Analysis of Data from Required Reporting of Mechanical Fitting Failures that result in a Hazardous Leak (§192.1009)

This procedure describes how PHMSA typically processes and analyzes data from operators of gas distribution pipelines for mechanical fitting failures that result in a hazardous leak as required in §192.1009. PHMSA intends to change the name of the information collection activity required in §192.1009 to Mechanical Joint Failure Reports (MJFR) in future rulemaking. In this document, the acronym MJFR will be used preferentially and synonymously with Mechanical Fitting Failure Reports (MFFR).

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Mechanical Joint Failure Reporting Requirements

Mechanical Joint Failure Reports (MJFR) for the previous calendar year are required to be submitted to PHMSA by March 15th of the next year per §192.1009. Operators are required to submit their reports electronically through the PHMSA Pipeline Data Mart (PDM) system. Raw data and analyses on MJFR is available to the public at http://primis.phmsa.dot.gov/dimp/perfmeasures.htm . The MJFR data is available to PHMSA personnel in the PDM, and the data is downloaded and analyzed. This procedure describes how PHMSA will process and analyze data from operators of gas distribution pipelines for mechanical joint failures that resulted in a hazardous leak as required in §192.1009.

Rulemaking is in progress to change the name of the Mechanical Fitting Failure Report to Mechanical Joint Failure Report to better characterize that the hazardous leak occurred within a joint connection of pipe and the apparent cause of leakage may not be due to equipment failure of the fitting.
The reporting requirements of §192.1009 are:

> *§192.1009 What must an operator report when compression couplings fail?*
> *(a) Except as provided in paragraph (b) of this section, each operator of a distribution pipeline system must submit a report on each mechanical fitting failure, excluding any failure that results only in a nonhazardous leak, on a Department of Transportation Form PHMSA F-7100.1-2. The report(s) must be submitted in accordance with § 191.12.*
> *(b) The mechanical fitting failure reporting requirements in paragraph (a) of this section do not apply to the following:*
> > *(1) Master meter operators;*
> > *(2) Small LPG operator as defined in § 192.1001; or*
> > *(3) LNG facilities.*

The MJFR Form collects information on the particulars of hazardous leaks involving mechanical joints so that any identified safety concerns can be addressed appropriately. Information collected includes the type of mechanical fitting involved, fitting material, manufacturer, year manufactured, year installed, the two materials being joined, leak location, and apparent cause of leak.

Overview of Analysis Processes

PHMSA's typical process for analyzing MJFR data is described in the following flowcharts and process descriptions along with expected outputs. The intent of the analysis to identify trends, and to that purpose, the following outputs are expected to be produced. These outputs are discussed in greater detail in this document.

The outputs will be analyzed and observations from the team's perspective will be documented by the MJFR Team in an electronic format suitable for transmission and filling. The format may include more informal dissemination of information through the DIMP website or presentations and discussion with stakeholders, or if more formal action is needed, a Memorandum, Technical Report, Advisory Bulletin, or email transmission to PHMSA Associate Administrator. The MJFR team is comprised of PHMSA engineers, data analysts and other staff.

Discussion

Prior to the initiation of the Mechanical Fitting Failure Report (MFFR) Information Collection (IC) activity, PHMSA issued two Advisory Bulletins, ADB-86-02, Plastic Piping, Mechanical Coupling, and ADB-08-02, Issues Related to Mechanical Couplings Used in Natural Gas Distribution Systems, communicating safety concerns with mechanical joints. In these bulletins, PHMSA identified safety concerns and advised owners and operators of gas pipelines to consider the potential failure modes for mechanical joints pressure-sealing two pipes together. Failures can occur when there is inadequate restraint for the potential stresses on two joined pipes, when the coupling is incorrectly installed or supported, or when the coupling components (such as elastomers) degrade over time. In addition, inadequate leak surveys that fail to identify leaks requiring immediate repair can lead to more serious incidents. Advisory Bulletins ADB-86-02 and ADB-08-02 urged operators to review their procedures for using mechanical couplings and to ensure coupling design, installation procedures, leak survey procedures, and personnel qualifications meet Federal requirements.

PHMSA previously issued Advisory Bulletin ADB-2012-07, titled Pipeline Safety: Mechanical Fitting Failure Reports, reminding operators that an MFFR report is required for all hazardous leaks involving a mechanical joint regardless of either the cause or the fitting's material composition, type, manufacturer, or size. These reporting requirements apply to all failures that result in a hazardous leak involving a mechanical joint, and may include failures in the body of the mechanical fitting, failures in the joints between the fitting and the pipe, indications of leakage from the seals associated with the fitting, and partial or complete separation of the pipe from the fitting. It is important to note that PHMSA does not seek information related to failures of cast iron bell and spigot joints unless the leak resulted from a failure of a mechanical fitting used to repair or reinforce a joint. In ADB-2012-07, PHMSA also provided guidance on an issue with the MFFR Form where there were two potential reporting options for a failure that apparently resulted from incorrect installation of the mechanical fitting. PHMSA subsequently revised the MFFR and Instructions (revision 10-2014) to address the issue, adding language to communicate the need for operators to provide the best information possible, especially for fitting manufacturer data and date of installation data. The MFFR Instructions were revised to provide the following guidance in Part C—Mechanical Fitting Failure Data: "Make an entry in each block for which data are available. Some companies may have very old pipe for which installation records do not exist. Estimate data if necessary. Avoid entering "Unknown" if possible." PHMSA reiterates that operators should enter the best information possible, even though some "unknown" and "other" data entries are inevitable.

The MFFR IC activity provided data that raised operators' awareness regarding probable causes of hazardous leaks involving mechanical joints, increased regulators' awareness of the existing and potential threat that mechanical joints may pose to the safe operation and integrity of a distribution pipeline system, and provided mechanical fitting manufacturers with apparent failure cause data for their products. The MFFR IC activity will continue from its renewal date of October 31, 2017, until it is determined that the data is no longer necessary. The MFFR IC activity is detailed under Office of Management and Budget (OMB) Control No. 2137-0522, which can be viewed at www.regulations.gov.

PHMSA is moving to change the name of the MFFR Form to Mechanical Joint Failure Report (MJFR) to more accurately characterize that the IC is collecting data on hazardous leaks that involve a mechanical

joint. Mechanical joint failure is not always a result of the mechanical fitting, but can have other apparent causes of failure. The name change to MJFR involves changing regulatory language in 49 CFR Parts 191 and 192, changes to the MFFR Form and Instructions, and revisions to inspection forms and materials.

There was an upward trend in the number of MFFRs submitted from 2011-2016, primarily in operator-submitted MFFRs in PHMSA's Central and Eastern Regions. The rate of hazardous leaks repaired or replaced from 2011-2016 (as reported in Gas Distribution Annual Reports submitted via PHMSA Form F 7100.1-1) involving a mechanical joint (as reported in MFFRs submitted via PHMSA Form F 7100.1-2) is 5.9 percent, with an upward trend (8.6 percent in 2016). Further analysis will occur this year and be published in PHMSA's annual report posted at https://primis.phmsa.dot.gov/dimp/perfmeasures.htm . The MFFR data should be discretely evaluated on a State-by-State and operator-by-operator level during regulatory inspections and periodic evaluations (§ 192.1007(f)) performed by operators to meet the Distribution Integrity Management Program regulatory requirements. PHMSA expects operators to document MFFR data as existing and potential threats in an operator's DIMP, when appropriate.

Please see the technical review and analysis in section 4 of this report for specific and detailed findings.

1.0 Receipt of Data and Initial Processing

The MJFR Team will obtain the previous calendar year's data from the PDM approximately one month following the deadline to allow for quality checks to be performed on the data by PHMSA IT personnel. The MJFR Team will scan the incoming data to ensure it meets their needs and note any issues to PHMSA IT personnel. Following the acceptance of the data for analysis purposes, the MJFR Team will begin analysis.

2.0 Data Triaging and Analyses

The MJFR Team members will analyze the MJFR data and generate the tables and charts outlined in this procedure. Typically, the data from PDM is moved into a computer application called "SAS" in which the data is manipulated for analysis. The output from SAS is moved into PowerPoint for presentation and discussion purposes. Other evaluations and analyses may be performed depending upon the analysis.

2.1 Gather Information to Support Analysis and Review of Data

Input: Excel Spreadsheet from PDM based on data received as of March 31, 2015

Output: Various tables and charts

Responsibility: MJFR Team

Description: The MJFR Team will use the following spreadsheets and tables to gather data in appropriate formats to support the analysis and review:

Table 1 – Spreadsheets and associated Tables required to perform analysis and expected Outputs

Description of Data to be analyzed	Description of Data Source(s)	Typical Output
2.2.1 General Overview of the MJFR Information	Total number of reports, operators, manufacturers and the amounts of missing information for a given year	Table 1
2.2.2 General information on the Age of the Mechanical Fittings that Failed	Year of manufactured/installed, amounts of missing information, and average time to failure and range (Part C Items 6 & 7)	Table 2
2.2.3 Decade of Installation of Mechanical Fitting that Failed	Decade of installation of the mechanical fittings that failed (Part C Items 6 or 8)	Table 3

Description of Data to be analyzed	Description of Data Source(s)	Typical Output
2.3.1 Average and Range Time to Failure by Fitting Material	Average and range time to failure by material type (Part C Item 13 compared to Item 6)	Table 4
2.3.2 Frequency of Material Type	Frequency of failure by Material Type (Part C Item 13)	Figure 1 and Table 5
2.3.3 Comparison of First Pipe Material by Second Pipe Material	First pipe material by second pipe material (Part C Item 14)	Tables 6
2.3.4 Fitting Material by Apparent Cause of Leak	Fitting Material (Part C Item 13) by Leak Cause (Part C Item 15)	Table 7
2.3.5 Sizes of Pipe being Joined	Number of failures by sizes of pipe being joined (First Pipe Nominal Size and Second Pipe Nominal Size) (Part C Item 14)	Tables 8
2.4.1 Apparent Causes of Leaks	Leak cause from cause categories (Part C Item 15)	Figure 2 and Table 9
2.4.2 Leak Cause Expanded	Leak causes expanded (Part C Item 15)	Table 10
2.5.1 Mechanical Fitting Involved	Mechanical Fitting Involved (coupling, adaptor, etc.) (Part C Item 4)	Figure 3 and Table 11
2.5.2 Mechanical Fitting Type	Mechanical Fitting Type (nut follower, stab, etc.) (Part C Item 3)	Figure 4 and Table 12
2.5.3 Fitting Material by Mechanical Fitting Involved	Fitting Material (Part C Item 13) by Mechanical Fitting Involved (Part C Item 3)	Tables 13 & 14
2.5.4 Material by Type of Mechanical Fitting	Fitting Material (Part C Item 13) by Type of Mechanical Fitting (Part C Item 4)	Table 15
2.6.1 Leak Location	Aboveground/Belowground, Outside/Inside and Meter/Service (Part C Item 5)	Figure 5 and Table 16
2.6.2 How the Leak Occurred	Leaked Through Seal, Leaked Through Body, or Pulled Out (Part C Item 16)	Figure 6

Description of Data to be analyzed	Description of Data Source(s)	Typical Output
2.6.3 Top 10 States reporting, Top 10 Steel State, and Top 10 Plastic States	Top 10 States reporting, Top 10 Steel State, and Top 10 Plastic States (Part C Items 1 & 13)	Table 17, 18 & 19
2.6.4 States by Cause	States reporting by causes of leaks (Part C Items 1 & 15)	Table 20
2.6.5 Leak Location (above or below ground) by Fitting Material	Fitting Material by Leak Location (above or below ground) (Part C Items 5 & 13)	Table 21
2.6.6 Leak Location (inside or outside) by Fitting Material	Fitting Material by Location (inside or outside) (Part C Items 5 & 13)	Table 22
2.6.7 Leak Location (service type) by Fitting Material	Fitting Material by Location (service type) (Part C Items 5 & 13)	Table 23
2.7 Quantification of the Role of Mechanical Joints in Hazardous Leaks	Total Number of MJFR submitted each year & Total Number of hazardous leaks repaired or replaced each year from PHMSA reports (primis.phmsa.dot.gov/dimp/perfmeasures.htm)	Table 24
2.7.1 Manufacturer of Fitting by Year Manufactured	Line plot of failures by manufacturer by year manufactured (Part C Items 7 & 9)	Figure 7
2.7.2 Manufacturer by Years in Service	Line plot of failures by manufacturer by years of service (Part C Items 6 & 9)	Figure 8
2.7.3 Top 10 Manufacturers of Fittings	Top 10 reported manufacturers (Part C Item 9)	Table 25
2.7.4 Manufacturer by Year of Failure	Line plot of number of failures by manufacturer by year of failure (Part C Items 2 & 9)	Figure 9
2.7.5 Manufacturer by Leak Causes	Manufacturer by leak causes (Part C Items 9 & 15)	Table 26
2.7.6 Manufacturer by Mechanical Fitting Involved	All years of manufacturer by mechanical fitting type involved (Part C Items 3 & 9)	Table 27
2.8.1 Operator by Year of Failure	Operators reporting by year of failure (Part A Item 2 & Part C Item 2)	Table 28

Description of Data to be analyzed	Description of Data Source(s)	Typical Output
4.1 Overview of Analysis	Graphic representation of MJFR by year	Figure 10 & Figure 11

2.2 General information from MJFR reports

2.2.1 General Overview of the MJFR Information

Input: Original Excel Spreadsheet from PDM

Output: Table 1 - General overview of the Mechanical Joint Failure Reports

Responsibility: MJFR Team

Description: General information about the number of reports, number of operators, and number of manufacturers and the amounts of missing information. The data is provided below in Table 1. From this information, the MJFR Team will develop observations on coverage and representation of the information reported.

Table 1. General overview of the Mechanical Joint Failure Reports, 2011-2016, as of 09/18/2017

	2011	2012	2013	2014	2015	2016
Number of Reports	8342	7608	9923	11762	14891	18043
Number of Reporting Operators	195	201	188	188	193	187
Number of states of origin	50 and DC	50 and DC	48 and DC	50 and DC	49 and DC	49 and DC
Number of Manufacturers	38	35	35	36	36	38
Percent of Missing Manufacturers	51%	48%	52%	53%	60%	71%

2.2.2 General information on the Age of the Mechanical Fittings that Failed

Input: Data analyzed from SAS Computer Application

Output: Table 2 - Year of installation and manufacture of failed mechanical fittings

Responsibility: MJFR Team

Description: General information about the year manufactured and/or installed the amounts of missing information, and the average time to failure and range. The data is provided below in Table 2. From this information, the MJFR Team will develop observations on the validity of data and accuracy of the average service life of reported failures.

Table 2. General information about the year of manufactured of mechanical fittings reported in Mechanical Joint Failure Reports, 2011-2016

	2011	2012	2013	2014	2015	2016
Percent Missing Year of Manufacture	89%	88%	88%	88%	90%	94%
Percent Missing Year of Installation	42%	36%	39%	33%	33%	26%
Overall Average Time to Failure and Range	33 Years (0 - 124)	33 Years (0 – 132)	34 Years (0 – 121)	37 Years (0 –124)	41 Years (0 –123)	45 Years (0-165)

*The percent of overlapping year of manufacturer and year of install is a subset of reported values and therefore is very small.

2.2.3 Decade of Installation of Mechanical Fitting that Failed

Input: Data analyzed from SAS Computer Application

Output: Table 3 – Decade of installation of failed mechanical fittings

Responsibility: MJFR Team

Description: Produce a table of decade of installation of the mechanical fittings that failed. Compare percentage of this table to percentages from the annual reports about mileage installed in given decades. The data is provided below in Table 3. From this information, the MJFR Team will develop observations on the validity of the data because the distribution across the decades should be similar to the distribution of pipe across the decades from the annual reports.

Table 3. Decade of installation of mechanical fittings that failed and were reported to the Mechanical Joint Failure Reports, 2011-2016

	2011 Count (%)	2012 Count (%)	2013 Count (%)	2014 Count (%)	2015 Count (%)	2016
Pre 1940s	41 (2%)	22 (3%)	15 (3%)	14 (4%)	91 (19%)	73 (19%)
1940s	23 (1%)	6 (1%)	25 (5%)	13 (4%)	27 (5%)	12 (3%)
1950s	191 (11%)	70 (9%)	59 (13%)	31(8%)	57 (12%)	36 (9%)
1960s	337 (19%)	168 (21%)	91 (19%)	53(14%)	61(13%)	54 (14%)
1970s	483 (27%)	232 (29%)	122 (25%)	81 (22%)	98 (21%)	65 (17%)
1980s	379 (21%)	185 (24%)	82 (17%)	101 (27%)	96 (20%)	83 (21%)
1990s	155 (9%)	60 (8%)	51 (11%)	59 (15%)	37 (7%)	40 (11%)
2000s	164 (9%)	33 (4%)	27 (6%)	15 (4%)	11 (2%)	16 (4%)
2010s	5 (1%)	6 (1%)	3 (1%)	6 (2%)	1 (1%)	6 (2%)

2.3 Fitting Material and Pipe Type

2.3.1 Average and Range Time to Failure by Fitting Material

Input: Data analyzed from SAS Computer Application

Output: Table 4 - Average time to failure by fitting material type

Responsibility: MJFR Team

Description: Produce a table of average and range time to failure by fitting material (Part C Item 13 of the form). The data is provided below in Table 4. Based on all data and other information, when the year of manufactured and the year of install are both reported, the majority of the dates are within a year of each other. Since, the dates are similar and the year of install is reported more, table 4 will use year of install. From this information, the MJFR Team will develop observations on time to failure on various fitting material types.

Table 4. Average and range of time to failure by fitting material type of mechanical fittings that failed and were reported to the Mechanical Joint Failure Reports, 2011-2016

	2011	2012	2013	2014	2015	2016
	Average (Range)	Average (Range)	Average (Range)	Average (Range)	Average (Range)	Average (Range)
Steel	39 (0 – 124)	41 (0 – 117)	42 (0 – 113)	44 (0-124)	48 (0-123)	50 (0 – 165)
Plastic	21 (0 – 70)	21 (0 – 87)	22 (0 – 84)	23 (0-115)	25 (0-102)	26 (0 – 105)
Combination (Steel and Plastic)	26 (0 – 76)	20 (0 – 90)	22 (0 – 113)	23 (0-115)	26 (0-90)	29 (0 – 71)
Unknown	42 (0 – 71)	37 (1 – 61)	39 (3 – 60)	43 (2-86)	48 (2-116)	53 (0 – 117)
Other	50 (0 – 111)	51 (1 – 117)	49 (0 – 121)	37 (2-113)	33 (0-94)	34 (23 – 81)
Brass	41 (0 – 82)	45 (0 – 132)	43 (0 – 69)	46 (1-113)	46 (0 – 95)	47 (0 – 87)

Based on all data, when the year of manufacture and the year of install are both reported, the majority of the dates are within a year of each other. Since, the dates are similar and year of install was reported more often, year of install was used.

2.3.2 Frequency of Failure by Material Type

Input: Data analyzed from SAS Computer Application

Output: Figure 1 and Table 5 - Frequency of mechanical fitting failures by material type

Responsibility: MJFR Team

Description: Produce a bar chart of material type with the percentages on the y-axis. The data is provided below in Figure 1. Table 5 will also be produced representing the data with the counts and percent. From this information, the MJFR Team will develop observations on the ratio of material types that are used and trends across years.

Figure 1. Frequency of mechanical fittings by material type reported to the Mechanical Joint Failure Reports, 2011-2015

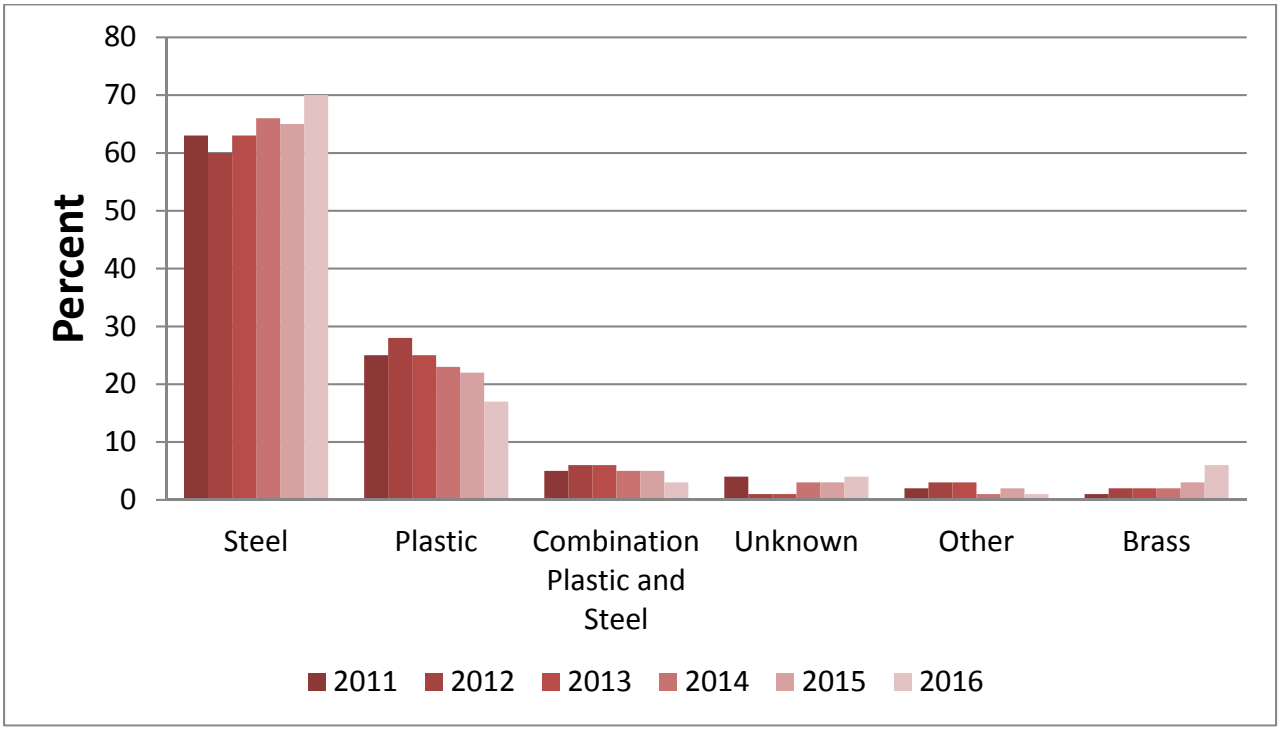


Table 5. Frequency of mechanical fittings by material type reported to the Mechanical Joint Failure Reports, 2011-2015

	2011 Count (%)	2012 Count (%)	2013 Count (%)	2014 Count (%)	2015 Count (%)	2016 Count (%)
Steel	5236 (63%)	4535 (60%)	6053 (63%)	7494 (66%)	9334 (65%)	12099 (69%)
Plastic	2069 (25%)	2065 (28%)	2459 (25%)	2673 (23%)	3161 (22%)	2880 (17%)
Combination (Steel and Plastic)	449 (5%)	450 (6%)	554 (6%)	567 (5%)	697 (5%)	475 (3%)
Unknown	341 (4%)	92 (1%)	127 (1%)	356 (3%)	447 (3%)	740 (4%)
Other	165 (2%)	184 (3%)	271 (3%)	125 (1%)	261 (2%)	80 (1%)
Brass	82 (1%)	168 (2%)	174 (2%)	219 (2%)	491 (3%)	1031 (6%)

Notes: Percentages are rounded based on total number. In 2016, 38% of fitting material had some plastic and 66% of fitting material had some steel

2.3.3 Comparison of First Pipe Material by Second Pipe Material Type

Input: Data analyzed from SAS Computer Application

Output: Table 6 – Comparisons of first pipe and second pipe materials being joined where mechanical fitting failure occurred

Responsibility: MJFR Team

Description: Produce a table comparing first pipe material and second pipe material (Part C Item 14). The highest numbers and percentages should be in the diagonal. Along with the table list the percentage of pipe material that had some plastic and the percentage of pipe material that had some steel. The data is provided below in Table 6. From this information, the MJFR Team will develop observations on how the various material types are combined. The various tables will also help identify any outliers.

Table 6. Comparison of first pipe material to second pipe material fittings of mechanical fittings that failed and were reported to the Mechanical Joint Failure Reports, (all years) 2011-2016

	Second Pipe Material Type							
First Pipe Material Type		**Cast/Wro**	**Copper**	**Ductile**	**Other**	**Plastic**	**Steel**	**Unknown**
	Cast/Wro	608 (1%)	8	12	1	48	69	3
	Copper	13	1075 (2%)	0	2	216	281	79
	Ductile	33	0	764 (1%)	0	6	7	0
	Other	0	5	0	81 (<1%)	9	1333	0
	Plastic	36	89	6	18	14544 (29%)	3129	40
	Steel	39	183	8	203	2751	23877 (47%)	136
	Unknown	0	2	0	1	18	26	513 (1%)

2.3.4 Fitting Material by Leak Cause

Input: Data analyzed from SAS Computer Application

Output: Table 7 - Fitting material by leak cause

Responsibility: MJFR Team

Description: Produce a table for Fitting Material (Part C Item 13) by Apparent Cause of Leak (Part C Item 15). The data is provided below in Table 7. The table is read comparing percentages in the year column to the other year column for the various causes and fitting material. From this information, the MJFR Team will develop observations on frequency of leak causes by material type.

Table 7. Fitting material by leak cause of mechanical fittings that failed and were reported to the Mechanical Joint Failure Reports, 2011-2016

	Corrosion	Equipment	Excavation	Incorrect Operation	Material or Weld	Natural Forces	Other	Other Outside Forces
Steel	6%	56%	3%	3%	6%	18%	7%	1%
Plastic	1%	30%	2%	23%	28%	6%	9%	1%
Combination	7%	24%	2%	17%	30%	10%	8%	2%
Unknown	4%	24%	3%	7%	20%	39%	2%	1%
Other	7%	34%	2%	2%	8%	32%	14%	1%
Brass	5%	75%	3%	1%	6%	7%	2%	1%
Total	5%	48%	3%	8%	12%	16%	7%	1%

2.3.5 Sizes of Pipe being Joined

Input: Data analyzed from SAS Computer Application

Output: Table 8 - Comparisons of first pipe and second pipe sizes being joined where mechanical fitting failure occurred

Responsibility: MJFR Team

Description: Produce a plot of the number of failures by pipe sizes being joined (Part C Item 14, First Pipe Nominal Size and Second Pipe Nominal Size). The data is provided below in Table 8. First pipe size is reflected in the rows and Second pipe size is reflected in the columns. From this information, the MJFR Team will develop observations on the number of reported failures from joining various pipe sizes with mechanical fittings.

Table 8. Sizes of pipe being joined by mechanical fittings that failed and were reported to the Mechanical Joint Failure Reports, (all years) 2011-2016

	¼ inch	½ inch	¾ inch	1 inch	1 ¼ inch	1 ½ inch	1 ¾ inch	2 inch	3 inch	4 inch	6 inch	8 inch or larger
¼ inch	164 (<1%)	55	26	7	4	2	0	2	0	0	0	0
½ inch	60	10094 (14%)	3129	692	55	4	0	225	7	26	12	4
¾ inch	24	1577	15422 (22%)	351	90	9	0	340	28	36	10	6
1 inch	8	577	411	14773 (21%)	186	13	2	91	12	25	10	3
1 ¼ inch	5	158	178	312	4087 (6%)	43	1	86	14	20	8	3
1 ½ inch	0	12	7	29	38	746 (1%)	0	9	0	2	0	1
1 ¾ inch	0	1	3	1	2	1	3 (0%)	0	0	1	0	0
2 inch	2	575	458	316	116	22	7	10503 (15%)	27	14	9	5
3 inch	1	26	34	41	19	1	26	38	348 (1%)	5	1	0
4 inch	0	56	47	89	43	2	0	44	7	1027 (1%)	14	1
6 inch	0	15	18	25	15	1	0	8	18	7	1087 (2%)	1
8 inch or larger	0	10	10	7	4	1	0	7	5	2	13	830 (1%)

Percentages are rounded based on total number

2.4 Causes of Hazardous Leak

2.4.1 Chart of Leak Causes

Input: Data analyzed from SAS Computer Application

Output: Figure 2 and Table 9 - Frequency of leak causes

Responsibility: MJFR Team

Description: Produce a bar chart of Apparent Cause of Leak (Part C Item 15) with percentages on the y-axis and causes on x-axis. The data is provided in Table 9 and is represented below in Figure 2. The table is read comparing percentages in the year column to the other year column for the various causes. From this information, the MJFR Team will develop observations on the distribution of leak cause.

Figure 2. Frequency of leak causes of mechanical fittings that failed and were reported to the Mechanical Joint Failure Reports, 2011-2016

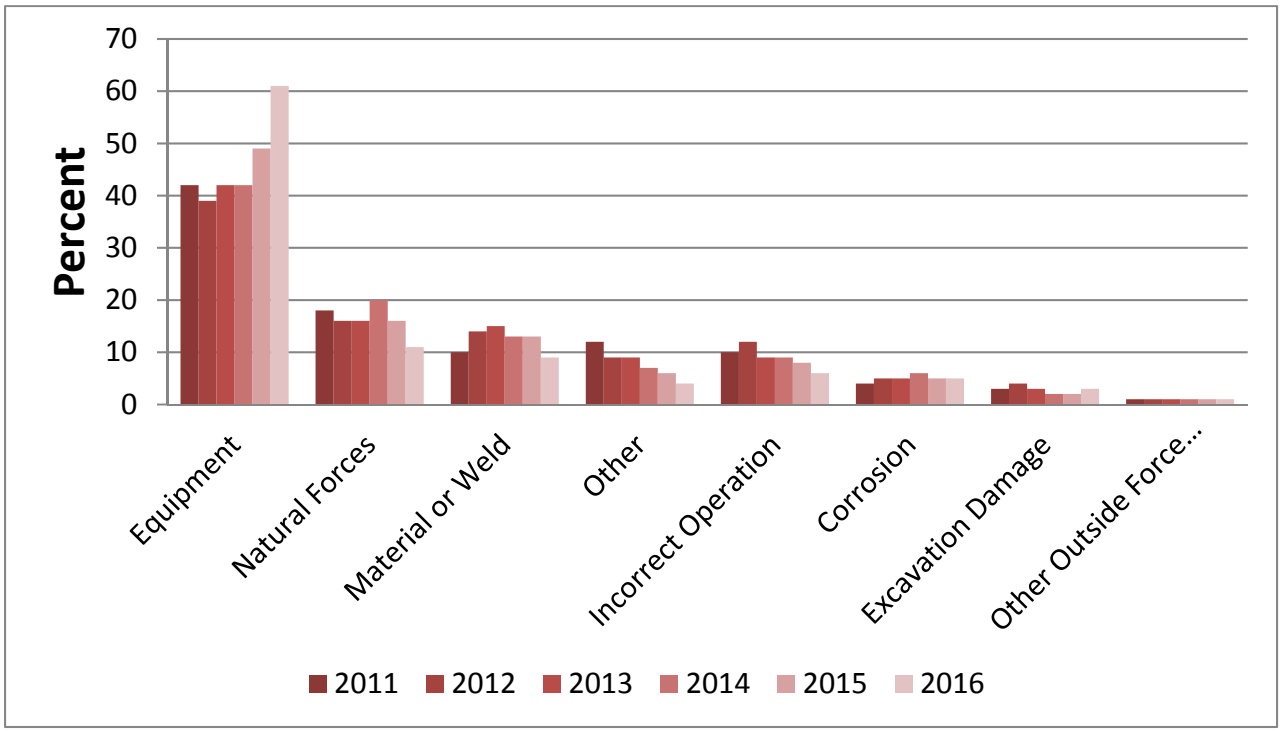


Table 9. Frequency of leak causes of mechanical fittings that failed and were reported to the Mechanical Joint Failure Reports, 2011-2016

	2011 Count (%)	2012 Count (%)	2013 Count (%)	2014 Count (%)	2015 Count (%)	2016 Count (%)
Equipment	3506 (42%)	2985 (39%)	4215 (42%)	4940 (42%)	7318 (49%)	11033 (61%)
Natural Forces	1558 (18%)	1201 (16%)	1614 (16%)	2336 (20%)	2326 (18%)	1980 (11%)
Material or Weld	802 (10%)	1093 (14%)	1483 (15%)	1572 (13%)	1999 (13%)	1679 (9%)
Other	1003 (12%)	718 (9%)	881 (9%)	852 (7%)	974 (6%)	832 (4%)
Incorrect Operation	807 (10%)	877 (12%)	910 (9%)	1068 (9%)	1137 (8%)	1121 (6%)
Corrosion	332 (4%)	389 (5%)	535 (5%)	692 (6%)	702 (5%)	820 (5%)
Excavation	229 (3%)	266 (4%)	223 (3%)	255 (2%)	351 (2%)	456 (3%)
Other	105 (1%)	79 (1%)	62 (1%)	47 (1%)	83 (1%)	100 (1%)

2.4.2 Leak Causes Expanded

Input: Data analyzed from SAS Computer Application

Output: Table 10 - Frequency of leak causes (expanded)

Responsibility: MJFR Team

Description: Produce a table with leak causes expanded as the title and Leak Cause Natural Forces Thermal Expansion/Contraction, Leak Cause Material/Welds and Leak Cause Excavation Damage Occurred presenting both the count and percent by report year. The data is provided below in Table 10. The table is read comparing percentages in the year column to the other year column for the various questions. From this information, the MJFR Team will develop observations on any issues identified in specific leak causes.

Table 10. Frequency of leak causes expanded information of mechanical fittings that failed and were reported to the Mechanical Joint Failure Reports, 2011-2016

Question	Responses	2011 Count (%)	2012 Count (%)	2013 Count (%)	2014 Count (%)	2015 Count (%)	2016 Count (%)
Leak Cause Natural Forces Thermal Expansion / Contraction	No	762 (57%)	650 (59%)	792 (50%)	856 (37%)	952 (41%)	1164 (59%)
	Yes	573 (43%)	459 (41%)	777 (50%)	1469 (63%)	1365 (59%)	812 (41%)
Leak Cause Material/Welds	Construction/Installation Defect	174 (21%)	311 (28%)	456 (31%)	396 (25%)	712 (35%)	632 (38%)
	Design Defect	628 (78%)	782 (72%)	1027 (69%)	1176 (75%)	1287 (65%)	1053 (62%)
Leak Cause Excavation Damage	At time of leak discovery	166 (75%)	228 (86%)	194 (87%)	229 (90%)	319 (91%)	421 (92%)
	Previous to leak discovery	54 (25%)	36 (14%)	28 (13%)	25 (10%)	32 (9%)	35 (8%)

2.5 Type of Fitting

2.5.1 Chart of Mechanical Fitting Involved

Input: Data analyzed from SAS Computer Application

Output: Figure 3 and Table 11 – Frequency of applications where failures are occurring

Responsibility: MJFR Team

Description: Produce a bar chart of percentages by Mechanical Fitting Involved (Part C Item 4 on the report form) with percentages on the y-axis and Type on x-axis. The data is provided below in Table 11 and presented in Figure 3. The table is read comparing percentages in the year column to the other year column for the various types of fittings. From this information, the MJFR Team will develop observations on the distribution of type of mechanical fitting failing.

Figure 3. Frequency of mechanical fitting involved of mechanical fittings that failed and were reported to the Mechanical Joint Failure Reports, 2011-2016

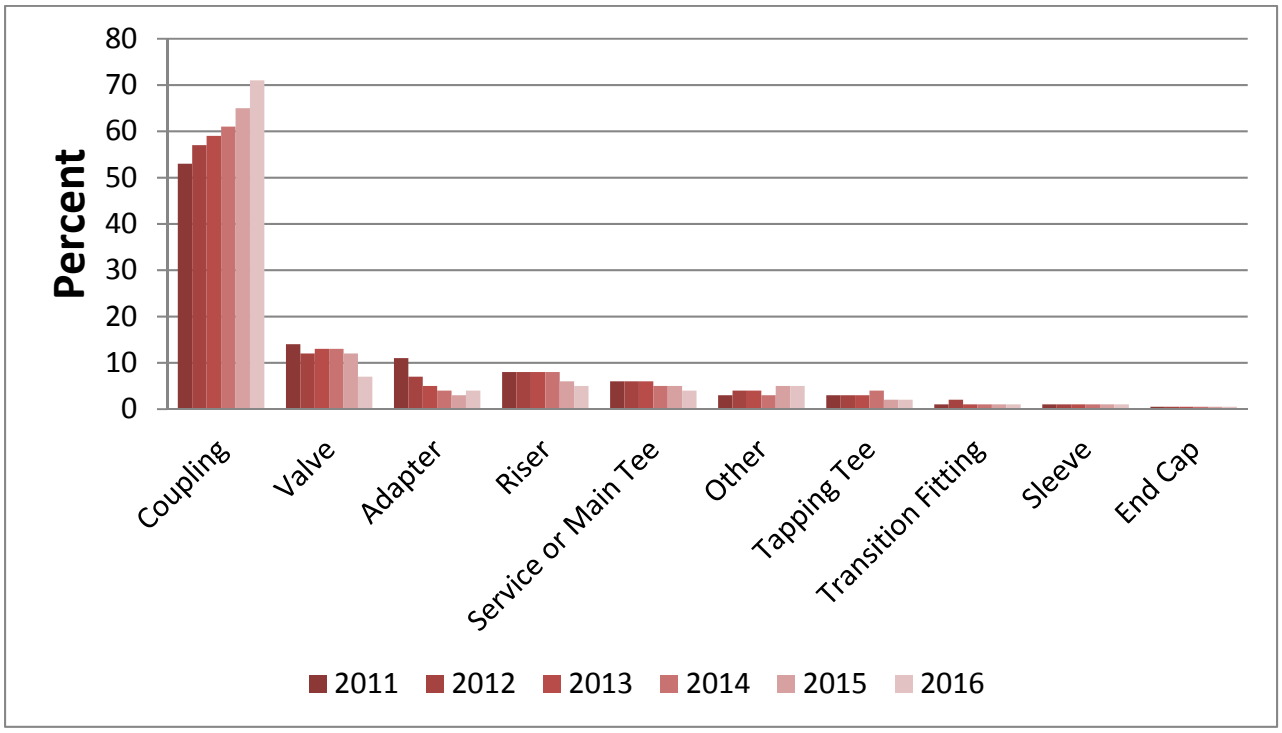


Table 11. Frequency of mechanical fitting involved of mechanical fittings that failed and were reported to the Mechanical Joint Failure Reports, 2011-2016

	2011 Count (%)	2012 Count (%)	2013 Count (%)	2014 Count (%)	2015 Count (%)	2016 Count (%)
Coupling	4421 (53%)	4364 (57%)	5856 (59%)	7173 (61%)	9647 (65%)	12926 (71%)
Valve	1196 (14%)	908 (12%)	1339 (13%)	1545 (13%)	1737 (12%)	1317 (7%)
Adapter	877 (11%)	507 (7%)	493 (5%)	388 (4%)	442 (3%)	737 (4%)
Riser	700 (8%)	602 (8%)	761 (8%)	986 (8%)	930 (6%)	927 (5%)
Service or Main Tee	471 (6%)	502 (6%)	571 (6%)	616 (5%)	789 (6%)	728 (4%)
Other	275 (3%)	301 (4%)	360 (4%)	365 (3%)	743 (5%)	825 (5%)
Tapping Tee	211 (3%)	205 (3%)	318 (3%)	444 (4%)	357 (2%)	373 (2%)
Transitional	98 (1%)	139 (2%)	140 (1%)	109 (1%)	132 (1%)	101 (1%)
Sleeve	66 (1%)	55 (1%)	51 (1%)	103 (1%)	62 (1%)	39 (<1%)
End Cap	27 (<1%)	25 (<1%)	34 (<1%)	33 (<1%)	52 (<1%)	70 (<1%)

2.5.2 Chart of Mechanical Fitting Type

Input: Data analyzed from SAS Computer Application

Output: Figure 4 and Table 12 - Frequency of failure by type of mechanical fitting

Responsibility: MJFR Team

Description: Produce a bar chart of percentages by Type of Mechanical Fitting (Part C Item 3 on the report form) with percentage on the y-axis and type of mechanical fitting on the x-axis. The data is provided below in Table 12 and presented in Figure 4. The table is read comparing percentages in the year column to the other year column for the various mechanical fitting types. From this information, the MJFR Team will develop observations on the distribution of type of mechanical fitting involved in the failure.

Figure 4. Frequency of mechanical fitting type of mechanical fittings that failed and were reported to the Mechanical Joint Failure Reports, 2011-2016

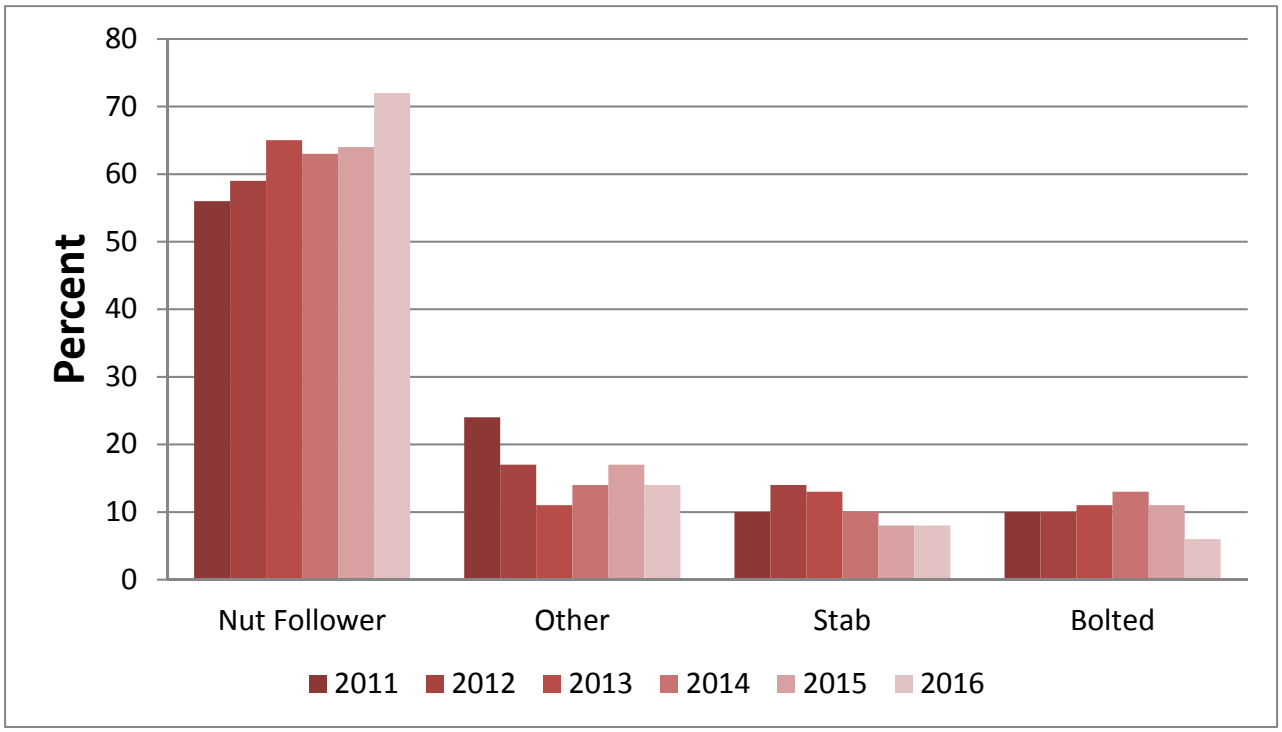


Table 12. Frequency of mechanical fitting type of mechanical fittings that failed and were reported to the Mechanical Joint Failure Reports, 2011-2016

	2011 Count (%)	2012 Count (%)	2013 Count (%)	2014 Count (%)	2015 Count (%)	2016 Count (%)
Nut Follower	4715 (56%)	4458 (59%)	6450 (65%)	7416 (63%)	9529 (64%)	12878 (72%)
Other	2011 (24%)	1286 (17%)	1127 (11%)	1720 (14%)	2601 (17%)	2491 (14%)
Stab	812 (10%)	1084 (14%)	1262 (13%)	1159 (10%)	1139 (8%)	1590 (8%)
Bolted	804 (10%)	780 (10%)	1084 (11%)	1467 (13%)	1622 (11%)	1084 (6%)

2.5.3 Material of Mechanical Fitting Involved

Input: Data analyzed from SAS Computer Application

Output: Table 13 and Table 14 - Frequency of failure of material of mechanical fitting involved

Responsibility: MJFR Team

Description: Produce a table of Fitting Material (Part C Item 13) by Mechanical Fitting Involved (Part C Item 3) by the reporting years. The data is provided below in Table 13. The table is read comparing percentages in the year column to the other year column for the various fitting material and types to identify trends. Table 14 is provided with all the data across the reporting years and is read comparing the percentages across the rows. From this information, the MJFR Team will develop observations on which type of mechanical fitting is most likely from the various material types.

Table 13. Frequency of material of mechanical fitting involved of mechanical fittings that failed and were reported to the Mechanical Joint Failure Reports, 2013-2016

	Bolted				Nut Follower				Stab				Other			
	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016
Steel	10%	14%	8%	5%	75%	70%	74%	81%	4%	1%	1%	1%	11%	15%	17%	20%
Plastic	7%	9%	9%	8%	44%	44%	42%	38%	36%	34%	30%	33%	13%	13%	19%	19%
Combo	3%	6%	20%	3%	59%	49%	46%	46%	20%	21%	13%	21%	18%	24%	21%	21%
Unk	6%	13%	60%	15%	80%	58%	33%	32%	1%	1%	1%	46%	13%	28%	6%	6%
Other	81%	32%	10%	10%	15%	59%	30%	69%	1%	3%	1%	0%	3%	6%	59%	59%
Brass	3%	5%	3%	1%	93%	88%	94%	93%	2%	4%	1%	1%	2%	3%	2%	3%
Total	11%	12%	11%	6%	65%	63%	64%	71%	13%	10%	8%	9%	11%	15%	18%	20%

Table 14. Frequency of material of mechanical fitting involved of mechanical fittings that failed and were reported to the Mechanical Joint Failure Reports, all years combined 2011-2016

	Bolted	Nut Follower	Stab	Other
Steel	9%	73%	2%	16%
Plastic	8%	42%	34%	16%
Combination	8%	52%	17%	23%
Unknown	23%	46%	19%	12%
Other	48%	31%	1%	20%
Brass	3%	91%	1%	5%
Total	10%	64%	10%	16%

2.5.4 Fitting Material by Type of Mechanical Fitting

Input: Data analyzed from SAS Computer Application

Output: Table 15 - Frequency of failure of material of mechanical fitting by its application

Responsibility: MJFR Team

Description: Produce a table of Fitting Material by Type of Mechanical Fitting. The data is provided below in Table 15. The table is read comparing percentages in the year column to the other year column for the various mechanical fitting and fitting material. From this information, the MJFR Team will develop observations based on percentages of material type and type of fitting.

Table 15. Frequency of fitting material by type of mechanical fitting of mechanical fitting involved of mechanical fittings that failed and were reported to the Mechanical Joint Failure Reports, (all years)

	Adapter	Coupling	End Cap	Other	Riser	Service or Main Tee	Sleeve	Tapping Tee	Transition Fitting	Valve
Steel	6%	71%	0%	3%	6%	4%	1%	2%	1%	6%
Plastic	1%	45%	1%	2%	6%	7%	0%	7%	1%	30%
Combination	6%	27%	0%	5%	41%	5%	1%	2%	9%	4%
Unknown	1%	55%	1%	22%	1%	11%	2%	0%	0%	7%
Other	1%	17%	0%	43%	2%	7%	5%	1%	0%	24%
Brass	3%	86%	0%	1%	1%	5%	0%	0%	0%	4%
Total	5%	63%	0%	4%	7%	5%	1%	3%	1%	11%

2.6 Location of Hazardous Leaks

2.6.1 Leak Location

Input: Data analyzed from SAS Computer Application

Output: Figure 5 and Table 16 – Leak location

Responsibility: MJFR Team

Description: Produce a bar chart with Leak Location (Part C Item 5) as the title and Aboveground/Belowground, Outside/Inside and Meter/Service on the x-axis with the percentages on the y-axis. The data is provided in Table 16 and represented in Figure 5. The table is read comparing percentages in the year column to the other year column for the various fitting material and types. From this information, the MJFR Team will develop observations on the general description of the leak location.

Figure 5. Frequency of the location of the hazardous leak of mechanical fittings that failed and were reported to the Mechanical Joint Failure Reports, 2011-2016

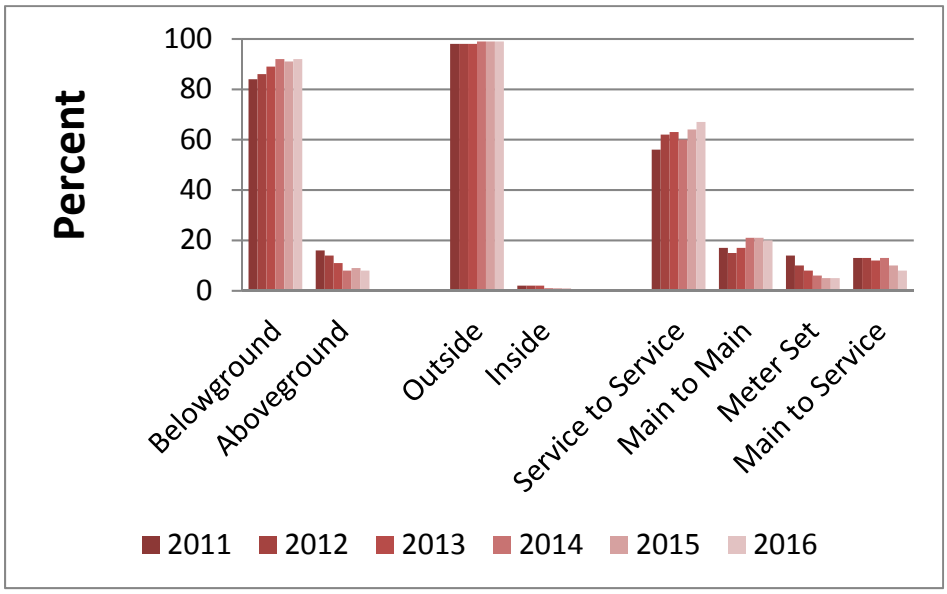


Table 16. Frequency of the location of the hazardous leak of mechanical fittings that failed and were reported to the Mechanical Joint Failure Reports, 2011-2016

	2011 Count (%)	2012 Count (%)	2013 Count (%)	2014 Count (%)	2015 Count (%)	2016 Count (%)
Belowground	6984 (84%)	6565 (86%)	8844 (89%)	10785 (92%)	13542 (91%)	16681 (92%)
Aboveground	1358 (16%)	1043 (14%)	1074 (11%)	977 (8%)	1349 (9%)	1354 (8%)
Outside	8214 (98%)	7440 (98%)	9752 (98%)	11627 (99%)	14714 (99%)	17776 (99%)
Inside	128 (2%)	168 (2%)	171 (2%)	135 (1%)	177 (1%)	267 (1%)
Service to Service	4702 (56%)	4689 (62%)	6248 (63%)	7025 (60%)	9475 (63%)	12053 (67%)
Main to Main	1389 (17%)	1110 (15%)	1741 (17%)	2507 (21%)	3134 (20%)	3636 (20%)
Meter Set	1147 (14%)	798 (10%)	781 (8%)	735 (6%)	821 (6%)	844 (5%)
Main to Service	1104 (13%)	1011 (13%)	1153 (12%)	1495 (13%)	1461 (11%)	1510 (8%)

2.6.2 How the Leak Occurred

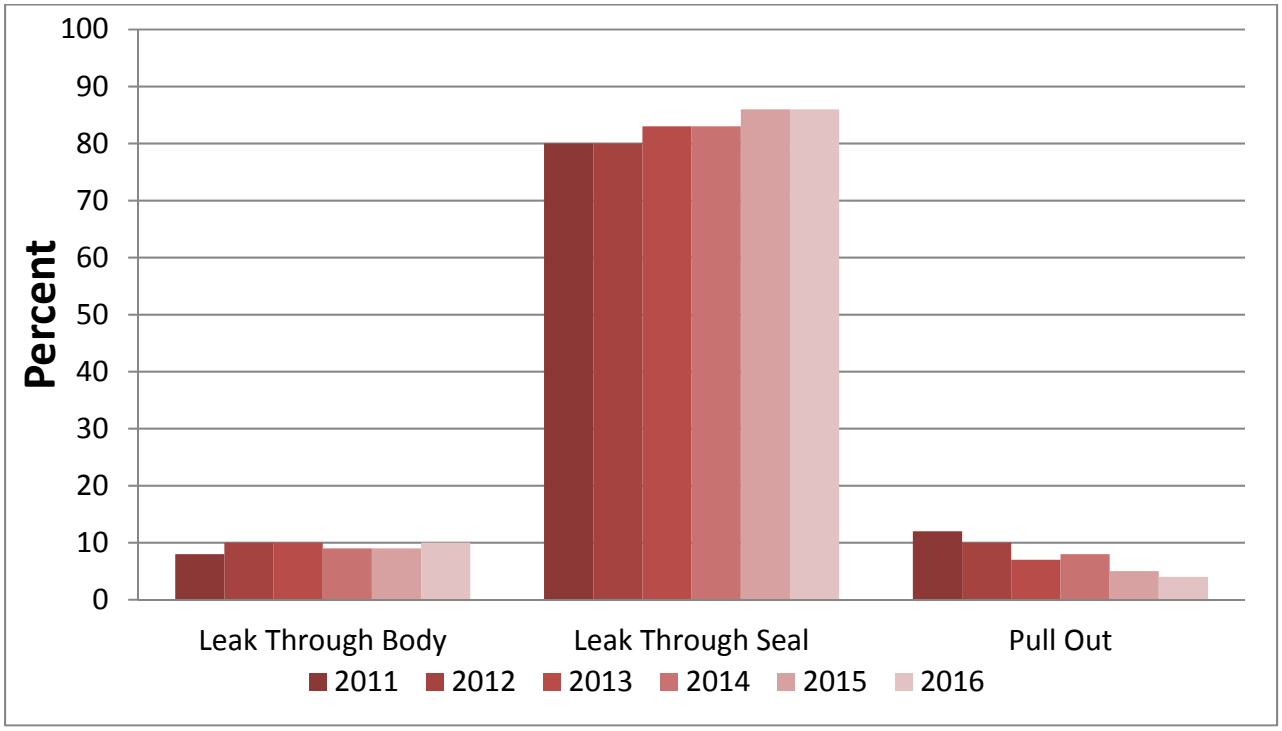
Input: Data analyzed from SAS Computer Application

Output: Figure 6 – Frequency of how the leak occurred

Responsibility: MJFR Team

Description: Produce a bar chart of how the leak occurred (Part C Item 16 of the report form) with percentage on the y-axis and options for how the leak occurred on the x-axis. The data is presented in Figure 6. From this information, the MJFR Team will develop observations on distribution of leak occurrence.

Figure 6. Frequency of how the leak occurred of mechanical fittings that failed and were reported to the Mechanical Joint Failure Reports, 2011-2016



2.6.3 Top 10 States reporting, Top 10 Steel State, and Top 10 Plastic States

Input: Data analyzed from SAS Computer Application

Output: Table 17 – Comparison of percentages of failures in States Overall
Table 18 – Comparison of percentages of failures in States for steel
Table 19 – Comparison of percentages of failures in States by plastic

Responsibility: MJFR Team

Description: Produce a table with the columns Top 10 States reporting (Table 17), Top 10 Steel State (Table 18), and Top 10 Plastic States (Table 19). This table takes into account where the MFF occurred based on the raw data of all reports. For reference, a column of the percentages of the total number of services in each State in 2011, based on annual report data, is also added for each category. From this information, the MJFR Team will develop observations on distribution of percentages of mechanical fitting failures in the States taking into context percentage of pipe material installed based on the annual reports.

Even with this information provided, PHMSA cautions users of this data analysis on the need to consider the information in the appropriate context. There is no definitive information publicly available about the number of fittings in a given State. Therefore, PHMSA is unable to adjust the failure reports data for comparison by the quantity produced or in use. For additional information specific to a certain State to help put numbers in better context, users are encouraged to contact the State.

Table 17. Percentage of MJFR by State, 2011-2016

Top 10 States – based on number of services reported from Gas Distribution Annual Reports						
Number of Services	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
CA 13%	TX 13%	TX 13%	TX 12%	PA 12%	VA 13%	VA 24%
TX 7%	IL 12%	IL 9%	PA 10%	TX 10%	PA 11%	MD 16%
IL 6%	PA 9%	PA 8%	IN 8%	IN 8%	TX 10%	PA 7%
OH 5%	OH 7%	IN 7%	NY 7%	VA 8%	MD 8%	IN 6%
MI 5%	IN 7%	MI 6%	IL 7%	OH 7%	IN 8%	TX 5%
NY 5%	NY 6%	NY 6%	TN 7%	NY 6%	NY 6%	IL 5%
PA 4%	MI 5%	OH 6%	VA 6%	IL 5%	MI 5%	MI 4%
NJ 4%	MS 3%	TN 5%	OH 6%	MI 5%	OH 4%	NJ 3%
GA 3%	CA 3%	CA 4%	MI 5%	TN 5%	IL 4%	OH 3%
IN 3%	VA 3%	VA 4%	CA 3%	WI 3%	CA 3%	NY 3%

Table 18. Percentage of MJFR Steel by State, 2011-2016

Top 10 Steel States– based on number of steel services reported from Gas Distribution Annual Reports						
Number of Steel Services	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
CA 17%	TX 19%	TX 18%	TX 16%	TX 13%	VA 16%	VA 28%
TX 9%	IL 18%	IL 13%	IN 12%	IN 11%	TX 13%	MD 21%
IL 5%	IN 9%	IN 10%	IL 9%	VA 9%	MD 11%	IN 8%
NY 4%	NY 6%	MI 6%	TN 9%	PA 8%	IN 10%	IL 7%
MI 4%	OH 6%	NY 6%	VA 6%	OH 7%	NY 6%	TX 7%
OH 4%	MI 5%	TN 6%	NY 6%	IL 6%	MI 6%	MI 4%
NJ 4%	MS 5%	OH 5%	MI 6%	TN 6%	IL 5%	DC 3%
PA 4%	TN 4%	VA 4%	OH 5%	NY 5%	OH 5%	NY 3%
LA 4%	CO 3%	MD 3%	PA 3%	MI 5%	PA 3%	OH 2%
CO 3%	VA 2%	MS 3%	WI 2%	MD 4%	TN 2%	MO 2%

Table 19. Percentage of MJFR Plastic by State, 2011-2016

Top 10 Plastic States - – based on number of plastic services reported from Gas Distribution Annual Reports						
Number of Plastic Services	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
CA 12%	PA 26%	PA 20%	PA 22%	PA 23%	PA 25%	PA 18%
TX 7%	OH 11%	CA 14%	CA 12%	OH 9%	CA 12%	CA 14%
OH 5%	CA 10%	OH 7%	OH 8%	CA 8%	VA 6%	VA 8%
NY 5%	NY 5%	NY 6%	NY 8%	VA 7%	OH 5%	OH 6%
MI 5%	GA 4%	AZ 5%	VA 6%	NY 6%	NY 5%	MO 4%
PA 5%	CT 4%	NV 4%	NV 4%	WI 5%	NV 4%	NV 4%
IL 5%	MA 4%	VA 4%	AZ 3%	GA 3%	AZ 4%	MD 3%
NJ 3%	MO 3%	TN 3%	TN 3%	TN 3%	WI 3%	AZ 3%
GA 3%	SC 3%	TX 3%	CT 3%	TX 3%	MA 3%	NY 3%
IN 3%	AZ 3%	CT 3%	MA 3%	CT 3%	MD 2%	WI 3%

2.6.4 States by Causes of Hazardous Leak

Input: Data analyzed from SAS Computer Application

Output: Table 20 - Comparison of frequency of failures in States by cause

Responsibility: MJFR Team

Description: Produce a table with the columns of states reporting and causes of leaks for all years of data. From this information, the MJFR Team will develop observations on distribution of which states the failures are occurring and the distribution of the causes in states.

Table 20. Number of MFF by leak cause by State for all years of data

State	Corrosion	Equipment	Excavation Damage	Incorrect Operation	Material or Weld	Natural Forces	Other	Other Outside Force Damage
AK	1	16	0	0	0	36	3	0
AL	34	156	12	49	157	91	9	10
AR	3	21	7	5	8	34	15	3
AZ	1	28	4	263	251	6	9	5
CA	42	7	22	1098	503	21	391	32
CO	6	605	51	5	25	100	6	3
CT	13	697	5	13	278	253	11	1
DC	49	827	25	36	0	1	0	6
DE	2	1	1	2	8	14	17	0
FL	8	114	17	23	22	6	56	2
GA	3	454	35	89	32	19	1	7
HI	5	2	2	1	0	0	82	0
IA	8	51	18	7	90	56	3	0
ID	0	0	4	48	46	1	8	1
IL	196	3012	72	36	142	779	128	22
IN	354	1907	87	127	296	1723	628	33
KS	90	230	21	23	23	124	2	13
KY	88	169	19	469	416	84	158	16
LA	6	185	14	27	62	37	18	2
MA	45	19	4	55	227	195	332	3
MD	114	4475	134	151	22	42	78	7
ME	0	0	0	13	0	3	1	0
MI	161	1875	245	118	66	849	174	17
MN	25	260	2	58	55	105	63	2
MO	36	896	144	36	82	85	165	39
MS	3	384	31	325	23	425	0	1
MT	0	22	22	0	16	69	0	2
NC	4	444	74	52	104	46	35	4
ND	0	3	4	1	16	34	0	1
NE	0	9	3	5	5	12	5	0
NH	21	131	3	8	2	14	19	0
NJ	176	418	18	232	160	502	36	32
NM	1	375	4	6	1	1	61	1
NV	0	26	1	290	326	11	5	1
NY	277	2577	39	165	304	67	243	4
OH	615	217	101	852	543	286	873	28
OK	14	5	2	10	72	9	18	0
OR	1	12	24	53	65	0	17	2
PA	319	1599	14	329	2510	1625	221	61
RI	0	3	0	3	2	1	5	1
SC	6	176	18	102	151	4	38	1
SD	3	13	3	3	36	54	0	0
TN	5	2052	23	40	138	122	19	4
TX	215	2227	190	152	325	2632	1013	80
UT	4	8	4	5	5	8	7	3
VA	343	7052	96	385	74	294	193	8
VT	0	10	0	13	0	30	0	0
WA	23	22	35	104	69	3	30	2
WI	136	183	104	29	746	55	16	12

2.6.5 Leak Location (above or below ground) by Fitting Material

Input: Data analyzed from SAS Computer Application

Output: Table 21 – Leak location

Responsibility: MJFR Team

Description: Produce a table of Fitting Material by Leak Location (above or below ground). The data is provided below in Table 21. The table is read comparing percentages in the year column to the other year column for the various locations fitting and fitting material. From this information, the MJFR Team will develop observations based on percentage of material type and location

Table 21. Comparison of Fitting Material by Leak Location, 2011-2016

	Aboveground						Belowground					
	2011	2012	2013	2014	2015	2016	2011	2012	2013	2014	2015	2016
Steel	79%	72%	75%	74%	68%	74%	59%	59%	62%	65%	64%	69%
Plastic	2%	3%	2%	2%	12%	13%	29%	31%	28%	25%	23%	16%
Combination	14%	16%	18%	19%	15%	7%	4%	4%	4%	4%	4%	2%
Unknown	2%	2%	1%	1%	1%	1%	4%	1%	1%	3%	4%	6%
Other	1%	2%	1%	1%	1%	1%	2%	3%	3%	1%	2%	1%
Brass	2%	5%	3%	3%	3%	5%	1%	2%	2%	2%	3%	6%
Total	16%	14%	11%	8%	9%	8%	84%	86%	89%	92%	91%	92%

2.6.6 Leak Location (inside or outside) by Fitting Material

Input: Data analyzed from SAS Computer Application

Output: Table 22 – Leak location

Responsibility: MJFR Team

Description: Produce a table of Fitting Material by Location (inside or outside). The data is provided below in Table 22. The table is read comparing percentages in the year column to the other year column for the locations and fitting material. From this information, the MJFR Team will develop observations on percentage of material type and location.

Table 22. Frequency of leak location (inside or outside) by fitting material of mechanical fittings that failed and were reported to the Mechanical Joint Failure Reports, 2011-2016

	Inside						Outside					
	2011	2012	2013	2014	2015	2016	2011	2012	2013	2014	2015	2016
Steel	70%	82%	89%	69%	71%	79%	63%	60%	63%	66%	65%	69%
Plastic	10%	6%	4%	13%	8%	8%	25%	28%	26%	23%	22%	16%
Combination	5%	5%	3%	6%	4%	3%	5%	6%	6%	5%	5%	3%
Unknown	2%	1%	1%	3%	1%	1%	4%	1%	1%	3%	3%	5%
Other	2%	0%	0%	1%	1%	1%	2%	3%	3%	1%	2%	1%
Brass	10%	7%	3%	8%	15%	8%	1%	2%	2%	2%	3%	6%
Total	2%	2%	2%	1%	1%	1%	98%	98%	98%	99%	99%	99%

2.6.7 Leak Location (main and service connection) by Fitting Material

Input: Data analyzed from SAS Computer Application

Output: Table 23 - Frequency of leak location (main or service connection) by fitting material

Responsibility: MJFR Team

Description: Produce a table of Fitting Material by Location (main and service connections). The data is provided below in Table 23. The table is read comparing percentages in the year column to the other year column for the various locations and fitting material. From this information, the MJFR Team will develop observations based on percentage of material type and location and identify trends.

Table 23. Frequency of leak location (main or service connection) by fitting material of mechanical fittings that failed and were reported to the Mechanical Joint Failure Reports, 2013-2016

	Main to Main				Main to Service				Meter Set				Service to Service			
	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016
Steel	77%	88%	78%	87%	67%	61%	65%	60%	70%	69%	59%	83%	58%	58%	61%	65%
Plastic	6%	4%	4%	3%	26%	27%	25%	25%	2%	5%	11%	3%	33%	32%	28%	20%
Combo	2%	1%	3%	1%	3%	4%	5%	3%	24%	23%	27%	11%	5%	4%	4%	2%
Unknown	2%	6%	13%	7%	2%	5%	2%	5%	1%	1%	1%	1%	1%	2%	1%	5%
Other	13%	1%	1%	1%	2%	2%	3%	1%	0%	1%	0%	0%	1%	1%	2%	1%
Brass	1%	1%	1%	1%	1%	1%	1%	5%	2%	1%	2%	2%	2%	3%	5%	8%
Total	17%	21%	21%	20%	12%	12%	10%	8%	8%	6%	6%	5%	63%	60%	64%	67%

2.7 Manufacturer of Fitting

Special note for this section: The section is based on the name of manufacturer associated with the MJFR as reported by the operator. PHMSA cautions users of this data analysis on potential data quality issues that may exist with the information reported and the need to consider the information in the appropriate context (e.g., number of fittings that may be in service, length of time a manufacturer may have been producing fittings, and number of fittings a manufacturer may produce (i.e. overall market share)). PHMSA conducted some additional conservative data analysis to improve the data quality mostly due to spelling errors. These tables are based on the frequency of reporting. There is no information available about the total number fitting various manufactures produced and sold. Therefore, PHMSA is unable to adjust the failure reports by the quantity in use. The best measure PHMSA can use to put the information into context based on other information reported is rate of hazardous leaks eliminated/repaired. The rate of hazardous leaks repaired involving a mechanical fitting for 2016 is the number of MJFR (18,044) divided by the total number of hazardous leaks reported as eliminated/repaired in 2016 (209,563) which is 8.6%. For additional information, specific to a certain manufacturer to help put numbers in better context such as amount fittings they may have produced or sold, users may contact the manufacturer. Manufacturers would not be able to provide information on number of fittings they've sold that were installed, as that is information the operators would have.

Table 24. Quantification of the Role of Mechanical Joints in Hazardous Leaks, Mechanical Joint Failure Reports, 2011-2016 (as of 8/5/2017)

	2011	2012	2013	2014	2015	2016	Total
Number of MJFRs submitted	8,342	7,607	9,923	11,762	14,900	18,044	70,578
Hazardous Leaks eliminated/repaired	191,630	187,198	190,791	205,870	213,831	209,563	1,198,883
% MJFR of Total Hazardous Leaks eliminated/repaired	4.35	4.06	5.20	5.71	7.00	8.61	5.89

2.7.1 Manufacturer of Fitting by Year Manufactured

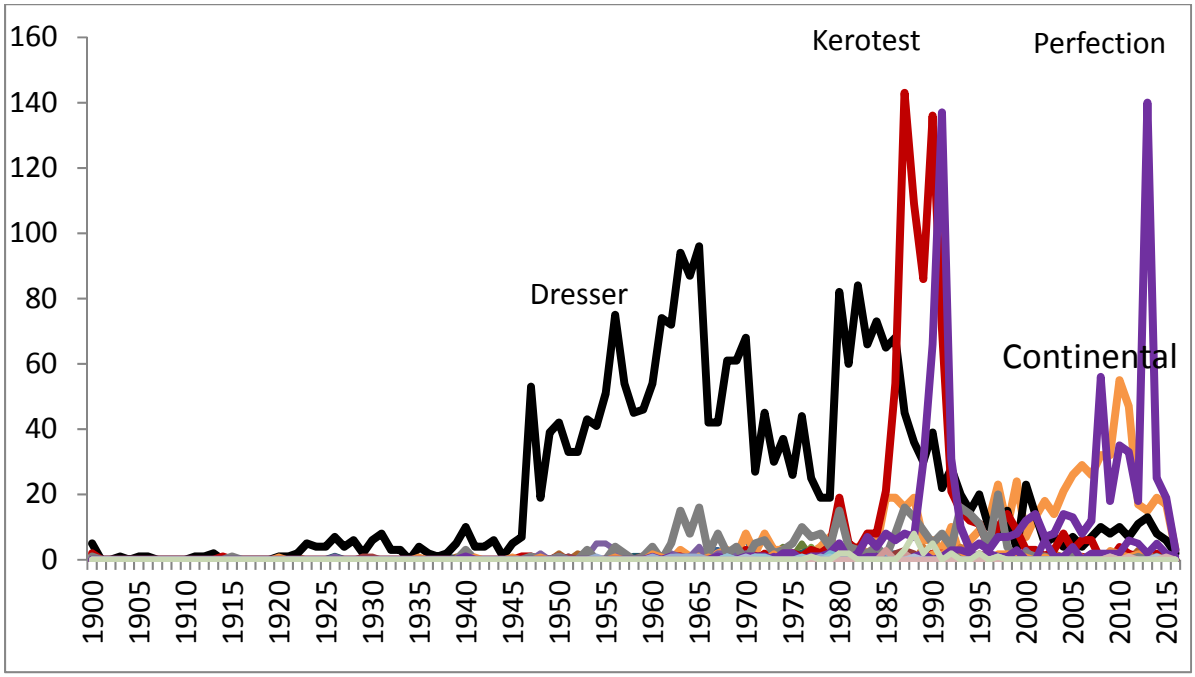
Input: Data analyzed from SAS Computer Application

Output: Figure 7 - Line plot of the number of failures by manufacturer by year fitting manufactured

Responsibility: MJFR Team

Description: Produce a line plot of the number of failures by manufacturer as reported by operators by year fitting manufactured on the x-axis. The data is presented below in Figure 7. From this information, the MJFR Team will develop observations on the validity of the data by those manufacturers with known issues for give manufactured years. Manufacturers with 3 or less MJFRs are put into the "Other" category and not plotted.

Figure 7. Line plot of the number of failures by manufacturer by year fitting manufactured, 2011-2016



2.7.2 Manufacturer by Years in Service

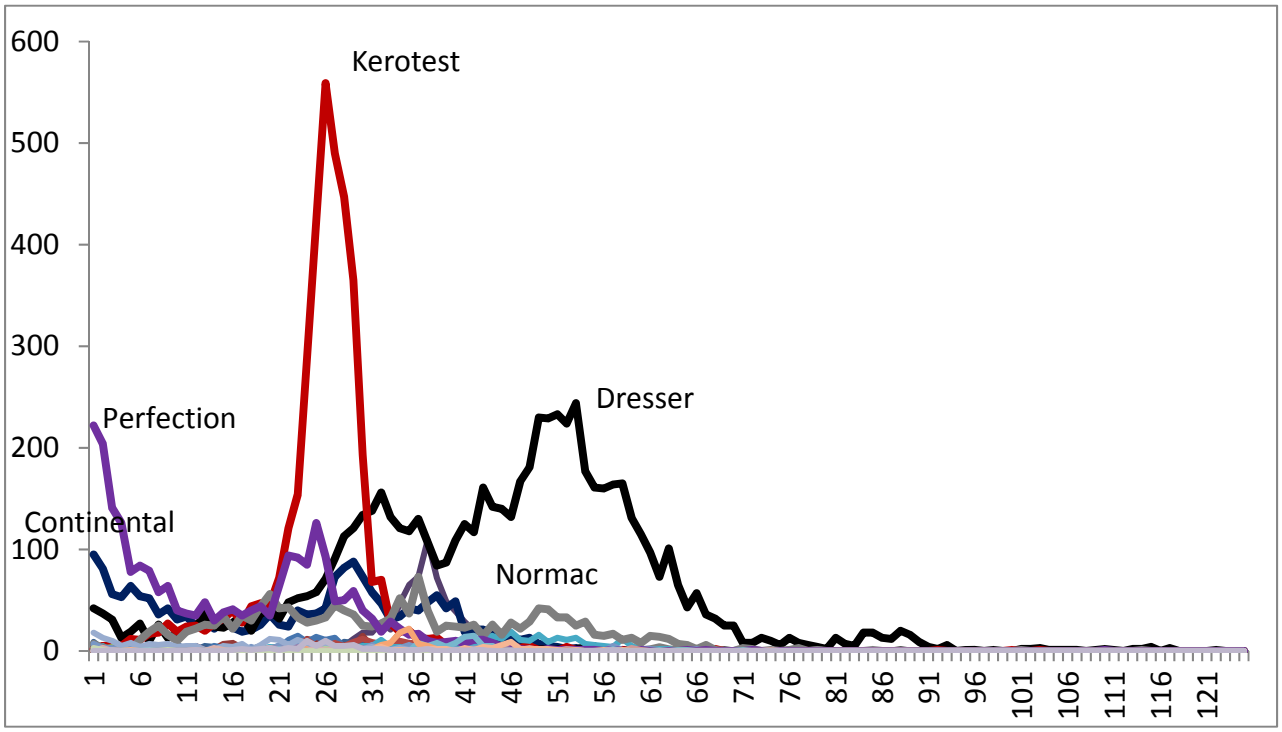
Input: Data analyzed from SAS Computer Application

Output: Figure 8 - Line plot of the number of failures by manufacturer by years of service

Responsibility: MJFR Team

Description: Produce a line plot of the number of failures by manufacturer as reported by operators by years of service on the x-axis. The data is presented below in Figure 8. From this information, the MJFR Team will develop observations on those manufacturers who do have longer/shorter times in service. Manufacturers with 3 or less MJFRs are put into the "Other" category and not plotted.

Figure 8 – Line plot of number of failures by manufacturer by years of service



2.7.3 Frequency of Manufacturers of Fittings

Input: Data analyzed from SAS Computer Application

Output: Table 25 – Manufacturers of failed mechanical fittings

Responsibility: MJFR Team

Description: Produce a table of the frequency of manufacturers reported by operators based on percentage of the data base. Due to the extent of the table only the first 10 are listed. The data is provided below in Table 25. The table is read comparing percentages in the year column to the other

year column for the various manufacturers. From this information, the MJFR Team will develop observations on prospective view of those manufacturers who have the highest reported number of failures and develop observations on the changes to the top 10 reported manufacturers.

Table 25. Frequency of manufacturers reported in MJFR data based on percentage of data, 2011-2016

Manufacturer	2011	Manufacturer	2012	Manufacturer	2013	Manufacturer	2014	Manufacturer	2015	Manufacturer	2016
Dresser	22%	Dresser	21%	Dresser	21%	Dresser	22%	Dresser	20%	Dresser	12%
Kerotest	9%	Perfection	7%	Kerotest	8%	Kerotest	7%	Kerotest	6%	Kerotest	4%
Normac	5%	Kerotest	6%	Perfection	5%	Normac	5%	Perfection	4%	Continental	3%
Perfection	4%	Normac	5%	Normac	4%	Perfection	5%	Continental	3%	Perfection	3%
Continental	4%	Continental	5%	Continental	4%	Continental	3%	Normac	3%	Normac	2%
AMP	1%	AMP	2%	AMP	1%	AMP	1%	AMP	1%	Chicago	2%
RW_Lyall	1%	Chicago	2%	Mueller	1%	Mueller	1%	Mueller	1%	AMP	1%
Muller	<1%	RW Lyall	1%	RW Lyall	<1%	RW Lyall	1%	RW Lyall	<1%	Mueller	<1%
Handley	<1%	Mueller	1%	Handley	<1%	RobRoy	1%	Central Plastics	<1%	Powell	<1%
Telsco	<1%	Inner-tite	<1%	Inner-tite	<1%	Central Plastics	<1%	Chicago	<1%	RW Lyall	<1%

2.7.4 Manufacturer by Year of Failure

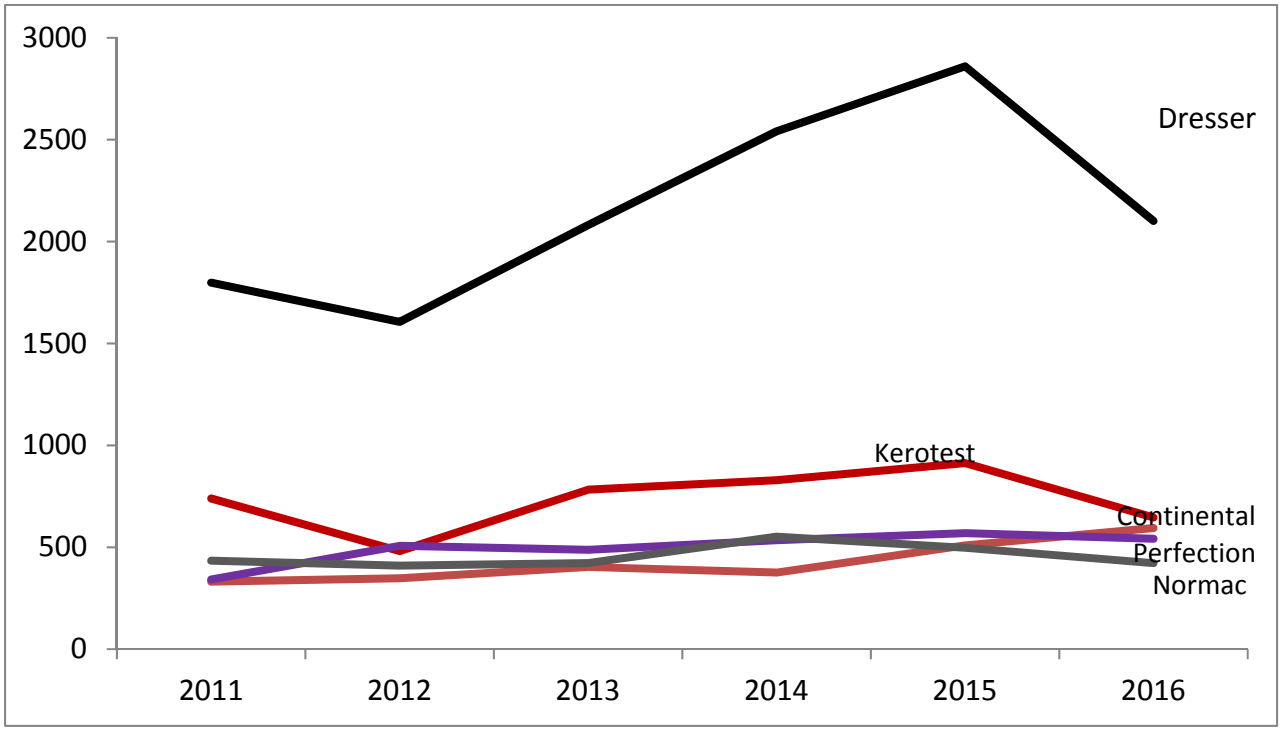
Input: Data analyzed from SAS Computer Application

Output: Figure 9 – Line plot of the number of failures by manufacturer by year of failure

Responsibility: MJFR Team

Description: Produce a line plot of the number of failures by manufacturer as reported by operators by year of failure on the x-axis. The data is presented below in Figure 9. From this information, the MJFR Team will develop observations on prospective view of those manufacturers who have an upward trend in the number of reported failures. Manufacturers with 3 or less MJFRs are put into the "Other" category and not plotted.

Figure 9 – Line plot of number of failures by manufacturer by year of failure



2.7.5 Manufacturer by Leak Causes

Input: Data analyzed from SAS Computer Application

Output: Table 25 – Frequency of manufacturers by reported apparent cause of leak

Responsibility: MJFR Team

Description: Produce a table of manufacturers reported by operators by reported apparent cause of leak (Part C Item 15) based on all data for all years. The data is provided below in Table 26. From this information, the MJFR Team will develop observations on manufacturers and leaks causes associated with those manufacturers. Manufacturers with 3 or less MJFRs are put into the "Other" category.

Table 26 – Manufacturers by reported apparent cause of leak, 2011-2016

Manufacturer	Corrosion	Equipment	Excavation Damage	Incorrect Operation	Material or Weld	Natural Forces	Other	Other Outside Force
ALDYL	0	3	1	0	3	1	3	4
AMERICAN	0	21	0	11	3	2	4	0
AMP	8	98	8	79	528	48	29	0
ANVIL RED	3	0	0	1	2	12	0	0
B K	0	8	0	0	0	0	0	0
CENTRAL PLASTICS (GEO	29	62	5	26	46	16	17	0

Manufacturer	Corrosion	Equipment	Excavation Damage	Incorrect Operation	Material or Weld	Natural Forces	Other	Other Outside Force
CHICAGO	38	420	4	37	12	22	2	2
CONINO	0	4	0	3	2	1	0	0
CONTINENTAL	136	707	61	747	573	154	153	0
CSI/SMITH BLAIR/ROCKWELL	15	71	3	13	23	29	9	25
DRESSER	652	7388	305	603	718	2411	847	0
DRISCO	3	27	4	1	9	3	3	0
DUPONT	1	3	1	27	29	2	3	0
EASTERN EBERHARD	1	1	1	1	2	1	4	58
FLO-CONTROL	0	1	0	0	0	18	0	1
HANDLEY	1	47	0	17	69	11	9	5
INNER-TITE	127	11	1	3	12	9	6	0
INTERNATIONAL	1	0	0	1	2	0	1	0
I-PEX	0	0	0	0	1	0	0	0
JM EAGLE	0	0	0	0	0	0	1	1
KEROTEST	23	1878	5	171	1898	176	219	2
LATIMER	7	1	0	0	1	0	0	0
M.T. DEASON	0	9	0	1	0	0	1	20
MET FIT	6	16	8	31	20	5	6	0
MGL	0	0	0	0	13	0	0	1
MUELLER	60	150	22	24	46	104	17	0
NORMAC	253	521	58	474	434	580	405	3
OTHER	18	67	9	32	47	55	62	0
PERFECTION	116	388	35	1296	625	145	350	10
PERFORMANCE	0	12	2	7	0	0	1	0
PLEXCO	0	11	2	14	20	0	1	12
POWELL	6	0	0	37	22	0	22	24
ROBROY	22	4	0	51	10	20	17	0
RW LYALL	14	71	48	77	66	25	23	0
SKINNER	3	10	1	2	1	10	3	0
SPEAR	0	0	0	1	0	8	0	0
SWEDGE LOCK	0	1	0	0	0	0	0	6
SWEDGELOCK	0	4	1	0	0	0	1	0
TELSCO	25	24	1	35	15	5	10	0
UNK	1888	21885	1193	2068	3339	7120	3018	1
UPONOR	2	15	0	8	3	5	3	0
US POLY	0	1	1	4	1	1	2	4
WAYNE	12	56	0	17	33	15	8	0

2.7.6 Manufacturer by Mechanical Fitting Involved

Input: Data analyzed from SAS Computer Application

Output: Table 27 – Frequency of manufacturer by mechanical fitting involved

Responsibility: MJFR Team

Description: Produce a table based on all years of manufacturer by mechanical fitting involved. The data is provided below in Table 27. From this information, the MJFR Team will develop observations on prospective view of those manufacturers and mechanical fitting involved associated with those manufacturers. Manufacturers with 3 or less MJFRs are put into the "Other" category.

Table 27 – Manufacturers by mechanical fitting type involved, 2011-2016

Manufacturer	Bolted	Nut Follower	other	Stab
ALDYL	1	1	9	0
AMERICAN	5	10	3	23
AMP	146	30	521	106
ANVIL RED	1	16	1	0
B K	0	0	8	0
CENTRAL PLASTICS (GEO	44	47	56	54
CHICAGO	4	101	429	3
CONINO	0	4	6	0
CONTINENTAL	418	741	644	757
CSI/SMITH BLAIR/ROCKWELL	69	60	34	3
DRESSER	1872	10106	802	207
DRISCO	3	14	17	17
DUPONT	3	3	63	2
EASTERN EBERHARD	8	3	0	0
FLO-CONTROL	0	16	3	0
HANDLEY	0	135	12	8
INNER-TITE	1	139	28	4
INTERNATIONAL	0	5	0	0
I-PEX	0	0	1	0
JM EAGLE	0	0	1	0
KEROTEST	64	4099	109	118
LATIMER	0	9	0	0
M.T. DEASON	0	10	1	0
MET FIT	2	4	60	26
MGL	6	0	7	0
MUELLER	59	268	85	14
NORMAC	23	2458	226	30
OTHER	56	131	87	28
PERFECTION	125	90	267	2498
PERFORMANCE	0	1	5	16
PLEXCO	2	11	21	14
POWELL	0	13	76	0
ROBROY	0	81	38	5
RW LYALL	91	38	100	101
SKINNER	19	6	5	0
SPEAR	0	10	0	0
SWEDGE LOCK	0	0	1	0
SWEDGELOCK	0	3	3	0
TELSCO	2	108	4	1
UNK	3811	26542	7451	2989
UPONOR	1	16	15	5
US POLY	0	0	7	3
WAYNE	0	107	23	11

2.8 Operators submitting MJFR

The MJFR Team members will analyze the MJFR data and generate the tables and charts outlined in this procedure. Typically, the data from PDM is moved into a computer application called "SAS" in which the data is manipulated for analysis. The output from SAS is moved into PowerPoint for presentation and discussion purposes. The most current data is available on the public and internal sides of the PDM. Other evaluations and analyses may be performed depending upon the trends in the data. For instance, the MJFR Team may decide to evaluate the number of MJFR by mile of main or service that an Operator is reporting and on an individual operator basis, as appropriate.

Similar to information provided by manufacturer, PHMSA cautions users of this data analysis on the need to consider the information in the appropriate context (e.g., amount and type of fittings an operator may have in their systems, system mileage, etc.). There is no definitive information publicly available about the number of fittings produced or installed. Many operators do maintain an inventory tracking system of the number of fittings that may have purchased vs. in stock vs. installed, but numbers can vary. Therefore, PHMSA is unable to adjust the failure reports by the quantity produced or in use.

2.8.1 Frequency of Operator by Year of Failure

Input: Data analyzed from SAS Computer Application

Output: Table 28 – Frequency of operators reporting fitting failures by year of failure

Responsibility: MJFR Team

Description: Produce a table of operators reporting by year of failure. The data is provided below in Table 28. From this information, the MJFR Team will develop observations on prospective view of operators and reports.

Table 28 – Operators reporting by year of failure

Operator	2011	2012	2013	2014	2015	2016
ALABAMA GAS CORPORATION	48	48	55	41	29	25
ALEXANDER CITY MUNICIPAL GAS	0	0	0	3	2	0
ALLIANT ENERGY - INTERSTATE POWER AND LIGHT COMPANY	0	7	7	6	8	5
AMEREN ILLINOIS COMPANY	136	141	171	192	352	347
AMERENUE	1	2	1	0	12	2
APPALACHIAN NATURAL GAS DISTRIBUTION COMPANY	0	0	0	2	0	0
ARKANSAS WESTERN GAS CO	1	1	0	0	0	0
ATLANTA GAS LIGHT CO	140	82	59	132	62	69
ATMOS ENERGY CORPORATION - COLORADO/KANSAS	3	4	13	3	3	2
ATMOS ENERGY CORPORATION - KY/MID-STATES (KENTUCKY)	14	19	21	18	24	14
ATMOS ENERGY CORPORATION - KY/MID-STATES (MID-STATES)	21	32	6	13	21	8
ATMOS ENERGY CORPORATION - LOUISIANA	8	23	14	22	29	31

Operator	2011	2012	2013	2014	2015	2016
ATMOS ENERGY CORPORATION - MID-TEX	453	382	482	397	593	404
ATMOS ENERGY CORPORATION - MISSISSIPPI	271	127	103	169	183	253
ATMOS ENERGY CORPORATION - WEST TEXAS	1	7	7	5	12	7
ATMOS PIPELINE - TEXAS	0	11	51	0	0	0
AUSTELL NATURAL GAS SYSTEM, CITY OF	1	0	0	0	0	0
AUSTIN UTILITIES	0	0	1	0	0	0
AVISTA CORP	19	37	32	52	53	42
BALTIMORE GAS & ELECTRIC CO	13	16	13	11	10	13
BANGOR GAS CO LLC	1	5	0	0	0	0
BERKSHIRE GAS CO	5	4	17	20	33	23
BLACK HILLS ENERGY	4	6	6	8	5	5
BLACKSTONE GAS CO	0	1	2	0	1	0
BOSTON GAS CO	5	2	2	1	2	1
BRADY MUNICIPAL GAS CORP, CITY OF	0	6	6	1	1	0
BRENHAM UTILITY, CITY OF	3	1	2	5	3	6
CALERA MUNICIPLE GAS SYSTEM, TOWN OF	2	0	0	0	0	0
CARTERSVILLE GAS DEPT, CITY OF	2	4	1	1	0	0
CASCADE NATURAL GAS CORP	0	0	0	0	0	1
CASTROVILLE UTILITY SYSTEM	0	1	0	293	0	1
CEDAR FALLS MUNICIPAL UTILITY	0	0	0	1	0	0
CENTERPOINT ENERGY RESOURCES CORP.	0	18	10	4	4	47
CENTERPOINT ENERGY RESOURCES CORP., DBA CENTERPOINT ENERGY MINNESOTA GAS	39	23	55	62	31	19
CENTERPOINT ENERGY RESOURCES CORPORATION	0	119	201	262	267	157
CENTERVILLE, TOWN OF	2	0	0	1	0	1
CENTRAL FLORIDA GAS CORP	0	0	3	0	0	1
CENTRAL HUDSON GAS & ELECTRIC CORP	25	27	30	15	7	8
CHAMBERSBURG GAS DEPT	0	0	0	1	0	0
CHATTANOOGA GAS CO	30	33	25	41	43	9
CHELSEA GAS AUTH	0	0	0	0	1	0
CHESAPEAKE UTILITIES CORPORATION	0	15	8	0	3	3
CHESAPEAKE UTILITY CORP	7	0	0	0	0	0
CHEYENNE LIGHT FUEL & POWER	0	1	4	0	1	0
CHIRENO MUNICIPAL GAS, CITY OF	0	0	0	0	7	0
CIRCLE PINES UTILITY	3	0	0	0	0	0
CITIZENS GAS & COKE UTILITY	190	236	378	228	219	183
CITY OF BENSON	0	0	0	1	3	0
CITY OF CALERA NATURAL GAS	0	1	1	1	0	1
CITY OF ROCKPORT	4	1	1	6	3	2
CLARKSVILLE GAS & WATER DEPT	0	0	0	0	0	3
COLORADO SPRINGS, CITY OF	6	7	7	10	4	8
COLUMBIA GAS OF KENTUCKY INC	13	30	64	64	50	44
COLUMBIA GAS OF MARYLAND INC	14	20	18	37	34	23
COLUMBIA GAS OF MASSACHUSETTS	91	44	95	86	104	91
COLUMBIA GAS OF OHIO INC	359	239	353	448	388	315
COLUMBIA GAS OF PENNSYLVANIA	52	74	89	117	59	70
COLUMBIA GAS OF VIRGINIA INC	45	60	117	140	142	180

Operator	2011	2012	2013	2014	2015	2016
COMMUNITY NATURAL GAS INC	2	0	0	0	0	0
COMMUNITY UTILITIES CO.	0	0	0	0	0	1
CONNECTICUT NATURAL GAS CORP	16	17	40	52	48	48
CONSOLIDATED EDISON CO OF NEW YORK	412	352	417	418	579	307
CONSUMERS ENERGY CO	368	397	470	448	671	698
CONSUMERS GAS UTILITY CO	0	1	0	0	0	0
CORINTH GAS DEPT, CITY OF	0	0	0	7	13	16
CORNING MUNICIPAL UTILITIES	1	1	3	2	1	1
CORPUS CHRISTI, CITY OF - GAS DIV	10	14	6	5	2	0
COVINGTON GAS DEPT, CITY OF	0	3	0	0	0	0
CPS ENERGY	360	224	254	10	414	294
CULLMAN - JEFFERSON CO GAS DIST	1	0	0	0	0	2
DALTON WATER LIGHT & SINKING FUND COMMISSION	0	1	0	0	0	0
DANVILLE, CITY OF	1	1	1	0	4	3
DECATUR UTILITIES - GAS DEPARTMENT	0	1	0	0	0	0
DELMARVA POWER & LIGHT COMPANY	1	1	1	6	6	5
DELTA NATURAL GAS CO INC	0	0	0	0	1	1
DOMINION EAST OHIO	76	63	62	51	39	41
DOMINION HOPE	12	19	19	19	18	6
DTE GAS COMPANY	0	0	8	3	3	2
DUBLIN, CITY OF	4	0	0	0	0	1
DUKE ENERGY KENTUCKY	1	10	11	3	6	9
DUKE ENERGY OHIO	26	78	26	39	23	21
DUPO GAS SYSTEM, VILLAGE OF	0	0	0	1	0	0
EASTERN NATURAL GAS CO	7	2	0	0	0	0
EASTON UTILITIES COMMISSION	0	0	0	3	1	2
ELIZABETHTOWN GAS CO	31	21	37	14	20	6
ELK RIVER PUBLIC UTIL DIST	0	0	0	2	0	0
ELKTON GAS SERVICE - DIV PENNS & SOUTHERN GAS CO	0	0	0	0	1	0
ENERGY NORTH NATURAL GAS INC	6	4	12	62	73	37
ENERGY WEST MONTANA	7	1	1	3	2	7
ENSTAR NATURAL GAS CO	14	13	2	16	6	4
ENTERGY GULF STATES	4	0	8	24	68	39
ENTERGY NEW ORLEANS, INC	3	5	3	6	7	3
ENTEX, A NORAM ENERGY COMPANY (FORM. DIV OF ARKLA	198	45	0	0	0	0
EQUITABLE GAS COMPANY, LLC	0	17	32	0	0	0
EQUITABLE RESOURCES (A.K.A EQUITABLE GAS CO)	10	0	0	0	0	0
ESSEX COUNTY GAS CO	0	2	0	0	0	0
FAIRBANKS NATURAL GAS	0	0	0	1	0	0
FAIRFIELD MUNICIPAL GAS UTILITY	2	1	0	0	0	0
FAIRHOPE GAS SYSTEM, CITY OF	0	1	0	0	0	0
FALFURRIAS UTILITY BOARD	0	18	6	43	11	0
FALLS CITY UTILITIES	0	1	0	0	0	0
FAYETTEVILLE PUBLIC UTILITIES GAS DEPT.	0	0	2	0	0	0
FITCHBURG GAS & ELECTRIC LIGHT CO	2	9	18	10	9	6
FLORENCE GAS DEPT, CITY OF	3	1	0	0	0	0
FLORIDA CITY GAS	1	0	0	0	2	0
FLORIDA PUBLIC UTILITIES CO	6	10	7	6	10	7
FORT HILL NATURAL GAS AUTH	0	0	0	0	5	5

Operator	2011	2012	2013	2014	2015	2016
FULTON MUNICIPAL GAS SYSTEM	0	0	0	0	0	2
GAINESVILLE REGIONAL UTIL GAS DEPT	1	0	0	0	0	1
GREAT PLAINS NATURAL GAS CO	4	1	0	0	2	1
GREATER MINNESOTA GAS INC.	0	0	0	0	1	0
GREENVILLE UTILITIES COMMISSION	2	1	9	3	7	7
GREENWOOD COMMISSION OF PUBLIC WORKS	2	9	2	2	3	0
GUYMON MUNICIPAL GAS CO	0	1	0	0	0	1
HALLS GAS DEPT, TOWN OF	1	0	0	0	0	0
HALSTEAD GAS DEPT, CITY OF	0	1	0	0	0	0
HAMILTON GAS DEPT, CITY OF	8	8	10	1	2	6
HASTINGS UTILITIES	2	0	0	0	1	0
HAWAI`IGAS	0	0	11	29	1	0
HAWAII GAS	0	0	0	0	3	11
HAWARDEN GAS DEPT, CITY OF	1	2	2	1	0	0
HENDERSON MUNICIPAL GAS	0	0	0	0	0	1
HOLYOKE GAS & ELECTRIC DEPT, CITY OF	0	1	9	16	14	0
HUMBOLDT UTILITIES - GAS DEPT	13	17	9	4	7	3
HUNTSVILLE GAS SYSTEM	13	9	13	15	26	11
INDIANA GAS CO INC	87	66	61	95	97	55
INDIANA NATURAL GAS CORP	0	0	0	0	1	0
INTERMOUNTAIN GAS CO	9	4	3	9	10	16
JACKSON ENERGY AUTHORITY	44	19	31	13	10	11
KANSAS GAS SERVICE	89	68	62	0	0	0
KANSAS GAS SERVICE COMPANY, A DIVISION OF ONE GAS, INC.	0	8	18	90	110	43
KEYSPAN ENERGY DELIVERY - NY CITY	1	0	0	0	0	0
KEYSTONE RURAL GAS DISTRICT #1	2	1	2	0	0	3
KINGS MOUNTAIN NATURAL GAS SYSTEM	0	0	0	2	0	1
KNG ENERGY INC	2	0	0	1	4	2
KNOXVILLE UTILITIES BOARD	6	7	12	16	11	15
LACLEDE GAS CO	181	11	91	128	261	292
LAKE APOPKA NATURAL GAS DISTRICT	4	2	0	1	6	8
LAKE PARK MUNICIPAL UTILITIES	1	0	0	0	0	0
LANCASTER MUNICIPAL GAS CO, CITY OF	10	4	5	5	4	7
LAS CRUCES, CITY OF	1	4	1	1	0	0
LAURENS COMMISSION OF PUBLIC WORKS	0	0	0	2	1	0
LAWRENCEBURG GAS DEPT, CITY OF	16	10	8	9	6	9
LAWRENCEVILLE, CITY OF	0	1	1	9	40	6
LEBO MUNICIPAL GAS SYSTEM	1	0	0	0	0	0
LEFORS GAS DEPT, CITY OF	0	1	0	0	0	0
LEWISBURG GAS DEPARTMENT	3	0	1	5	2	1
LEXINGTON GAS SYSTEM	7	8	5	6	11	6
LIBERTY UTILITIES (NEW ENGLAND NATURAL GAS COMPANY) CORP	0	0	0	0	0	1
LIBERTY UTILITIES MASSACHUSETTS	0	0	8	11	12	9
LITTLE RIVER MUNICIPAL SYSTEM, CITY OF	0	0	1	0	0	0
LIVE OAK GAS DEPT, CITY OF	0	1	0	0	0	0
LONG BEACH GAS DEPT, CITY OF	9	7	7	6	7	17
LOUISVILLE GAS & ELECTRIC CO	167	174	207	186	135	109
LUMBERPORT - SHINNSTON GAS CO	0	0	0	0	1	0

Operator	2011	2012	2013	2014	2015	2016
LYTLE MUNICIPAL SYSTEM	0	1	0	0	0	1
MADISON GAS & ELECTRIC CO	2	2	3	0	0	0
MADISON, CITY OF	5	9	0	0	0	0
MAINE NATURAL GAS	0	0	0	1	0	2
MARIANNA, CITY OF	1	1	2	1	1	1
MARSHALL COUNTY GAS DISTRICT	5	7	11	5	2	2
MEMPHIS LIGHT GAS & WATER DIVISION	106	247	546	423	203	212
METROPOLITAN UTILITIES DISTRICT	4	2	0	3	4	2
MICHIGAN CONSOLIDATED GAS CO (MICHCON)	2	5	0	0	0	0
MICHIGAN GAS UTILITIES CO	19	30	29	42	19	8
MIDAMERICAN ENERGY COMPANY	41	58	38	36	22	36
MIDDLEBOROUGH GAS & ELECTRIC DEPT	0	0	0	1	70	1
MIDDLEBOROUGH GAS & ELECTRICT DEPT	5	0	0	0	0	0
MIDWEST NATURAL GAS CORP	2	0	3	0	0	0
MIDWEST NATURAL GAS INC	1	0	0	0	0	0
MINNESOTA ENERGY RESOURCES CORPORATION	1	1	0	1	1	1
MISSISSIPPI RIVER GAS LLC	2	1	0	0	0	0
MISSOURI GAS ENERGY	1	1	0	0	19	68
MOBILE GAS SERVICE CORP	15	8	14	19	15	8
MONROE NATURAL GAS DEPT, CITY OF	0	0	1	0	0	0
MONTANA - DAKOTA UTILITIES CO	23	23	20	50	46	45
MOULTON MUNICIPAL GAS SYSTEM	0	0	1	0	0	0
MOULTRIE GAS DEPT, CITY OF	1	0	0	0	0	0
MOUNTAINEER GAS CO	7	5	5	0	1	1
MT CARMEL PUBLIC UTILITY CO	0	1	0	0	0	0
NATIONAL FUEL GAS DISTRIBUTION CORP	22	33	36	63	54	54
NATIONAL FUEL GAS DISTRIBUTION CORP - NEW YORK	40	64	99	121	92	57
NATIONAL GAS & OIL CORP	23	21	67	200	74	37
NAVASOTA, CITY OF	0	4	2	0	0	0
NEW ALBANY GAS SYSTEM	5	0	0	0	0	0
NEW ENGLAND GAS COMPANY	3	5	1	0	0	0
NEW JERSEY NATURAL GAS CO	20	34	47	61	51	53
NEW MEXICO GAS COMPANY	116	84	77	53	51	61
NEW YORK STATE ELECTRIC & GAS CORP	0	23	34	19	14	24
NGO TRANSMISSION, INC.	0	0	0	2	0	0
NIAGARA MOHAWK POWER CORP	8	4	2	9	25	9
NORTH SHORE GAS CO	4	4	1	0	1	13
NORTHERN ILLINOIS GAS CO	780	425	350	273	178	533
NORTHERN INDIANA PUBLIC SERVICE CO	139	127	274	509	617	778
NORTHERN STATES POWER CO OF MINNESOTA	74	43	80	63	45	44
NORTHERN STATES POWER CO OF WISCONSIN	12	0	1	6	3	6
NORTHERN UTILITIES INC (ME)	1	0	0	3	0	4
NORTHERN UTILITIES, INC. (NH)	0	0	0	2	0	1
NORTHWEST ALABAMA GAS DISTRICT	0	1	2	7	9	2
NORTHWEST NATURAL GAS CO	20	27	9	8	7	13

Operator	2011	2012	2013	2014	2015	2016
NORTHWESTERN CORPORATION	0	0	0	0	0	2
NORTHWESTERN ENERGY LLC	13	5	5	4	2	0
NORWICH DEPT OF PUBLIC UTILITIES, CITY OF	0	1	0	3	2	1
NSTAR GAS COMPANY	0	1	0	11	15	0
NV Energy	13	18	52	35	18	18
OHIO GAS CO	3	2	0	1	1	0
OHIO VALLEY GAS CORP	0	0	0	0	0	1
OKLAHOMA NATURAL GAS CO	15	8	0	0	0	0
OKLAHOMA NATURAL GAS COMPANY, A DIVISION OF ONE GAS, INC.	0	0	23	13	14	15
ORANGE & ROCKLAND UTILITY INC	0	0	48	96	137	70
ORWELL NATURAL GAS CO	0	0	0	0	1	0
PACIFIC GAS & ELECTRIC CO	229	288	296	219	408	439
PALO ALTO, CITY OF	1	2	0	0	0	0
PASCAGOULA NATURAL GAS SYSTEM, CITY OF	0	0	2	5	2	2
PECO ENERGY CO	7	15	5	3	3	4
PENSACOLA, ENERGY SERVICES OF	4	26	7	1	0	0
PEOPLES GAS LIGHT & COKE CO	68	107	138	90	47	16
PEOPLES GAS SYSTEM INC	8	9	16	11	24	15
PEOPLES NATURAL GAS COMPANY LLC	21	20	36	49	401	620
PEOPLES TWP LLC	3	4	3	1	0	0
PERRY GAS SYSTEM, CITY OF	0	0	0	0	0	1
PHILADELPHIA GAS WORKS	248	203	425	626	606	378
PIEDMONT NATURAL GAS CO INC	3	58	89	136	222	106
POWELL CLINCH UTIL DIST	0	2	3	8	3	10
PRESQUE ISLE ELECTRIC & GAS COOPERATIVE	1	2	1	1	2	3
PUBLIC SERVICE CO OF COLORADO	139	95	112	148	109	145
PUBLIC SERVICE CO OF NORTH CAROLINA	11	7	24	37	51	30
PUBLIC SERVICE ELECTRIC & GAS CO	71	38	64	178	154	368
PUGET SOUND ENERGY	38	42	20	36	21	40
QUESTAR GAS COMPANY	33	45	1	1	1	0
RANTOUL, VILLAGE OF	0	0	0	1	0	0
RELIANT ENERGY ARKLA, DIV OF RELIANT ENERGY RESOURC	56	0	0	0	0	0
REMSEN MUNICIPAL UTILITIES, TOWN OF	0	0	1	0	0	0
RICHMOND NATURAL GAS & SEWAGE WKS	0	0	0	0	0	1
RICHMOND, CITY OF	41	47	52	53	66	21
ROANOKE GAS CO	10	16	27	31	30	24
ROBSTOWN GAS SYSTEM, CITY OF	2	0	0	0	0	0
ROCHESTER GAS & ELECTRIC CORP	0	11	28	11	13	18
Rock Energy Cooperative	0	0	0	0	1	0
ROCKY MOUNT MUNICIPAL SYSTEM, CITY OF	4	0	0	2	1	3
ROZEL MUNICIPAL GAS SYSTEM, CITY OF	1	1	0	0	1	0
SAN DIEGO GAS & ELECTRIC CO	0	2	4	6	2	2
SANDPIPER ENERGY	0	0	0	1	4	0
SAVANNAH PUBLIC UTILITY DEPT	3	1	0	0	0	0
SEMCO ENERGY GAS COMPANY	50	49	33	54	54	31
SEVIER COUNTY UTIL DIST	0	2	1	0	3	1

Operator	2011	2012	2013	2014	2015	2016
SHELBY GAS DEPT, CITY OF	0	0	0	0	1	0
SOMERSET GAS SERVICE	4	2	11	2	4	0
SOURCEGAS ARKANSAS INC.	0	0	5	5	4	0
SOURCEGAS LLC	5	1	6	3	4	1
SOUTH ALABAMA GAS DISTRICT	7	0	0	0	0	0
SOUTH CAROLINA ELECTRIC & GAS CO	101	77	50	40	59	42
SOUTH JERSEY GAS CO	26	36	30	59	78	78
SOUTHEAST ALABAMA GAS DISTRICT	0	0	0	0	6	6
SOUTHEASTERN NATURAL GAS CO	1	0	0	0	0	0
SOUTHERN CALIFORNIA EDISON CO	0	0	1	1	0	0
SOUTHERN CALIFORNIA GAS CO	0	23	27	28	26	13
SOUTHERN CONNECTICUT GAS CO	15	7	20	22	24	17
SOUTHERN INDIANA GAS & ELECTRIC CO	121	93	91	146	201	127
SOUTHERN PUBLIC SERVICE CO	1	0	0	0	0	0
SOUTHWEST GAS CORP	116	178	192	113	249	221
SOUTHWESTERN VIRGINIA GAS CO	2	6	10	4	4	1
SPRINGFIELD GAS SYSTEM	0	2	0	0	0	0
SPRINGFIELD, CITY UTILITIES OF	56	40	72	75	92	66
ST CROIX VALLEY NATURAL GAS CO INC	0	0	0	0	5	5
SUBURBAN NATURAL GAS COMPANY	1	0	0	0	0	0
SUGAR HILL NATURAL GAS SYSTEM, CITY OF	2	0	0	0	0	0
SUPERIOR WATER LIGHT & POWER CO	0	7	3	0	0	0
SWEENY GAS SYSTEM, CITY OF	0	0	6	1	0	0
SWEETWATER BOARD OF PUBLIC UTILITES	0	0	0	1	1	1
SYCAMORE GAS COMPANY	4	8	4	4	5	2
TALLAHASSEE, CITY OF	29	0	0	0	0	0
TEAVEE OIL & GAS INC	0	0	1	0	0	0
TEXAS GAS SERVICE COMPANY	92	141	0	0	0	0
TEXAS GAS SERVICE COMPANY, A DIVISION OF ONE GAS, INC.	0	4	129	157	105	109
THE EMPIRE DISTRICT GAS COMPANY	3	1	1	0	0	0
THE GAS COMPANY	16	20	1	0	0	0
TRUSSVILLE, UTILITIES BOARD, CITY OF	1	5	7	0	0	1
UGI CENTRAL PENN GAS, INC	5	9	1	2	9	4
UGI PENN NATURAL GAS	199	115	105	152	169	95
UGI UTILITIES, INC	143	140	209	315	351	189
UNICOI COUNTY MUNICIPAL UTILITY AUTH	0	0	0	0	0	1
UNION OIL & GAS INC	0	1	7	6	1	0
UNION UTILITY DEPT, CITY OF	3	0	0	0	1	0
UNISOURCE ENERGY SERVICES	3	13	12	6	7	4
VALLEY ENERGY, INC.	2	1	46	40	10	5
VECTREN ENERGY DELIVERY OF OHIO	44	17	33	70	100	69
VERMONT GAS SYSTEMS INC	5	16	4	8	19	1
VILLAGE OF MORTON	1	0	0	0	0	0
VIRGINIA NATURAL GAS	16	41	116	228	220	147
WALLER, CITY OF	0	0	1	0	0	0
WALNUT MUNICIPLE GAS SYSTEM, TOWN OF	1	2	1	1	1	0
WASHINGTON GAS LIGHT CO	238	298	471	930	2973	7338
WATERTOWN MUNICIPAL GAS DEPT	0	0	0	1	0	0
WATERVILLE GAS & OIL CO	2	1	4	4	2	0
WE ENERGIES	12	0	0	0	0	0

Operator	2011	2012	2013	2014	2015	2016
WEST POINT GAS SYSTEM	0	0	2	0	0	0
WEST TEXAS GAS INC	0	0	4	0	1	3
WESTFIELD GAS CORP	0	0	0	0	0	2
WILLMUT GAS & OIL CO - MAIN OFFICE	4	3	1	3	3	3
WILSON GAS DEPT, CITY OF	0	11	4	6	11	6
WISCONSIN ELECTRIC POWER COMPANY DBA WE ENERGIES	0	1	0	46	28	38
WISCONSIN GAS CO	7	0	0	0	0	0
WISCONSIN GAS LLC DBA WE ENERGIES	0	38	219	356	258	211
WISCONSIN PUBLIC SERVICE CORP	4	4	1	3	0	0
YANKEE GAS SERVICES CO	140	121	177	231	168	101
YORK COUNTY NATURAL GAS AUTH	0	0	1	0	0	1

3.0 Future Analysis Ideas and Concepts

Additional years of data will allow for the application of the appropriate statistics. The format of the tables and figures will need to change over time to accommodate the additional information, and more line plots have been used in this year's report with 6-years' worth of data having been collected.

3.1 Limitations

Due to the nature of the data some types of analysis cannot be accomplished. For example, some analysis requires multiple years' worth of information. For surveillance systems, 5 years is the generally accepted minimum. Now that this threshold is met, the MJFR is still a surveillance system, and the information collection activity will continue. The largest limitation facing MJFR is the absent of denominator information. The information of how many and what type of fittings have been installed and where the fittings were installed is not available. Another limitation that is common among surveillance systems is issues with the interpretation of the report form itself. The MJFR team has made attempts to edit any potential misunderstandings with the report form and instructions for the report form. Also, as with any other surveillance system there is the variance of data quality between reports. An example would be the naming convention of manufacturers from submitted MJFRs with varying manufacturer names describing the same manufacturer. The MJFR Team has mapped common names for a given manufacturer together when appropriate.

3.2 Updates

Data submitted for 2016 shows similar trends to the previous years of data. At this time, no other additional analysis has been identified for inclusion. In the future, the Team plans on including a historical list of updates or changes to the form, updates to the electronic submittal process, discussion of advisory bulletins pertaining to MJFR, etc.

Rulemaking is in progress to change the name of the Mechanical Fitting Failure Report to Mechanical Joint Failure Report to represent that the hazardous leak occurred within a joint connection of pipe and the apparent cause of leakage may not be due to equipment failure of the fitting.

4.0 Technical Review and Analysis

Input: Figures, Tables, Data generated from Analysis in Section 2

Output: This procedure with updated tables and figures inserted into the document or other appropriate documentation

Responsibility: MJFR Team

Description: The MJFR Team meets to discuss the initial analysis, vet out concepts and ideas about what the data analysis represents, and potential additional analysis. The meetings will be held in person and via web-based meeting. Meeting minutes documenting initial observations and recommendations will be distributed for comments and review internally within PHMSA.

Following MJFR Team annual discussions of the data and analysis, observations and recommendations will be documented in an electronic format suitable for transmission and filling. This documentation is typically the completion of this procedural document. Other documentation may include more informal dissemination of information through the DIMP website or presentations and discussion with stakeholders, or if more formal action is needed, a Memorandum, Technical Report, Advisory Bulletin, or email transmission to PHMSA personnel. The analysis should include consideration and discussion of, but not limited to, the following:

- Trends in data analysis
- Suspect materials, specific models of mechanical fittings, etc.
- Identification of issues that represent a threat to the integrity of the nation's distribution pipeline system
- Areas of concern identified by the MJFR Team

4.1 Overview of Analysis

Analysis of the MJFR data received to date is consistent with what was expected when we initiated this information collection activity and is consistent with other data sources (e.g., data from Gas Distribution annual reports). Data submitted for 2016 shows similar trends to previous 5 years of data collection, and trends in the data are within acceptable variance.

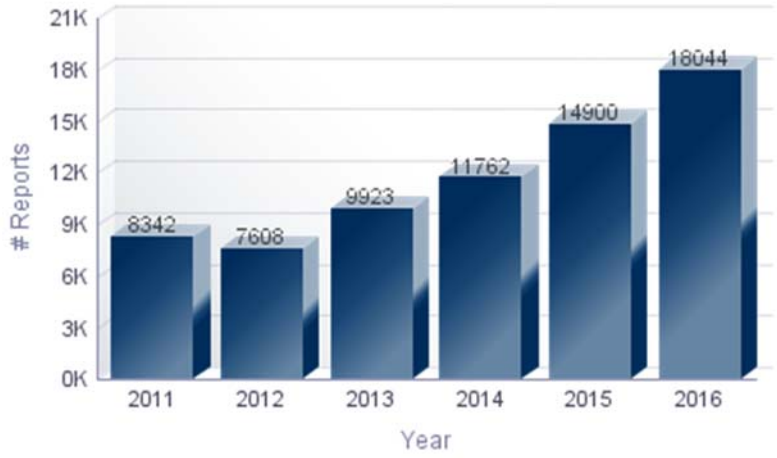
In summary, the majority of mechanical joint failures resulting in a hazardous leak involve nut-follower, coupling type fittings. In 2016, data analysis provides the following insights:

- Equipment failure is the leading reported cause of leaks (61%), and Natural forces is second (11%)
- Majority of leaks occur outside (99%), belowground (92%) involving service-to-service connections (67%)
- Steel fittings (69%) are involved in most reports, and plastic fittings are second (17%)
- Valves are involved in 7% of reported failures in 2016.
- Mechanical joint failures involve mostly coupling type steel fittings that are most belowground
- Number of reports averages 10,000-15,000/year
- Average time to failure by fitting material type of mechanical fittings in 2016 for steel is 50 years and for plastic is 26 years

Communication of Performance Data is through the DIMP web page. To view MJFR data, go to: http://primis.phmsa.dot.gov/dimp/perfmeasures.htm
Total Report Submitted Numbers (08/05/2017):

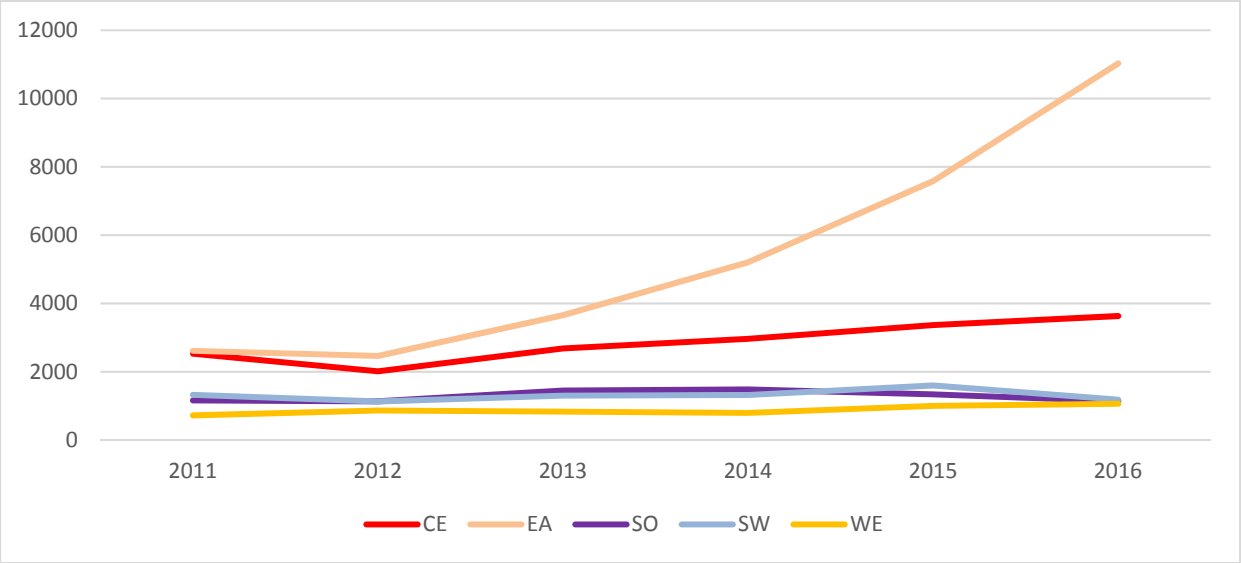
MJFRs submitted in 2011 – 8,342
MJFRs submitted in 2012 – 7,608
MJFRs submitted in 2013 – 9,923
MJFRs submitted in 2014 – 11,762
MJFRs submitted in 2015 - 14,900
MJFRs submitted in 2016 - 18,044

Figure 10 – Graphic representation of MJFR by year, as of 08/5/2017



To further break down the rising trend in the number of submitted MJFRs, we looked at PHMSA Regional data (see Figure 11). The PHMSA Region data shows upward trends in Central and Eastern Regions. The MJFR Team thinks the state-by-state data is more meaningful as PHMSA Regions cover great distances both east to west and north to south. Differences in climate and stratigraphy in PHMSA Regions as well as the varying ages of distribution systems make drawing conclusions based on PHMSA Regions difficult. We draw the reader's attention to Tables 17-20 on the MJFR failure data by state as we think this is more meaningful for drawing conclusions as a particular state's data could lead investigation into installation age and other meaningful variables. The same number of operators are submitting MJFRs as in previous years, and the data analysis does not provide a specific reason for the upward trend in the number of MJFRs submitted. The MJFR data needs to be discretely evaluated on a state-by-state and operator-by-operator level during regulatory inspections and during periodic evaluations performed in integrity management programs by operators to meet regulatory requirements.

Figure 11 – MJFR data submitted by PHMSA Region per year



The Mechanical Joint Failures are being identified in many Operator's DIMPs as a significant threat requiring risk mitigation measures. The rate of hazardous leaks repaired or replaced involving a mechanical fitting for 2016 is the number of MJFRs (18,044) divided by the total number of hazardous leaks reported as eliminated/repaired in 2016 (209,563) which is 8.6%. This percentage of hazardous leaks eliminated/repaired that involve a mechanical fitting is rising as previously shown in Table 24.