at Attachment A.

[24] *See* Pipeline and Hazardous Materials Safety Administration, PHMSA Response to NTSB Safety Recommendation P-80-065 (Mar. 17, 1986), http://www.ntsb.gov/safety/_layouts/ntsb.recsearch/Recommendation.aspx?Rec=P-80-065.

in the Assessment, the data should be a recording of observations, specifically avoiding the current requests for opinions or conjecture. This should not be done haphazardly or piecemeal, but rather as part of a well thought out plan that is proposed to the public for comment. As such, publications based on these proposed queries would violate OMB rules and guidelines for ensuring data quality.[25]

2. Proposed Use of the Terms "Joint" and "Fitting" are Inaccurate and Must Be Corrected

Definitions are the heart and soul of any language. Without them, meaningful communication is impossible. Without precise use of language, the OMB requirement for maximizing clarity cannot be achieved. PHMSA, after consultation with OMB, has indicated its intention to initiate rulemaking to modify regulations 191.12 and 192.1009 to correct conflation of the terms "joint" and "fitting" throughout its regulations, forms, and instructions, even going so far as to retroactively correct prior publications and undertake rulemaking to correct this deficiency.[26] PHMSA should make similar corrections to the forms under consideration in this Notice, and align all affected language within these forms with existing PHMSA definitions of "Joint" and "Fitting" as follows:

> Joint: *Refers to the connection between two lengths of pipe such as the weld joint for steel pipe and the heat fusion or glue joint for plastic pipe. Joint is also used as a slang term meaning a length of pipe i.e., joint of pipe*.

[25] *See* Treasury and General Government Appropriations Act For Fiscal Year 2001, P.L. 106-554, § Section 515, https://cms.dot.gov/sites/dot.gov/files/docs/DOT%20Information%20Dissemination%20Quality%20Guidelines.pdf (directing OMB to issue government-wide guidelines to Federal agencies for ensuring and maximizing the quality (objectivity, utility and integrity) of information disseminated by Federal agencies).

[26] Pipeline and Hazardous Materials Safety Administration, Pipeline Safety: Information Collection Activities, Revisions to Incident and Annual Reports for Gas Pipeline Operators, 78 Fed. Reg. 71,033 (Nov. 27, 2013) (PHMSA Initial Comment Response is available at http://www.reginfo.gov/public/do/DownloadDocument?objectID=44870401; PHMSA's Revised Comment Response is available at http://www.reginfo.gov/public/do/DownloadDocument?objectID=*50880701*).

> Fitting: *A part used in a piping system, for changing direction, branching or for change of pipe diameter, and which is mechanically joined to the system.* [27]

These definitions are not new. They have been industry standards since before federal safety regulations took effect in 1970. Over the years, this important distinction in meaning has been diminished, causing errors and misunderstandings. The "fitting" is a product, just as welding wire is a product. The quality of a "joint" is dependent on how one uses the product, as explained by PHMSA in 1982:

> *Specifically, Mr. Butler's letter requested a review of test data from Southwestern Laboratories to determine whether or not the joint complies with §192.273 of Part 192, Title 49 of the Code of Federal Regulations, a general safety standard for joining pipe by means other than welding. The report from Southwestern Laboratories includes data on hydrostatic tests and tensile tests with Grade B ERW pipe, and states that the test results meet American Petroleum Institute requirements. It appears that the connection is capable of producing a joint that can withstand the contraction and expansion forces and external and internal loads mentioned in §192.273(a), and that it is gastight as required by §192.273(b). However, actual compliance with §192.273 would depend on proper installation of the connection by a pipeline operator or his contractor under field conditions, a matter which we cannot judge based upon the test results alone.*
>
> *Our determination whether the mechanical joint meets §192.273 is not necessary for Mr. Butler to market the product. This standard is written in performance language, allowing the pipeline operator flexibility in choosing the best joining methods to achieve pipeline safety. It is not our policy to endorse proprietary methods or products that meet the applicable requirements of the Federal standards. The selection and use of particular joining methods are ultimately the pipeline operator's responsibility.* [28]

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[27] PHMSA Operations & Maintenance Enforcement Guidance, Part 192, Subparts L and M.

[28] PHMSA Interpretation #PI-82-008 (May 14, 1982), http://phmsa.dot.gov/portal/site/PHMSA/menuitem.6f23687cf7b00b0f22e4c6962d9c8789/?vgnextoid=115ddb65dde0b110VgnVCM1000009ed07898RCRD&vgnextchannel=2b9b34d513f95410VgnVCM100000d2c97898RCRD&vgnextfmt=print.

To properly investigate reportable incidents, all stakeholders must use the terms "joint" and "fitting" in accordance with the standard accepted definitions. Further, as PHMSA develops and executes a plan in accordance with the Assessment, PHMSA must rigorously vet the language used so that it is precise, meaningful, and avoids any confusion.

3. Sections 191.12 and 192.1009 of PHMSA's Regulations and the MFFR program (Form F 7100.1-2) are Fatally Flawed and Therefore Should Not Be Integrated Into the F 7100.1 Incident Report Form.

   a) The MFFR is a prime example of a data collection design that fails to meet OMB requirements. The "apparent cause" section of the MFFR asks respondents to provide findings or conclusions rather than observations. This type of flaw is highlighted on the PHMSA Assessment flow chart which reads "Observations become data!" As indicated by the exclamation point, anything other than a cold observation should not be used as data! If it's not observable, it cannot be factual.

   b) PHMSA's non-public interagency discussions with OMB regarding the appropriate path forward for ensuring data quality underlying the MFFR and associated regulations are unknown to NORMAC. However, as PHMSA is well aware of the content of those discussions, it should apply the lessons learned from OMB in all data collection efforts, including those addressed herein.

IV. CONCLUSION

For the reasons discussed above, NORMAC proposes that the instant reporting forms may have passed their useful life and do not provide the level of factual data quality necessary to support the PHMSA's mission of continually improving safety. To properly address safety and regulatory actions in today's environment of Integrity Management programs and increased emphasis on root cause analyses, PHMSA must utilize a collaborative Total Quality Management approach. This requires an overall reevaluation of the need for the forms under consideration in the present Notice. Essential to success is the proper employment of a team of talented and experienced subject matter experts. To begin this journey, PHMSA would be well advised to engage the services of experts in information gathering design, methodology and execution along with industry stakeholders to modernize the overall program and create a replacement based on the 1980 recommendations from NTSB, the 2009 Data Quality Assessment, and OMB requirements for data quality.

NORMAC is committed to continued transparency in incident reporting as an important initial step towards achieving accurate and comprehensive identification of the root causes of pipeline accidents and incidents. But enough is enough. As demonstrated above, PHMSA has created confusion within the pipeline industry through its various data collections because of the lack of linkage to its performance-based federal pipeline safety regulations, definitional inconsistencies across its forms and prejudicial questionnaires and associated instructions within its forms, particularly F 7100.1-2 (MFFR). PHMSA must take steps to remedy the damage that these actions have caused to the pipeline industry and insure that future reporting requirements are designed to achieve accurate and comprehensive analytical root cause analysis of pipeline accidents and incidents. To that end, NORMAC requests that PHMSA adopt the comments and suggested recommendations discussed above, in order to collect accurate, transparent and objective data that will enhance pipeline safety.

Respectfully submitted this 12th day of July 2016.

NORTON MCMURRAY MANUFACTURING COMPANY

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Attachment A: NORMAC, Presentation to the AGA Ops Conference: "Compression Fittings — How Long Do They Last?" (April 21, 2016)

Compression Fittings – How Long Do They Last?

Presentation to AGA Ops Conference April 21, 2016

Phoenix, AZ

Glenn McMurray, Deepaknatraj Selvaraj, Conrad Wojtan

Norton McMurray Manufacturing

NORMAC

Abstract: Designed in 1890 compression joints contain a massive rubber gasket that receives tons of hydraulic pressure during installation, assuring high margin of safety and long-term fitness for service. Author will address myths surrounding the MFFR and explain why as many as 400 million compression joints in service last so long.

Disclaimer: The views and opinions expressed in this presentation are those of the presenters and do not necessarily reflect or represent the views and opinions held by any other person or entity, nor are they associated with or endorsed by any other person or entity.

Introduction

- Compression joints have been used to join natural gas piping since 1888.
- Compression joints have a service record of longevity in natural gas distribution systems unsurpassed by any other underground joining method. This means not only is the design and capability of the equipment robust, but also that the installers have done a great job.
- Research by Dresser from 1972 can be used to show a secure seal in compression joints is predicted to remain for 1,140 years or longer with 5:1 margin of safety or higher.
- Testing by NORMAC also predicts pressure in gasket will remain above line pressure for centuries.
- The long record of success to date of compression joints is a direct result of proper tightening of the joint during installation which overcomes the effects of compression stress relaxation (CSR) in the rubber gasket.
- Because CSR is not well understood, some mistakenly report that the nuts loosen or the gaskets shrink in compression joints. The combined factual research by NORMAC and Dresser disproves these myths and legends.
- PHMSA's claim in ADB-08-02 that gaskets in compression joints leak because of age and degradation is proven wrong by data collected via the MFFR. The advisory bulletin must be corrected.
- MFFR publications stating that equipment causes leaks is based on flawed research and must be retroactively corrected.
- NORMAC estimates total population of 400 million compression joints across the US.
- With a denominator of 400 million, a numerator from MFFR data of 7,200 the success rate of compression joints is 99.998%.

The combination of long term in-service success, backed by sound research by Dresser and NORMAC proves that compression joints and the wide variety of fittings used to make them are essential to extending the amazing safety record of the natural gas distribution community far into the future. Despite their strength and value, compression fittings have come under a lot of scrutiny in recent years. Much of the dialogue has been misdirected and ill-informed. The purpose of this paper is to clarify the facts by summarizing engineering research that explains how and why joints made with wedge type compression fittings have such a long history of success.

Compression Fittings 101

At the 2011 AGA Operations Conference, NORMAC's presentation titled *Compression Fittings 101* offered basic information on compression fittings, their use in making compression joints, an overview of compression fitting design, function, applications, regulations and standards, potential failure modes and techniques for forensic root cause analysis in case of failure. Unfortunately, certain decisions, including the implementation of regulations 191.12 and 192.2009 (the MFFR), about compression fittings have been made based on inadequate reviews of case history. For a thorough listing of in-depth documentation related to leaks in compression joints, see 'Reference Information' included as an appendix to the formal detailed *Compression Fittings 101*paper. A copy of both the PowerPoint slides and the paper is available in the AGA Plastic Materials Library.

A Joint Is Not A Fitting

Recently, a misguided focus of the industry has named the fitting as the cause of failure in leak situations. In fact, the fittings have not been failing, the joints between the pipe and the fitting have leaked. This is not a difference of opinion or a matter of mere semantics. A joint is separate and apart from a fitting. Joints are made by operators during construction. Joints might be welded, fused or made with compression fittings. These joints are regulated.

Fittings, on the other hand, are made in a factory and shipped to the customer for installation. They are carefully engineered and tested before being accepted by the operators for use in their systems. Just like any other piece of equipment, to perform their function properly, they must be installed properly.

NORMAC has taken exception to a number of statements PHMSA has published regarding the performance of compression fittings. Suffice it to say that PHMSA publications regarding responses to question 15 of the MFFR (identifying the equipment as causing leaks) are fatally flawed and that statements made by PHMSA in ADB-08-02 and elsewhere regarding age and degradation of gaskets causing leaks are not supported by the evidence.[1] These incorrect statements have been communicated to NAPSR, NARUC, PSC's, industry associations, operators and the public. PHMSA has more recently indicated that the focus of the MFFR has actually been on joints rather than fittings and accordingly has indicated that they may take up the appropriate rulemaking to change "fitting" to "joint" throughout the regulations and other

[1] *See* "Comments, Recommendations and Request for Immediate Retraction of Norton McMurray Manufacturing Company", filed April 23, 2008 in Docket No. PHMSA-RSPA-2004-19856. See also "Renewed Request of Norton McMurray Manufacturing Company For Immediate Retraction and Adoption of Recommendations" filed February 24, 2009.

documents, but has not committed to a timeframe.[2] NORMAC takes the position that such actions are too little too late and do not address the fundamental flaw within the MFFR – that PHMSA's data collection methodology for collecting information in response to question 15, Apparent Cause, is not capable of providing information that is accurate or meaningful, which in turn makes the PHMSA findings stating that the leading apparent cause of leaks is the "equipment" invalid. The longer that inaccurate information remains in the public view, the harder it becomes to correct. These fallacies, unfortunately, have become legends in some sectors of the natural gas industry. As with most legends, the more they get repeated, the more believable they become. The research presented herein demonstrates that information that PHMSA has published in the last 10 years about compression fittings does not hold up to scrutiny and must be corrected retroactively without delay.

Compression Fittings – A Brief Primer

Compression fittings were invented in about 1888 by Solomon Dresser as a means to make "permanent" joints in underground piping systems. In the ensuing decades, especially in the post-war baby-boom era, gas distribution companies relied heavily on compression fittings to join mains and service lines into suburbs across the nation. Up until about 1965 the only other popular means to join steel pipe was welding.

Compression fittings come in two types; nut-follower and bolted as shown below.

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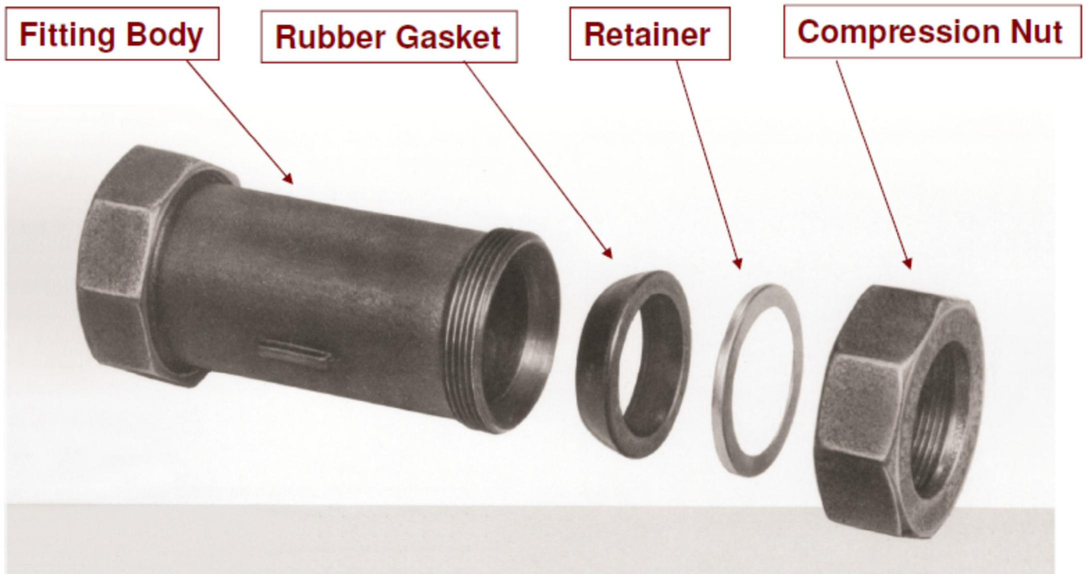
[2] *See* Pipeline Safety: Information Collection Activities, Revisions to Incident and Annual Reports for Gas Pipeline Operators, 78 Fed. Reg. 38,803 (June 27, 2013) *available at* http://www.gpo.gov/fdsys/pkg/FR-2013-06-27/pdf/2013-15339.pdf. Initial Comment Response: http://www.reginfo.gov/public/do/DownloadDocument?documentID=448704&version=1. Revised Comment Response: http://www.reginfo.gov/public/do/DownloadDocument?documentID=508807&version=1.



Nut-follower compression joints are tightened using two pipe wrenches. One wrench holds the fitting body stationary while a second wrench turns the compression nut which in turn crushes th gasket against the pipe. Just like when making up a joint that includes pipe threads, simple training and supervised experience give the installer everything they need to know about how to make the joint. It is important to note that NORMAC installation instructions provide a minimum amount of force to apply to the wrenches. There is no maximum when joining the fitting to steel or polyethylene pipe.

How Do Compression Joints Work?

As indicated by their name, compression joints operate by squeezing a rubber gasket tightly against the piping. This squeeze, or compression, creates pressure in the gasket, which must be higher than the line pressure, otherwise a leak will occur. The pressure created in the gasket by sufficient tightening is what gives compression joints their margin of safety. The pressure within gaskets of properly installed compression joints is many times higher than line pressure. As with any properly engineered system, this margin of safety is essential to long-term in-service success. Catastrophic failures can occur if the wrenches are not turned with enough force during installation. In an industry where failure exposes risk to human life, it is critical to minimize the potential of it occurring.

To clarify, NORMAC installation instructions do not use torque in foot-pounds. Rather, the minimum force in pounds that should be applied to the end of a particular size pipe wrench is listed. This is because tightening is so simple that operators do not need to use torque wrenches in the field. For clarity, this paper uses “torque” as often as possible.

It is important to understand that the compressive force applied to the gasket during installation does not stay constant over time. This is primarily due to a material property common to all elastomers under compression known as compression stress relaxation (CSR), also known as force decay, which is explained as follows. As a rubber gasket experiences a constant strain (in this case compression) over time, it takes less stress to keep the gasket at the given strain because of the properties of viscoelastic materials like rubber.[3]

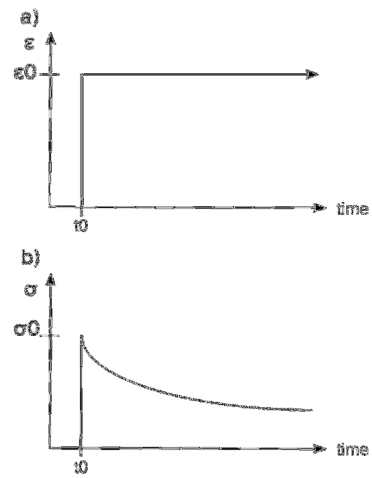


Figure 1

Applied Strain (ε) and Stress (σ) as a function of time for a viscoelastic material such as rubber. Here we can see stress relaxation[4]

The amount of relaxation that occurs is a function of a variety of factors. All of these are accounted for and overcome by the margin of safety inherent to the design of compression fittings and manufacturers recommended installation procedures.

This bears repeating. Relaxation of sealing pressure in the gasket is overcome by proper tightening of the joint.

[3] ASTM D6147 - 97(2014) Standard Test Method for Vulcanized Rubber and Thermoplastic Elastomer—Determination of Force Decay (Stress Relaxation) in Compression.
[4] Stress Relaxation. (2015, November 03). Retrieved April 03, 2016, from https://en.wikipedia.org/wiki/Stress_relaxation

Rubber gaskets under compression naturally relax and creep over decades in service.[5] Unfortunately, this natural and normal phenomenon is not well understood by many in the gas industry. When observing a compression joint that has been in the ground for some time and noticing a relatively small amount of torque remaining on the joint, some remark that the nut backed off. Others say that the gasket shrunk. These ill-informed judgements are wrong, but they have been spread as legends from generation to generation. As will be shown, these observations are usually the result of stress relaxation in combination with low torque on the joint during installation.

Of course, the particular elastomeric material chosen from which to make the gasket is important. The material that has typically been used since the time of WWII is either a form of Buna-N or Buna-S, both of which are also used successfully in a wide variety of sealing mechanisms throughout natural gas distribution systems including meters, swivels, regulators, compressors, stab fittings, etc. These are synthetic materials. Prior to WWII the only available material was natural rubber which has less robust material properties than modern synthetics.

Another factor that affects long-term sealing is known as "shape factor." One guide to designing with elastomeric seals explains "The gasket's plan view and thickness have an effect on its relaxation characteristics."[6] The plan, or section view of wedge shaped gaskets used by NORMAC and Dresser is based on the power of the inclined plane, one of the 6 simple machines. This shape is perfectly suited to the application, directing the force applied by the wrenches inward toward the pipe to create a secure seal.

[5] Gaskets – Design, Selection and Testing. Czernik, Daniel. McGraw-Hill, 1996.
[6] Ibid, page 96

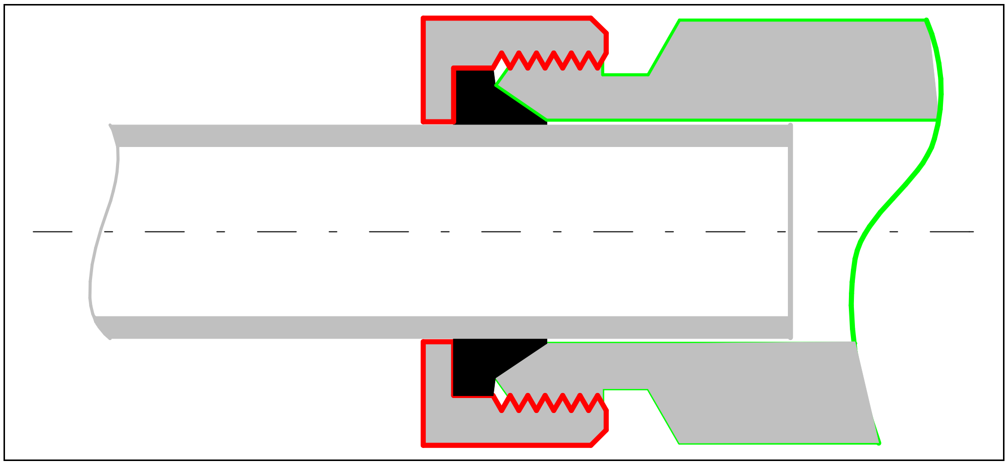


Figure 2

Wedge gaskets also present a large area for sealing against the pipe. This large surface area combined with high pressurization of the gasket through proper tightening makes it possible for compression joint to seal across larger imperfections or abnormalities, such as the rough surface of a casting, than those with lesser surface area in contact with the pipe.

Wedge type gaskets are relatively large compared to those found in other types of mechanical fittings. As such, they can be compressed to higher pressures without physical damage and can store a higher level of pressure for a longer time than smaller gaskets much like a larger battery has more power stored than a smaller one.

Another factor is the degree to which the gasket might bulge or escape the cavity into which it gets compressed. If allowed to bulge, creep can occur and gasket pressure can be lost. Compression fittings have been carefully designed to minimize annular space and constrain the gasket from bulging. There are two areas where bulging might occur. These are at the small end of the gasket in the space between the pipe and the fitting body and at the opposite end of the gasket in the area between the pipe and the compression nut or follower ring. Both Dresser and NORMAC have designed gaskets that contain metal inserts molded into the gasket that fills the gap between the gasket and fitting body, constraining the gasket from bulging.

Compression joints are simple and straightforward to install. As the saying goes, history repeats itself. The recent concerns about compression fittings and joints have already been discussed and resolved. In the 1970's when questions about joints made with compression fittings on plastic pipe also arose, it was determined that as long as the joints were properly installed, compression joints and the fittings used to make them are perfectly acceptable for joining natural gas piping. In reviewing the field in preparation for implementing new regulations, the precursor to PHMSA, the Materials Transportation Bureau (MTB) found "the joining procedures are so simple that persons making joints should only need to show that they have followed the procedures to be qualified."[7]

The original design goes back to Solomon Dresser in about 1888. His design took advantage of all these factors – use a wedge shaped gasket, make it a big one, constrain the gasket so it can't bulge, and most importantly instruct users to tighten them fully during installation. That combination has produced 125 years of success, so far, and is a testament to his invention.

Success Over Time is Determined by Tightening Force Applied During Installation

When you assemble a compression joint, the force applied to the wrenches crushes and pressurizes the rubber gasket. When the joint is tightened to manufacturer's recommendations the pressure in the gasket can be as high as 3900 psi immediately after tightening. The pressure

[7] Federal Register Vol 44, No. 142 July23, 1979 page 42972

reduces exponentially over time. It initially decays rather rapidly but then essentially remains constant, virtually immeasurable, over the life of the joint. The pressure in the gasket, being considerably higher than the line pressure in the natural gas piping system provides a margin of safety for many years. In fact, as will be shown, the pressure in the gasket is predicted to remain above line pressure not just for years or decades, but for centuries.

In layman's terms the reduction in sealing power flatlines within a month or so after installation. As with any exponential curve, a point in time is reached after which the rate of change is extremely small, virtually zero, making further reductions of sealing power of compression joints immeasurable. The pressure in the gasket in this flatline stage might be 1400psi, far greater than any line pressure in a natural gas distribution system making a leak virtually impossible.

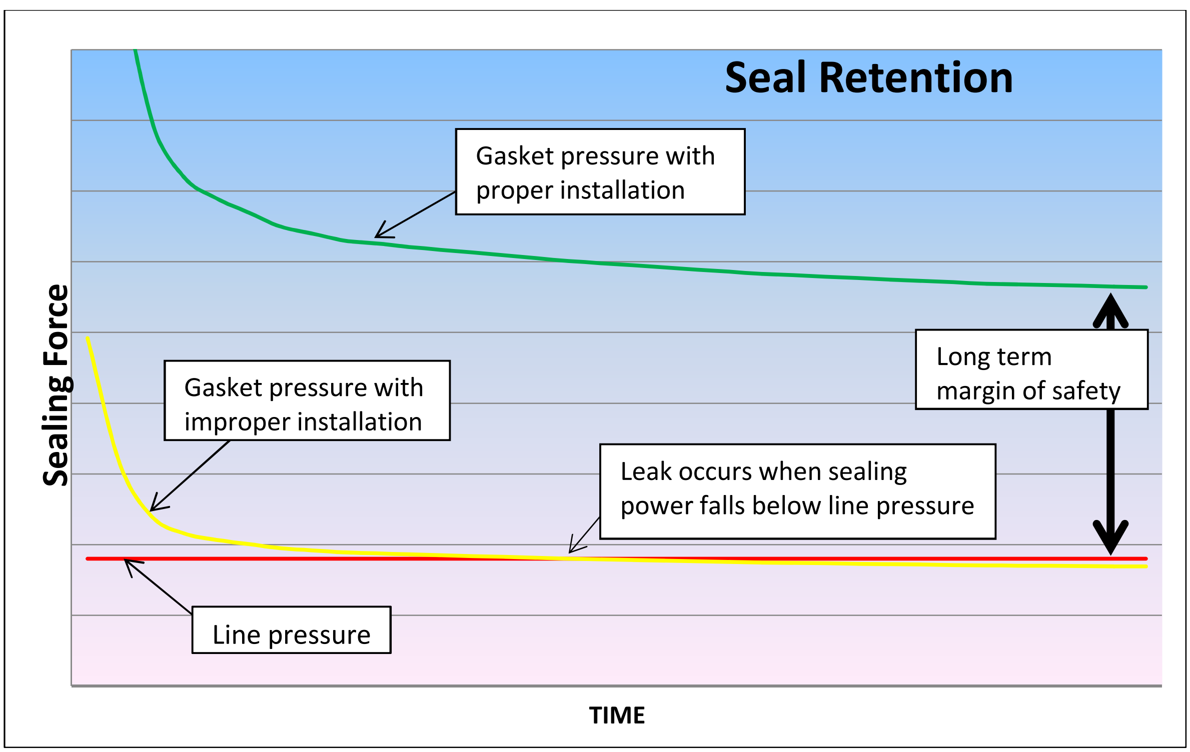


Figure 3

However, as illustrated by the yellow line in figure 3, if a joint is installed with less force applied to the wrenches than the manufacturer recommends, a premature leak is more likely. With less tightening, the reduction in gasket pressure curve takes the same shape, but with a lower starting point the long-term gasket pressure is reduced and the margin of safety can be compromised. NORMAC testing has shown that even with very little pressure applied to the pipe wrenches during installation, it is still possible to seal against line pressure shortly after the joint is assembled. For example, a test on a NORMAC 2” compression joint revealed that 60psi air pressure can be sealed with only 10 pounds of force applied to the end of a 24” wrench. If this joint were installed in a natural gas distribution system, given that the rubber in the gasket will relax over time the joint might pass a pressure test, but a premature leak might occur within days or weeks.

Our experience since 1938 investigating leaks reported to us makes it clear that the leading cause, by far, of leaks in compression joints is the insufficient tightening of the joint during installation.

Material Science of Elastomers - Testing for Compression Stress Relaxation

In order to more fully understand why compression joints have such strong performance, we may examine how the rubber material in the gasket reacts over time. It has been established (Dresser 1972) that Compression Stress Relaxation (CSR) of the gasket during its life in service is important to the long term sealing capability of compression joints. The material science and test method used to compare the CSR of one elastomer compound to another is found within ASTM

D 6147. Bear in mind that engineering decisions require balancing priorities and examining multiple factors against one another. One may focus on CSR, for example, or other individual aspects of the rubber compound, but these must always be balanced against other factors such as performance at varying temperatures, the effect of any chemical reactions as a result of contact with natural gas, compression set, the shape of the gasket and the effects of friction during assembly. These must all be taken into consideration as part of the overall process of design and development. Testing the overall assembly is essential to demonstrating the function and performance. A functional test can serve as a compilation of the multitude of test methods executed in an attempt to capture real world behavior. Functional tests are best executed in parallel with validated test methods to complete the picture. This form of supportive testing reveals major influential factors regarding expected performance. The actual performance of the assembled joint is what is important as opposed to generalizing from material characterization testing alone.

Focused Research

This research addresses only Dresser/NORMAC style compression joints with wedge shaped gasket. Other designs will perform differently. The wedge shaped gasket gets “wedged” between the body of the fitting and the surface of the pipe. The wedge is one of the six “simple machines” that leverage or amplify the forces that get inputted. In the case of compression fittings, the torque applied to the nut (or nuts on bolted type) is amplified to create pressures within the gasket up to as much as 3900 psi so that gasket pressure is maintained above line pressure for as long as is needed.

Wedge style compression fittings are one type of mechanical fitting. These have distinct advantages over other mechanical fittings, particularly their long-term sealing power. Other mechanical fittings generally have smaller gaskets, some use o-rings, some use other shaped gaskets. Certain mechanical fittings include limiters that stop the compression of the gasket at a certain point. This paper addresses only the capabilities of compression fittings that utilize wedge shaped gaskets. As will be shown, the reason for the longevity of wedge style compression joints is the combination of the large size of the gasket, the wedge shape of the gasket and the high level of pressure applied to that gasket by following the manufacturer recommendations for proper installation. Research herein demonstrates that this combination is predicted to provide a seal against line pressure that lasts for centuries.

Dresser 1972 Research on Long-Term Sealing

Comparison of Long-Term Sealing Characteristics of Compression Type Couplings on Steel & Polyethylene Pipe

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In the six years prior to 1972, Dresser had sold fittings that made well over one million nut-follower type compression joints on plastic pipe. With plastic pipe being relatively new to the industry, this quantity gives a glimpse into the volume of compression connections, or joints, that were being installed onto steel and copper materials. To assure those who raised questions about whether compression joints on plastic pipe would provide the same reliable sealing power as had been proven on steel pipe for over 80 years, Dresser did the research. The question centered on the elastomeric nature of the polyethylene pipe. Would the plastic deform through compression stress relaxation (CSR) over time to a degree that the joint may lose its seal? Dresser engineer

Rothwell summarized research designed to answer that question in a report to the 4th AGA Plastic Pipe Symposium, in November 1972 that confirmed that yes, compression joints on polyethylene pipe demonstrate virtually identical long-term performance as on steel.

The Dresser research provides an excellent explanation of how they accomplish such long term success – by providing sufficient initial loading to the gasket during installation by turning the wrenches with sufficient force. Put more simply, the success of compression joints depends primarily on being tightened at least to the minimum force recommended by the manufacturer.

Initial testing of nut-follower type joints provided inconclusive results. Dresser shifted their testing to bolted type. Because the two types are remarkably similar, testing of bolted type may reasonably serve as a proxy for the performance of nut-follower type compression joints.

Dresser used a sequence of three different methods to determine the amount of pressure retained in the gasket over time. The first method measured the reduction in bolt strain via strain gages on a bolted down, assembled compression joint. Because of the linear relationship between stress and strain ($\sigma = E*\varepsilon$), where E is a material's Young's Modulus or stress-strain constant, this reduction in strain on the bolt over time is easily translatable to the measure the stress relaxation. They took strain measurements over 10,000 hours and plotted the strain against log time as seen in figure 4.[8] A second test method confirmed these findings.

[8] Dresser data is presented in log-log format to compress time frame of exponential curve

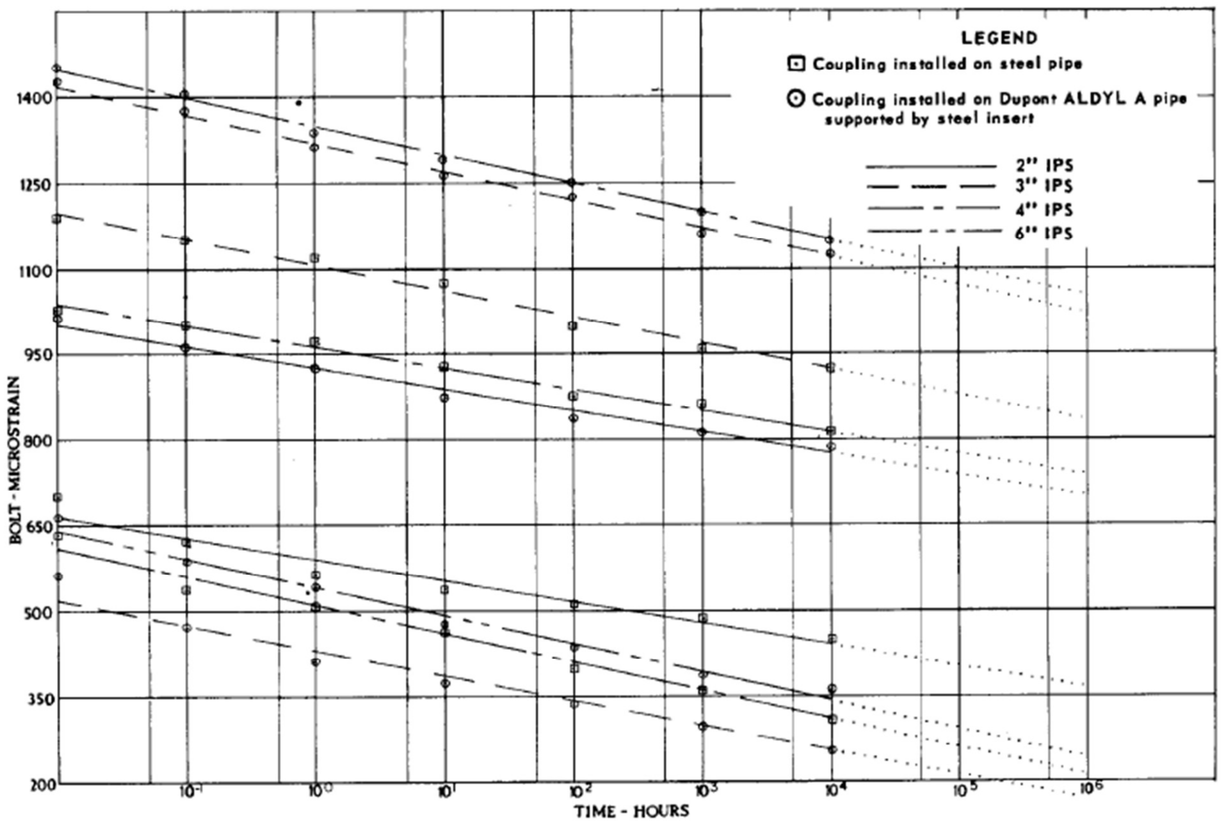

Figure 4 Bolt Strain vs Log Time

Dresser used a second set of tests to confirm the curves established in the bolt-strain testing and to determine gasket pressures. Dresser also used the second testing to help determine actual gasket pressures. Results are shown in Figure 5.

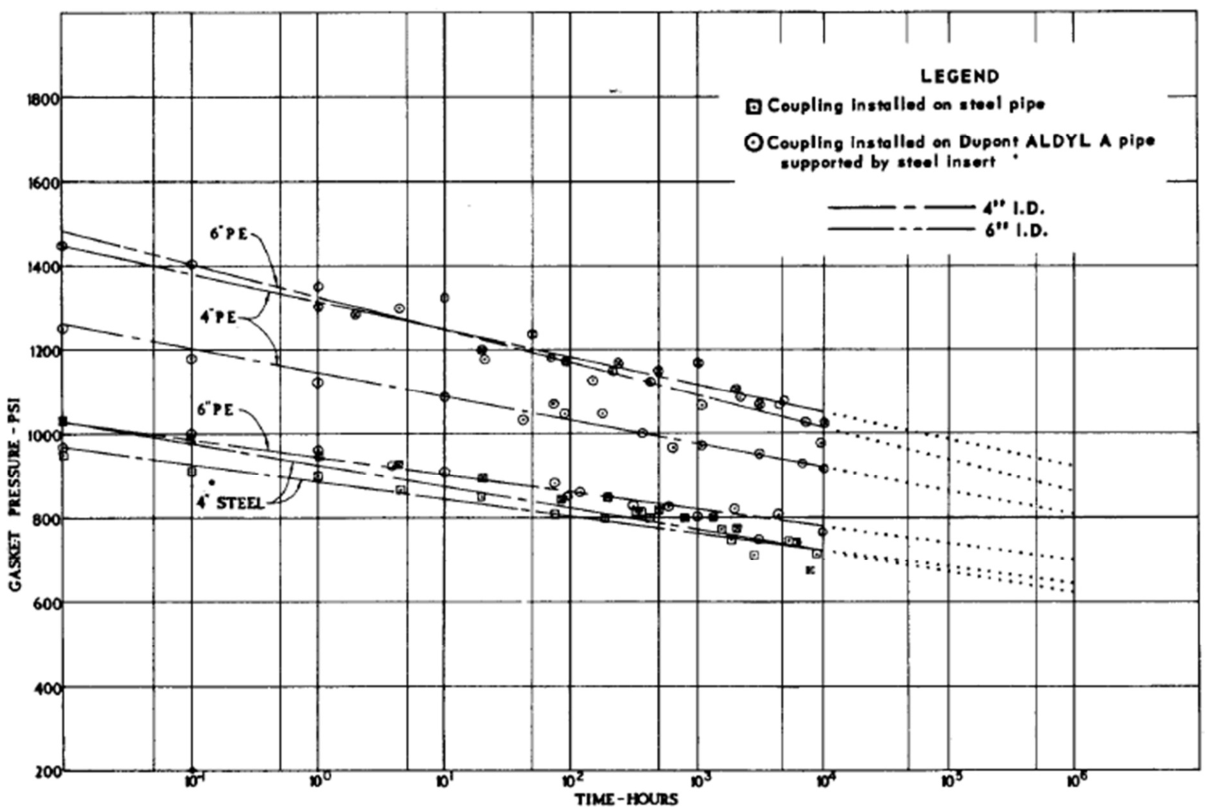

Figure 5 Gasket Pressure vs Log Time

After 13 months and about 2 weeks, gasket pressure in all cases was consistently above 600 psi. Dresser extrapolated that gasket pressure should remain above 600 psi at 10^6 hours, or 114 years on both steel and plastic pipe, thereby demonstrating the answer to the research question. Compression joints on polyethylene pipe will last as long as had been proven successful for over 80 years in service on steel pipe.

Dresser performed an additional test to examine the effect of imparting a lesser amount of force to the gasket during installation. They summarized the result of that test by saying "… the higher the initial gasket loading, the more reliable will be the seal in terms of remaining gasket pressure after extended periods of time." The test results supporting this statement are included in Figure

4, where sizes of pipe were tested in pairs. There are two lines for each size, except for 3" which has a third line. This is the lowest line on the graph. The strain on the bolts for this test starts just above 500 in micro-strain units and crosses the bottom axis (approximately 200psi gasket pressure) after about 10^5 hours, or 11.4 years. The other two curves for 3" start much higher, at about 1200 and 1400 units and remain much higher, in the range of 750psi or above after 10^6 hours, or 114 years.

Discussion – Dresser Research

Engineered systems must be designed with an appropriate margin of safety. As noted above, the pressure in the gasket must remain above the pressure it is meant to seal, otherwise a leak will occur. At 500 psi gasket pressure, sealing against a 100psig natural gas distribution system provides a 5:1 margin of safety. Dresser's 1972 research predicts that this 5:1 margin of safety will be present after 114 years.

In 1972, Dresser had about 80 years of success. In 2016, there is now 125 years of in-service experience without any evidence that leaks are correlated to the age. Now that the 114 years predicted in 1972 has been surpassed, further extrapolation from Dresser's data is reasonable. Extending the data lines on Dresser's chart by one more order of 10 predicts that pressure in the gasket will remain above 500psi after to 10^7 hours, or 1,140 years.

This research demonstrates why properly made compression joints last so long – proper tightening of the joint pressurizes the gasket to provide margins of safety that overcome the effects of all factors at play within the joint, including CSR. This provides strong evidence that compression joints can be expected to seal properly for centuries.

Dresser's research also indicates that less than recommended force applied to wrenches during installation can result in premature leaks.

NORMAC Research

Knowing NORMAC and Dresser products as well as we do, NORMAC understands that the results of Dresser's research on bolted joints also apply to nut-follower joints. To confirm that understanding, NORMAC undertook the challenge beginning in 2008.

Overview:

NORMAC testing follows a similar path as the research done by Dresser. By determining 1) the actual pressure in the gasket, and 2) the rate at which gasket pressure changes, one may determine how long the gasket pressure will be sustained.

The tests were:

- Hydrostatic pressure testing of joints 1000 days, or 33 months after joint was assembled to determine gasket pressure.
- Measurements of torque on properly assembled joints over 8 years to determine rate of change.

Hydrostatic Testing

Hydrostatic tests were performed in 2013 on several joints in various sizes ranging from ¾" to 2" made up between NORMAC bead-tipped fittings and steel pipe. Tightening force was set at minimum recommended in NORMAC installation instructions. Joints sealed in the range of 3500- 3900psi on ¾" and 800 to 1800psi on 2". Fittings, pipe and joints were preserved for future comparison testing.

Figure 6 HydrostaticTesting Setup

In 2016, approximately 1000 days later, the same joints were retested. The ¾" joint sealed pressures ranged from 1400 to 1600psi. The 2" joint sealed in a range from 350 to 600psi.

Torque Retention Testing

In 2008, NORMAC joints were assembled onto medium density polyethylene pipe by an independent lab following manufacturer's instructions. Tightening force was controlled to match the minimum recommended torque published in the instructions. The independent lab then measured the amount of torque on the joints every 6 months. As expected, the results formed an exponential curve. The torque retention curve in Figure 7 shows the rate of change of torque of six 2" joints.

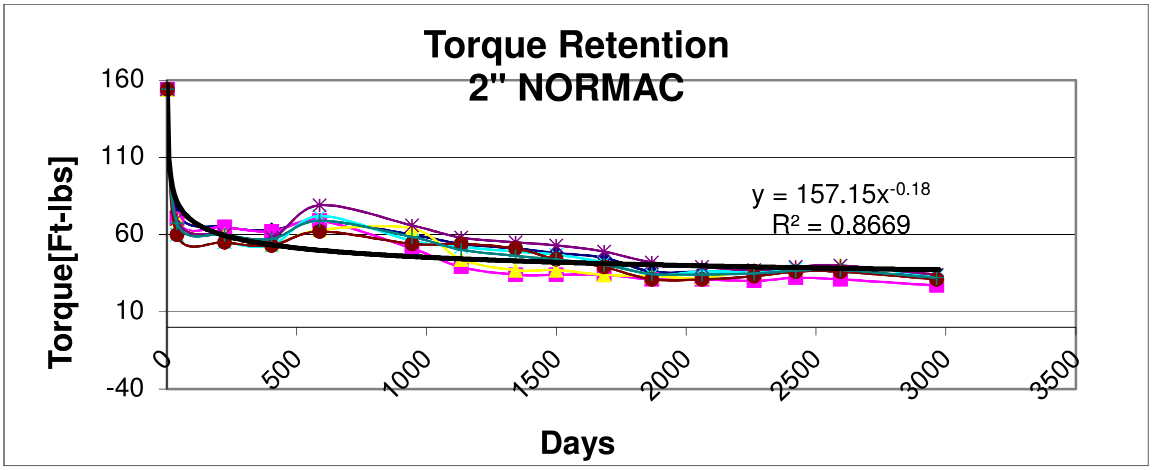

Figure 7

A curve with a goodness of fit of approximately 0.87 was fit for the data points of torque recorded over 8 years. Using the power trend line option of MS Excel, the equation of the curve is obtained as:

$$y = 157.15\, x^{-0.18}.$$

<u>Translate Torque to Gasket Pressure</u>

Dresser stated that the relationship between bolt torque and gasket pressure is directly linear. NORMAC has found the same with nut-follower joints. As such, the torque on the compression nut is an indicator of the pressure within the gasket.

The average torque retained after approximately 1000 days on the six 2" joints was 45.4 ft.lbs. Hydrostatic tests after 1000 days held pressure of 350psi. This gives a ratio of 7.71:1 which can be inputted to the equation as constant (k value). Additional work to establish such a correlation provided results that would result in longer times before gasket pressure would be predicted to fall below 100psi.

Taking the conservative value of 7.71, now the equation of curve to analyze declination of pressure within the gasket over time becomes

$$y = 7.71 * 157.15\, x^{-0.18}$$

Results

Results predict that the joint should be expected to hold pressure of 100 psi for 2,862 years.

Limitations

The pieces involved in both the torque retention and hydrostatic tests were disturbed by the testing process. The hydrostatic testing protocol disturbs the parts in several ways. These disturbances, including actual leaks caused by testing, create conditions that are worse than are found in actual service.

The method used to perform torque retention tests was changed at an unknown point in time. At first, the force needed to move the nut in the forward direction (tightening) as little as possible was measured and recorded. The compression nut was not returned to the witness marks made on the compression nut and fitting body at the time the joint was originally made up. Each successive measurement tightens the joint. This is the technique that NORMAC has used extensively for many years, but only for limited number of measurements per joint. As indicated by the individual plot lines on the chart above, this technique produced measurements that seem to indicate that the torque is not declining exponentially.

After consulting with NORMAC, the methodology was changed. The original witness marks were lined up and amount of torque required to loosen the joint was recorded.[9] After each measurement the witness marks were lined up and assemblies placed in storage.

Despite that two different methods were used to collect torque measurements, the results, taken as a whole, are appropriate for use for establishing the rate of change in gasket pressure. In particular the earliest measurements, being higher than the fitted curve, skew the data to a faster time to failure by increasing the slope of the rate of change. Lastly, each time a measurement is taken, the joint is disturbed. It is likely that an undisturbed joint would retain more torque.

A limited number of data points were available in each portion of the testing. Overall, the data inputted to the calculations were selected to present the information in as conservative manner possible.

Discussion

Research that demonstrates an expected gasket pressure above 100psi for 2,862 years supports and supplements the findings by Dresser. When viewed in light of 125 years in-service success,

[9] When measuring torque remaining on joints that have been in service, NORMAC recommends avoiding "breakaway" torque as an indicator of torque remaining due to corrosion and other factors interfering with accuracy of measurement. The joint should be freed up and then the torque required to re-tighten the compression nut to its original position should be noted.

this is a strong indicator that properly made joints with wedge shaped gaskets in natural gas distribution should remain fit for service for many centuries.

Effects of Reduced Tightening Torque

A ¾" joint assembled to minimum recommended torque held pressure up to 3500-3900psi in hydrostatic testing and after 1000 days held pressure of 1433psi average across 6 tests with the lowest being 1400psi. A separate ¾" joint assembled at the same time to 50% of minimum recommended torque initially held pressure up to 2500psi. After 1000 days, this joint was also hydrostatic tested and held pressure to an average of 825psi across 6 tests with lowest being 800psi. This demonstrates that a joint installed with a greater amount of force applied to the wrenches will provide a stronger seal against pressure after 1000 days. Because after 1000 days, the effects of CSR are well into the "flatline" stage, this also provides a preliminary insight into how little torque might need to be applied during installation in order for a ¾" NORMAC joint to leak on a line running typical pressures in distribution.

Cumulative Analysis - NORMAC and Dresser

The combination and accumulation of test results by both Dresser and NORMAC explain why compression joints have 125 years of success so far and why sufficient installation torque is critical to long-term success. These also provide a clear understanding of the effects of CSR and why reports of nuts "loosening" or gaskets "shrinking" are myths. While the NORMAC results indicate a shorter time to "failure", the NORMAC analysis included numerous efforts to input conservative measures. Both provide evidence that the gasket pressure within properly made wedge-type compression joints can be predicted to maintain appropriate margin of safety and fitness for service for centuries.

<u>400 Million Joints = 99.998% Success</u>

PHMSA reports approximately 7,200 leaks per year related to compression joints.[10] Reporting raw quantities of leaks in isolation is not useful. PHMSA recognizes this and have noted that the largest limitation of their research is the lack of a denominator against which the number of leaks can be compared.[11] Further, PHMSA indicates that such a number is unavailable. Without this important information, decisions may be based on fear rather than on rational logic. To determine the percentage, one must know the total population to be used as a denominator, against which the number of leaks can be compared. NORMAC has calculated conservative estimate of the total number of compression joints installed since 1890 is 400 million.

7,200 leaks compared to 400 million joints equates to a 99.998% success rate. While remarkable to some, this is the level of integrity that is expected by our industry, because we deliver natural gas.

In 1972 an article titled "Study of Major Gas Distribution Utilities in the United States Having 5000 or More Customers" was published that reported miles of main and number of services in natural gas distribution systems. [12]

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[10] PHMSA / MFFR data analytics website https://hip.phmsa.dot.gov/analyticsSOAP/saw.dll?PortalPages

[11] Analysis of Data from Required Reporting of Mechanical Fitting Failures that result in a Hazardous Leak (§192.1009) November 17, 2015 http://primis.phmsa.dot.gov/dimp/docspm/MFFR_Data_Analysis_Procedure_2015_Report_11172015.pdf

[12] Title of publication unknown. Data from the article kept by NORMAC has been confirmed by

Such data from the year 1972 is important because that was at a point in history where plastic pipe was just starting to gain wide acceptance. As more plastic pipe was laid, fewer compression joints were installed. Engineers decided to move toward an all plastic system and minimize the work needed to protect against corrosion, being that compression fittings are generally made of metal due to the high forces that are generated by compressing the rubber gasket. By having a record of the miles of main and number of services circa 1972, one can calculate the number of compression joints installed by that date.[13] This makes it safe to say that greater than 99% of all pipe in the ground was metallic in 1972. One can then also estimate the number of additional joints added per year since then to arrive at a total quantity of joints today.

As has been noted elsewhere, a coupling is different from a joint. Being that a coupling is a fitting that sits between two pieces of pipe, each coupling is used to make two joints.

Steel pipe was available in either 20 or 40 foot lengths. Because the data regarding mains from the 1972 article is in miles, the number of couplings per mile can be established by dividing a mile by 30 feet, with 30 feet being halfway between the 20 and 40 foot lengths of pipe that may have been used. This puts the number of couplings per mile at 176.

comparing to initial Pipeline and Gas Journal Top 500, published 1981. See addendum.

[13] This method was also used to estimate 600,000 couplings with 40-50 leaks over a 5 year period in PREPARED ANSWERING TESTIMONY OF LEWIS M. BINSWANGER ON BEHALF OF PEOPLES GAS SYSTEM; BEFORE THE FEDERAL ENERGY REGULATORY COMMISSION AES Ocean Express, LLC v. Florida Gas Transmission Company, Docket No. RP04-249-001

To estimate the number of couplings on service lines, one must examine a typical service line. The diagram below shows an elbow at the connection to the main, a curb cock with compression joints on both ends and two compression couplings on piping leading to the meter, for a total of 8 couplings or 16 joints. There can be additional compression joints in a service line as well, particularly on long-side services where the main is at a greater distance from the meter. To be conservative the calculations herein used two couplings (4 joints) per service line.

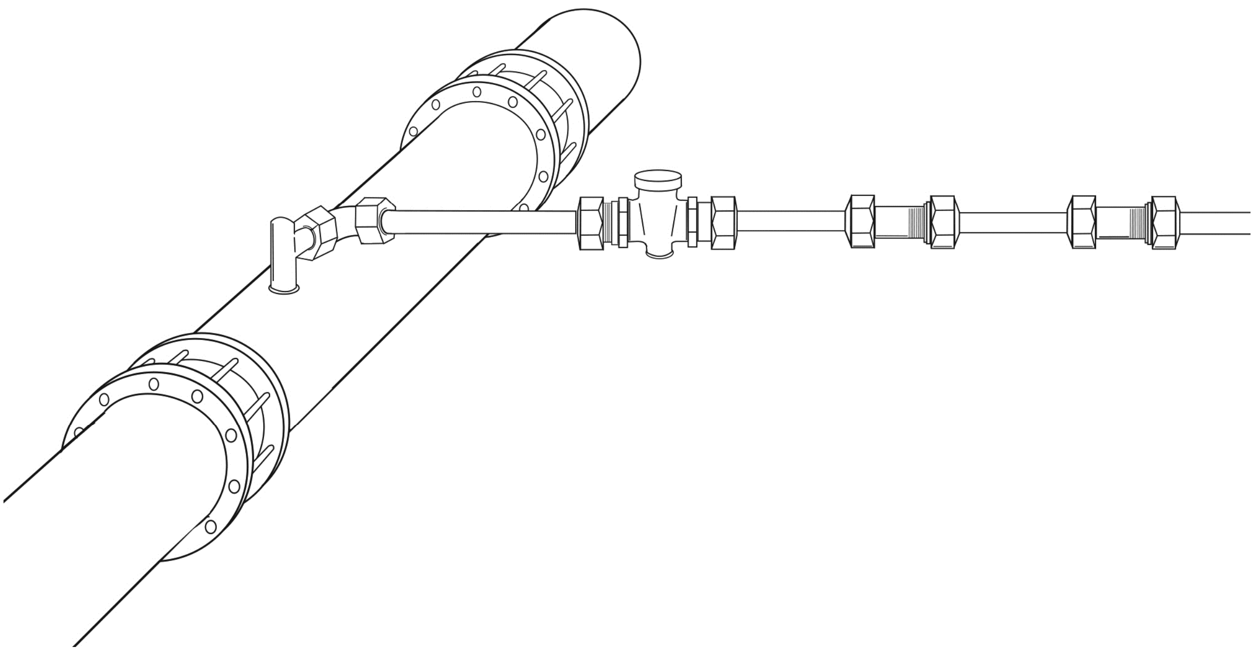

Figure 8

The 1972 study listed 274 natural gas distribution companies. A sampling of 16 of these yielded 95,437 miles of main and 7,504,373 services. At 176 couplings per mile of main and 2 couplings per service the total is 31,805,658 couplings.

Because each coupling represents two joints, the total number of compression joints in 16 of 274 operators in 1972 is 63,611,316.

Extrapolating from the 16 operators to the total of 274 produces 1,089,343,787 compression joints across the U.S. or nearly 1.1 billion joints. However, it is understood that not all operators used compression fittings. A number of systems were built of cast iron with bell joints while others were constructed with welded joints. Further, the number of joints in the systems in the 16 chosen as the sample may not be representative of the total population. To accommodate these factors, and to be conservative in estimating, the 1.1 billion must be reduced, substantially. By reducing by 70%, the number of joints in the U.S. as of 1972 can be an estimated at 326,803,136.

Compression fittings have continued to be used since 1972, but not at the same pace, largely because plastic pipe is available in longer lengths than steel and the broader adoption of alternative joining methods such as butt fusion, electrofusion, and stab type fittings. To estimate the number of joints installed between 1972 and 2016, the average rate of installation prior to 1972 was calculated and then factored down by a percentage. The average rate was calculated by dividing the estimated 326,803,136 joints in the U.S. as of 1972 by the number of years since compression fittings were invented. Having been invented in about 1890, the denominator is 82 so the average number of compression joints installed per year prior to 1972 is 3,985,404.

By factoring down the average number of joints installed annually prior to 1972 by 55%, the number installed per year after that time is 1,793,432. This means that in the 44 years since 1972 an additional 78,911,001 compression joints have been installed.

This brings the total number of compression joint installed in the U.S. to 405,714,137.

Success rate

With 400,000,000 as an estimated denominator compared a numerator of the 7,200 leaks per year reported via the MFFR program, the success rate of compression joints stands at 99.998%.

Consider, too, that this is a success rate not only of the equipment, but of the operators' installation practices across the nation as well. Over 300 million compression joints were installed prior to any regulation of the industry, prior to OQ, and prior to drug and alcohol testing. As with any joining method, compression joints must be installed correctly and the record of success of compression joints demonstrates that the vast majority of installers did just that.

If the estimate is off by a factor of 4, a denominator of 100 million compression joints puts the rate of success still at an astounding 99.993%.

Further, an argument can be made that the quantity of leaks per year is not the appropriate numerator. PHMSA has reported a total of approximately 36,000 leaks since initiating the MFFR in 2011. Using this total as numerator against 100 million denominator, puts the success rate at 99.964%.

Misinformation Published by PHMSA

The MFFR publicizes that the "equipment" is causing the leaks. It is important to recognize that PHMSA has not ensured that the sources of this information are reliable or qualified to draw accurate conclusions about the apparent cause of leaks in compression joints. For this reason and others, the responses to the question "apparent cause" are suspect at best. PHMSA's advisory bulletin also claimed compression fittings leak due to the deterioration over time of the elastomeric materials they contain. Research presented herein and elsewhere contradicts and discredits what PHMSA has said.

Age and Degradation – Fact or Fallacy?

The factual data collected in the MFFR about the age of leaking joints demonstrates that the hypothesis that leaks are caused by the degradation of the gasket is but a myth, a fallacy. If age and degradation were a true problem, there would be a clear pattern where the oldest leak first. While the MFFR program is flawed in many ways, data about year installed, being factual, is valid. Most reported leaks are on joints installed in the 1960's to 1980's.

If the theory that age causes leaks were true, the data would appear as in Figure 9. The oldest would be failing more often than newer installations.

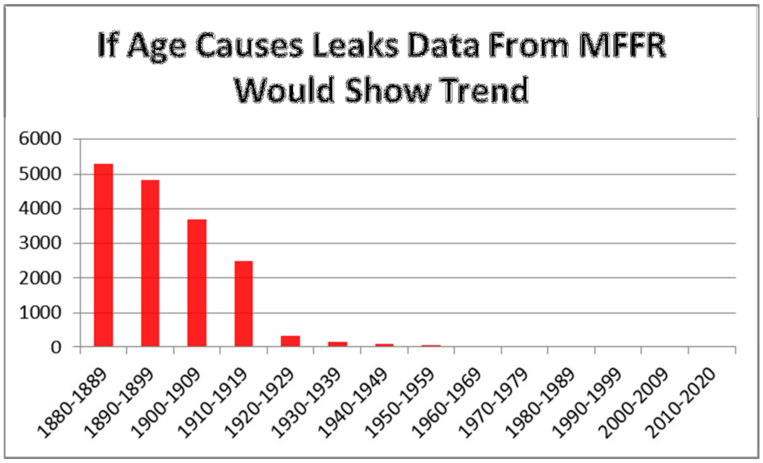

Figure 9 MFFR data would show oldest failing more often than newer if leaks were caused by age.

However, the actual data shows a radically different situation (Figure 10):[14]

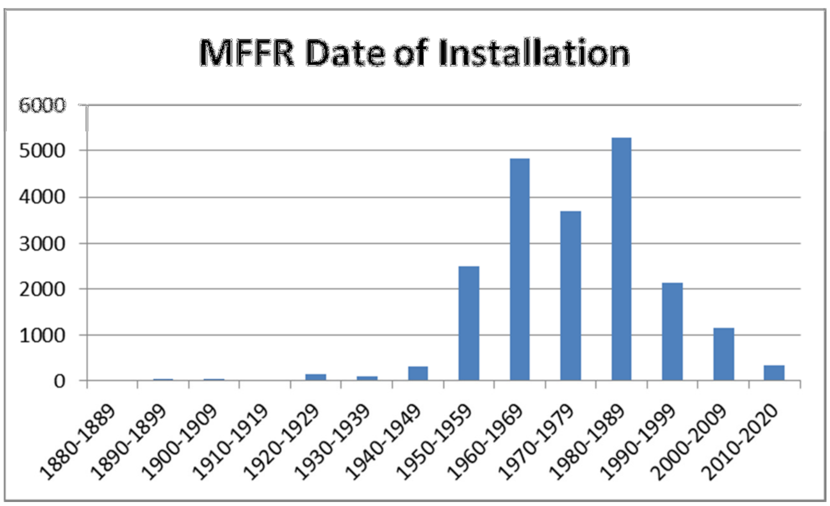

Figure 10 MFFR data shows more joints failing that were newer installations.

PHMSA's statement that leaks are caused by the age of the gasket in the 2008 advisory bulletin has yet to be supported by any evidence. The data provided in the MFFR, combined with research presented herein, demonstrate evidence against PHMSA's claim. Yes, a good number of

[14] Mechanical Fitting Failure Data from Gas Distribution Operators , PHMSA website http://phmsa.dot.gov/portal/site/PHMSA/menuitem.6f23687cf7b00b0f22e4c6962d9c8789/?vgnextoid=06cc95f181584410VgnVCM100000d2c97898RCRD&vgnextchannel=3430fb649a2dc110VgnVCM1000009ed07898RCRD&vgnextfmt=print

compression joints have been retired, replaced, etc. But that cannot explain the MFFR data. It would be very hard to imagine that virtually all of those installed prior to 1950 have been removed. Further, prior to WWII the only choice of material was natural rubber which has less robust material properties than modern synthetics. As with most modern materials, synthetic elastomers perform better than their natural counterparts. This is important to note because it demonstrates that even with an elastomer compound that is not as strong as today's compression joints made with natural rubber continue to seal properly.

Problems with the MFFR – Is it really "Equipment" Failure?

Sound research requires that information be accurate and valid. Data collection methodology is a specialized field of study with specific rules and guidelines for collecting data that is accurate and reliable. The design of the MFFR did nothing to ensure the accuracy or validity of the responses to any of the questions, including number 15 which asks for the apparent cause of the leak. Consider one example. How is an operator to accurately report a leak on a steel line that gets replaced by relining or a copper line that gets replaced by parallel boring? In these cases, the "apparent cause" must be recorded as unknown because the leak is never seen. However, because "unknown" is not an option, PHMSA forces respondents to make choices that are not necessarily accurate.

There were several situations where patterns of leaks occurred in compression joints in the years just prior to the ADB being published in 2008. In those cases, the causes were consistently identified as the inappropriate use of a joint that could not pass the tests outlined in 49CFR192.283(b), or more commonly, by incorrect installation – particularly insufficient tightening of the joint per manufacturers recommendations.[15] A simple rule of logic, commonly known as Ockham's Razor, states that the simplest answer is also the most likely. As such, before any other steps are taken, it makes sense to first rule out any possibility that installation practices may have caused the problem.

Both the ADB and publications by PHMSA stating that the apparent cause being the "equipment" are not supported by the facts. It is not age and degradation. It's not the equipment that is causing leaks. Sadly, these incorrect understandings have been widely distributed to NAPSR, NARUC, industry associations, and others. These publications do not advance our understanding of the safety record of compression joints, they actually distract our efforts. To assure that history does not repeat itself and to assure that lessons learned are properly embedded in the industry knowledge base, PHMSA should correct the record.

Conclusion

The engineering behind compression fittings and compression joints is not complicated. The robust design and immense margin of safety are easily understood. The facts presented by Dresser in 1972 and by NORMAC research herein show clearly that the key to long term success is proper installation. The tighter you assemble the joint, the longer it will last. Properly installed compression joints prevent leaks for time periods measured in centuries, not decades.

There is no better test of a product than actual in-service performance. The big picture is that greater than 99.9% of compression joints function safely. This is the kind of time-tested

[15] This statement may not be readily apparent if one reads only the most widely disseminated reports of the time. As noted previously, Compression Fittings 101 includes 'Reference Information' which provides extensive in-depth information.

information that is most reliable-- ie, hard, empirically sound, longitudinal data. Longitudinal data of this nature requires no speculation or conjecture.

Compression joints are incredibly simple to install and the installers in our industry have done a great job making sure that safety comes first. However, in a select few cases insufficient force has been applied to the wrenches making premature leaks inevitable.

To preserve and uphold our collective duty to ensure safe delivery of natural gas, we must place premium value on engineering facts that are properly supported by concrete observations. The natural gas industry contains some of the most incredible engineering marvels of our time. Compression joints performing at above 99.9% success rate are integral to that amazing record of safety. To continue to build on that level of success, we must guard against bad research, question all assumptions, and develop a transparent, accessible knowledge base that can be relied upon.

Addendum – Calculations for 400 Million Compression Joints

Estimated Total Number of Compression Joints in United Stated Natural Gas Distribution Systems

Norton McMurray Manufacturing, April 4, 2016

1972 Data Derived from Magazine Article "Study of Major Gas Distribution Utilities in the United States Having 5000 or More Customers." June, 1972 Title of Magazine Unknown.

Because June 1972 Magazine Article Cannot Currently be Located, Data is Confirmed by First Similar Article in Pipeline and Gas Journal "The PC&J 500", August 1981

405,714,137 Estimated Total Number of Compression Joints Installed Since 1890

	1972 Miles of Main	P&GJ 500 - 1981 Miles of Main	1972 Number of Services	P&GJ 500 - 1981 Number of Customers
Alabama Gas	4,952	6,094	302,728	352,479
Atlanta Gas	13,822	16,069	619,458	794,202
Baltimore Gas	3,912	4,235	480,630	510,451
Consumers Energy, Jackson, Michigan	15,635	19,224	886,000	1,138,109
Corning Gas	225	312	11,826	11,623
New York State Electric & Gas	2,024	2,384	123,830	127,947
Niagra Mohawk	5,658	6,063	409,012	423,035
Nebraska Natural	300		17,746	
Peoples Energy - Chicago	4,123	4,042	951,219	884,085
Peoples Energy - North Miami, FL	1,740		120,000	
North Shore Gas - Chicago	1,417	1,585	78,688	96,635
Rochester Gas & Electric	2,865	3,224	196,030	213,157
PSE&G	11,670	12,369	1,322,825	1,306,952
Washington Gas Light	5,475	5,762	537,626	554,342
LILCO	5,507	5,676	385,557	387,310
Lone Star	16,112	2,736	1,061,198	1,174,686

Total: 95,437 Miles of main

	503,907,360	Feet of main	7,504,373	Number of services
	16,796,912	Couplings on mains (Using 30 foot for lengths of pipe)	15,008,746	Number of couplings on service lines (2 per line)
Each coupling has 2 joints	33,593,824	Number of Joints on mains	30,017,492	Number of Joints on Services

63,611,316	Total conservative estimate of joints on mains plus services on 16 selected LDC's out of 274 total
6%	16 of 274 LDC's as %
1,089,343,787	Calculated total compression joints in all 274 LDC's as of 1972
326,803,136	**Total Joints Reduced by 70% to account for LDC's that did not use compression fittings and other uncertainties**
3,985,404	Average quantity installed per year since 1890 until 1972
1,793,432	Average quantity installed per year since 1972 (45% of prior annual average)
44	Years since 1972
78,911,001	Additional joints installed since 1972
405,714,137	**Total Conservative Estimated Number of Joints**