

# UNIFIED FACILITIES CRITERIA (UFC)

## NATURAL GAS AND LIQUEFIED PETROLEUM GAS (LPG) DISTRIBUTION PIPELINES



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**UNIFIED FACILITIES CRITERIA (UFC)**

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NAVAL FACILITIES ENGINEERING COMMAND

AIR FORCE CIVIL ENGINEER CENTER

Record of Changes (changes are indicated by \1\ ... /1/)

<b>Change No.</b>	<b>Date</b>	<b>Location</b>

## FOREWORD

The Unified Facilities Criteria (UFC) system is prescribed by MIL-STD 3007 and provides planning, design, construction, sustainment, restoration, and modernization criteria, and applies to the Military Departments, the Defense Agencies, and the DoD Field Activities in accordance with [USD \(AT&L\) Memorandum](#) dated 29 May 2002. UFC will be used for all DoD projects and work for other customers where appropriate. All construction outside of the United States is also governed by Status of Forces Agreements (SOFA), Host Nation Funded Construction Agreements (HNFA), and in some instances, Bilateral Infrastructure Agreements (BIA). Therefore, the acquisition team must ensure compliance with the most stringent of the UFC, the SOFA, the HNFA, and the BIA, as applicable.

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UFC are effective upon issuance and are distributed only in electronic media from the following source:

- Whole Building Design Guide web site <http://www.wbdg.org/ffc/dod>.

Refer to UFC 1-200-01, *DoD Building Code (General Building Requirements)*, for implementation of new issuances on projects.

### AUTHORIZED BY:



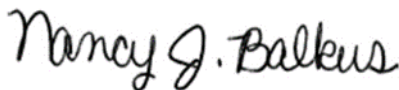
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**UNIFIED FACILITIES CRITERIA (UFC)  
REVISION SUMMARY SHEET**

**Document:** UFC 3-430-05, *Natural Gas and Liquefied Petroleum Gas (LPG) Distribution Pipelines*

**Superseding:** This change supersedes UFC 3-430-09 Exterior Mechanical Utility Distribution, dated 16 January 2004, with Change 1.

**Description:** This UFC provides guidance to the design and installation of new or modifications to existing distribution pipelines that convey natural gas, manufactured gas, or LPG in the vapor phase, that are installed on Government owned property. These requirements must be followed by the Government or its contractors when the Government is the responsible operator of the distribution pipeline. Where the Government is not the responsible operator, this UFC is intended to inform Government personnel of the requirements typically implemented by the responsible operator of the distribution pipeline.

**Reasons for Document:**

- This UFC has been completely rewritten in this change to comply with the Code of Federal Regulations, Title 49, Part 192 (49 CFR 192), Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards.

**Impact:**

- This change increases the initial and maintenance costs of gas distribution pipelines but ensures compliance with 49 CFR 192 in support of the requirements for reporting to the Pipeline and Hazardous Material Safety Administration (PHMSA). Proper application of these requirements also supports the transfer of responsible operation of compliant gas distribution pipelines from the Government to a Utility Privatization (UP) contractor or local gas provider.

**Unification Issues**

There are no unification issues with the guidance written herein.

## TABLE OF CONTENTS

<b>CHAPTER 1 INTRODUCTION.....</b>	<b>1</b>
<b>1-1 PURPOSE AND SCOPE.....</b>	<b>1</b>
<b>1-2 APPLICABILITY.....</b>	<b>1</b>
<b>1-3 PIPELINE DISTRIBUTION.....</b>	<b>1</b>
1-3.1 Natural and Manufactured Gas. ....	1
1-3.2 Liquefied Petroleum Gas (LPG). ....	3
<b>1-4 PIPELINE NOMENCLATURE.....</b>	<b>4</b>
1-4.1 Gas. ....	4
1-4.2 Gathering Lines. ....	4
1-4.3 Transmission Lines. ....	4
1-4.4 Distribution Lines.....	4
1-4.5 Master Meter Operators (MMO).....	5
1-4.6 Administering Agencies. ....	6
1-4.7 Plans and Reports. ....	6
<b>1-5 ORGANIZATION OF 49 CFR 192. ....</b>	<b>7</b>
<b>1-6 USE OF ASME B31.8.....</b>	<b>8</b>
<b>1-7 GLOSSARY.....</b>	<b>8</b>
<b>1-8 REFERENCES.....</b>	<b>8</b>
<b>CHAPTER 2 DISTRIBUTION PIPELINE DESIGN.....</b>	<b>9</b>
<b>2-1 SYSTEM PLANNING.....</b>	<b>9</b>
2-1.1 System Layout.....	9
2-1.2 Pipeline Location. ....	9
2-1.3 Location Classification. ....	9
<b>2-2 ENGINEERING ANALYSIS, PLANS, AND SPECIFICATIONS.....</b>	<b>10</b>
2-2.1 Engineering Analysis. ....	10
2-2.2 Plans. ....	10
2-2.3 Specifications. ....	10
<b>2-3 DISTRIBUTION PIPELINE DESIGN.....</b>	<b>11</b>
2-3.1 Load Diversity.....	12
2-3.2 Design Pressure for Steel Pipe. ....	12
2-3.3 Design Pressure for Plastic Pipe.....	12
2-3.4 Maximum Allowable Operating Pressure (MAOP).....	13

2-3.5	Increasing the MAOP by Uprating. ....	14
2-3.6	Alternative MAOP.....	14
2-3.7	Test Requirements.....	14
<b>CHAPTER 3</b>	<b>MATERIALS AND COMPONENTS.....</b>	<b>17</b>
<b>3-1</b>	<b>LPG STORAGE CONTAINERS.....</b>	<b>17</b>
<b>3-2</b>	<b>PIPE MATERIAL SELECTION.....</b>	<b>17</b>
3-2.1	Exceptions of DoD Installations. ....	17
3-2.2	Restricted Materials. ....	18
<b>3-3</b>	<b>DESIGN OF PIPELINE COMPONENTS.....</b>	<b>19</b>
3-3.1	Fittings. ....	19
3-3.2	Valves. ....	21
3-3.3	Control of Gas Pressure and Over Pressure Protection.....	21
3-3.4	Customer Meters, Regulators and Service Lines.....	24
3-3.5	Excess Flow Valve (EFV). ....	25
3-3.6	Vaults. ....	26
<b>CHAPTER 4</b>	<b>CONSTRUCTION OF DISTRIBUTION PIPELINES.....</b>	<b>27</b>
<b>4-1</b>	<b>QUALIFICATION OF PROCESSES.....</b>	<b>27</b>
<b>4-2</b>	<b>WELDING OF STEEL PIPE.....</b>	<b>27</b>
4-2.1	Welding Procedures for Steel Pipe. ....	27
4-2.2	Welder Qualifications. ....	27
4-2.3	Inspection and Testing of Welds. ....	27
<b>4-3</b>	<b>HEAT FUSION JOINING OF PLASTIC PIPE.....</b>	<b>28</b>
4-3.1	Written Joining Procedures. ....	28
4-3.2	Joint Maker Qualifications. ....	28
<b>4-4</b>	<b>PIPELINE INSTALLATION AND REPAIR.....</b>	<b>28</b>
4-4.1	Plastic Pipe Installation. ....	29
4-4.2	Steel Pipe Installation. ....	29
<b>CHAPTER 5</b>	<b>CONTROL OF CORROSION.....</b>	<b>31</b>
<b>5-1</b>	<b>METALLIC PIPELINES.....</b>	<b>31</b>
<b>5-2</b>	<b>DISTRIBUTION PIPELINE INTEGRITY MANAGEMENT PLAN.....</b>	<b>31</b>
<b>CHAPTER 6</b>	<b>NATURAL GAS COMPRESSORS.....</b>	<b>33</b>
<b>6-1</b>	<b>COMPRESSOR STATIONS PER 49 CFR 192. ....</b>	<b>33</b>
<b>6-2</b>	<b>FUEL GAS BOOSTER COMPRESSORS.....</b>	<b>33</b>

**APPENDIX A BEST PRACTICES ..... 35**

**A-1    WHOLE BUILDING DESIGN GUIDE..... 35**

**A-2    GUIDANCE..... 35**

        A-2.1    DOT Manual for Operators of Small Natural Gas Systems. .... 35

        A-2.2    State Compliance..... 35

**APPENDIX B GLOSSARY ..... 37**

**B-1    ACRONYMS..... 37**

**APPENDIX C REFERENCES..... 39**

**FIGURES**

**Figure 1-1    Example 49 CFR 192 Natural Gas Pipeline Network..... 2**

**Figure 1-2    Example Typical Natural Gas Distribution System..... 3**

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## CHAPTER 1 INTRODUCTION

### 1-1 PURPOSE AND SCOPE.

This UFC is written to provide guidance for development of distribution pipelines carrying natural gas, manufactured gas or Liquefied Petroleum Gas (LPG) in its vapor phase, that are installed on Department of Defense (DoD) owned property, from the point of delivery by the gas supplier to the points of connection to the buildings' fuel gas piping. This UFC implements the regulations written in the Code of Federal Regulations (CFR), Title 49, Part 192 (49 CFR 192), Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards. This UFC applies where the DoD is the responsible operator of the distribution pipeline. Where a private utility provider is designated as the responsible operator, this UFC is to inform Government personnel of the requirements that apply to the distribution pipeline.

This document does not cover building fuel gas piping, which is the piping system that connects to the last downstream component of the distribution pipeline, either isolation valve, service regulator or meter, and supplies fuel gas to individual appliances. Refer to National Fire Protection Association (NFPA) 54, the International Code Council (ICC) fuel gas code and Unified Facilities Guide Specifications (UFGS) 23 11 25 Facility Gas Piping for guidance when installing building fuel gas piping.

This document does not cover systems used to convey LPG in its liquid phase. Refer to 49 CFR 195 and UFC 3-460-01 for liquid phase LPG pipelines and transfer systems. Refer to NFPA 58, the ICC fuel gas code and UFGS 23 11 25 Facility Gas Piping for guidance when installing a single LPG storage tank with LPG service to a single building.

### 1-2 APPLICABILITY.

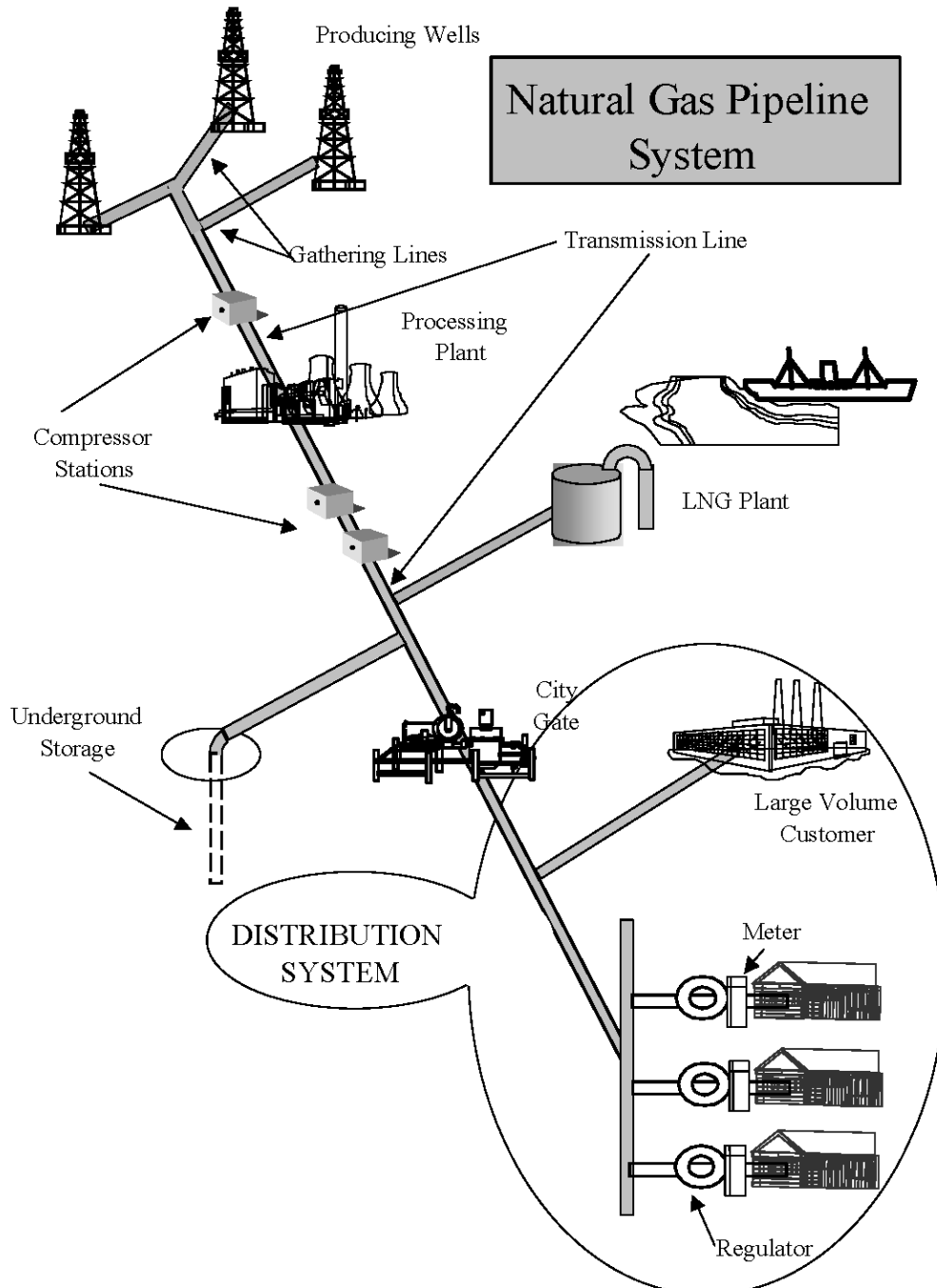
This UFC applies to all planning, design, design, construction, operations and maintenance for the gas distribution pipeline and all of the appurtenances where the DoD is designated as the responsible operator.

### 1-3 PIPELINE DISTRIBUTION.

#### 1-3.1 Natural and Manufactured Gas.

Regulations written in 49 CFR 192 apply to every part of gas pipelines from the point of gas production to the point of connection of the service line components to a building's fuel gas piping system. An electronic version of 49 CFR 192 can be found at the Electronic CFR website: [https://ecfr.io/Title-49/cfr192\\_main](https://ecfr.io/Title-49/cfr192_main). Within 49 CFR 192, three distinct types of pipelines are described 1) Gathering Pipelines, 2) Transmission Pipelines and 3) Distribution Pipelines. See Figure 1-1 for a graphical representation of the 49 CFR 192 natural gas pipeline system. Gathering pipelines are not under the authority or scope of this UFC. Transmission pipelines typically owned and operated by gas suppliers and not covered by this UFC. Transmission lines installed on DoD installations are under an easement from the DoD to a responsible owner.

Figure 1-1 Example 49 CFR 192 Natural Gas Pipeline Network

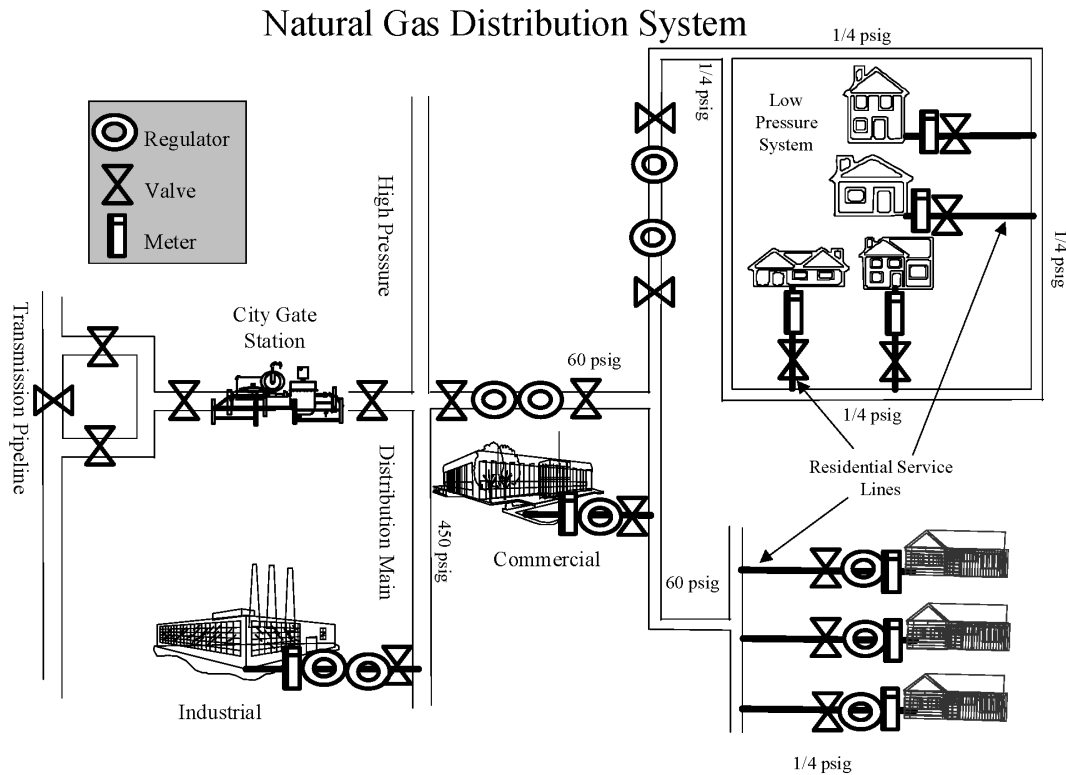


Courtesy of the DOT Guidance Manual for Operators of Small Natural Gas Systems, January 2017

Gas pipelines for which the DoD is the responsible operator are typically classified as Distribution Pipelines and are characterized as a pipeline that receives gas from a gas

utility purveyor who delivers, meters, and regulates the pressure of gas supplied to the distribution pipeline that is located on a DoD installation. See Figure 1-2 for a graphical representation of the natural gas distribution pipeline.

**Figure 1-2 Example Typical Natural Gas Distribution System**



Courtesy of the DOT Guidance Manual for Operators of Small Natural Gas Systems, January 2017

### 1-3.2 Liquefied Petroleum Gas (LPG).

49 CFR 192 also applies to LPG distribution pipelines that convey LPG in the vapor phase. Piping that conveys liquid LPG is not covered under 49 CFR 192, but is regulated by 49 CFR 195: Transportation of Hazardous Liquids by Pipeline. 49 CFR 195 §195.1 (b) (1) writes an exception to applicability for any hazardous liquid transported in a gaseous state. This exception implements, by default, 49 CFR 192 as the regulating document. 49 CFR 192 §192.11 refers to the vapor phase of LPG as 'petroleum gas' and requires that petroleum gas pipelines comply with 49 CFR 192 and NFPA 58, with NFPA 58 prevailing in the event of conflict. NFPA 58 applies to liquid LPG pipelines, liquid LPG storage containers, and pipelines that convey LPG in the vapor phase. This UFC provides guidance for the vapor phase distribution pipeline and the liquid storage container that serves that distribution pipeline. Please refer to UFC 3-460-01 for guidance on liquid phase LPG piping systems.

49 CFR 192 §192.1 (b) (5) allows two exceptions to applicability for any pipeline system that transports only petroleum gas.

*“(5) The regulations of 49 CFR 192 do not apply to a pipeline system that transports petroleum gas or petroleum gas/air mixture to:*

- (i) Fewer than ten customers, if no portion of the system is located in a public place  
– or –*
- (ii) A single customer, if the system is located entirely on the customer’s premises  
(no matter if a portion of the system is located in a public place).”*

However, the requirements of NFPA 58 do apply. The exception allowed in paragraph (i) must not be applied on a DoD installation. On DoD installations, there is the likely possibility that a system will expand to include 10 or more customers. These exceptions do not change the materials or installation practices, as these are dictated by NFPA 58. What is exempted is the qualification of installation practices, installer qualifications, and reporting regulations of 49 CFR192. Therefore, the risk is that a system installed that does not comply with 49 CFR 192 regulations is very difficult, if not impossible, to expand into the scope of 49 CFR 192.

#### **1-4 PIPELINE NOMENCLATURE.**

Gas pipelines are described in 49 CFR 192 using the following nomenclature.

##### **1-4.1 Gas.**

Each time the term ‘Gas’ is used in this UFC, it is understood that the term applies to natural gas, manufactured gas, liquefied petroleum gas in its vapor phase, and any other flammable gas.

##### **1-4.2 Gathering Lines.**

Gathering lines transport gas from a gas production facility to the transmission pipeline or main. Gathering lines are not under the authority or control of DoD installations.

##### **1-4.3 Transmission Lines.**

Transmission lines are typically owned and operated by gas suppliers and are not operated by the DoD installation.

##### **1-4.4 Distribution Lines.**

Distribution lines transport gas from the transmission line or LPG storage container to each individual customer. Pipeline that operates at a hoop stress of 20% or more of the specified minimum yield stress (SMYS) must also meet the requirements of a transmission line.

#### **1-4.4.1 Main.**

A main is defined as a distribution line that serves more than one service line. Note that 49 CFR 192, Subpart G appears to apply only to transmission pipelines because it is entitled 'General Construction Requirements for Transmission Lines and Mains'. Whenever 49 CFR 192 discusses a Main, the requirement applies to the distribution pipeline.

#### **1-4.4.2 Service Line.**

A service line is a distribution line that transports gas from a main to an individual customer's meter, regulator, or isolation valve upstream of the customer's piping. Note that this point of connection is the demarcation between the pipeline as governed by 49 CFR 192 and the fuel gas piping governed by NFPA 54.

#### **1-4.4.3 High Pressure Distribution System.**

A distribution system that operates with a gas pressure in the main that is higher than the pressure provided to the customer.

#### **1-4.4.4 Low Pressure Distribution System.**

A distribution system that operates with a gas pressure in the main that is substantially the same as the pressure provided to the customer.

Refer to 49 CFR 192 §195.3 for the official definition of each of these terms.

#### **1-4.5 Master Meter Operators (MMO).**

Small natural gas distribution systems are sometimes designated as Master Meter Systems (MMS). This designation is typically reserved for owners of apartment buildings, trailer parks, or other types of property managers. The 49 CFR 192 refers to MMO, the operator of an MMS, but does not provide clearly defined criteria for determining who is and who is not an MMO. The reporting regulations for an MMO are significantly less than the reporting regulations for the distribution pipeline operator; however, the requirement to obtain and retain complete knowledge of the system operated are nearly equal for each operator.

It is routine for natural gas systems installed on DoD installations to connect to transmission or distribution lines owned and operated by a natural gas purveyor through a metered and pressure regulated connection. Because of this method of connection and the limited reporting responsibility of an MMO, it is tempting for engineers, contractors, and operators to claim a natural gas distribution system to be a master meter system. No natural gas systems that are installed on a DoD installation shall be considered a master meter system without expressed written approval from the authorized administrator(s) of all applicable regulations.

#### **1-4.6 Administering Agencies.**

The Pipeline and Hazardous Material Safety Administration (PHMSA) is assigned as the administrator in 49 CFR 192 and is tasked with enforcing the regulations presented therein. Transmission line operators and distribution line operators are required by the regulations to report specific information to PHMSA. The reporting regulations are different and more detailed for the transmission line operator than for the distribution line operator. But, none the less, the distribution line operator is required to report to PHMSA. These reporting requirements create the need for the pipeline operator to obtain and retain complete knowledge of each pipeline segment and component installed in the system that the operator is responsible for. Details of the plans, procedures and reports that must be available for PHMSA review for distribution pipelines are defined in 49 CFR 192, Subparts L and P. A more comprehensive discussion of reporting requirements can be found in the January 2017 revision of "Guidance Manual for Operators of Small Natural Gas Systems", Chapter VIII, authored by the Department of Transportation (DOT). Paragraph 1-3.7 of this UFC briefly describes these reporting requirements to emphasize the importance of the detailed design and construction submittal process necessary to support the DoD installation in complying with the reporting regulations of 49 CFR 192.

State agencies may also enforce pipeline safety regulations that are more stringent than the regulations presented in 49 CFR 192. Local municipalities, gas purveyors, and the transmission line operator may also apply more stringent regulations. The distribution line operator must know the regulations that apply to the distribution pipeline that he operates and should transfer the requirements to design engineers and installing contractors who perform work on this system.

It is necessary that the Designer of Record (DoR) for any distribution pipeline projects such as construction, addition, rehabilitation, and repair on a DoD installation contact the person or department responsible for operating the pipeline to understand the requirements that apply.

#### **1-4.7 Plans and Reports.**

All operators of gas pipelines are required to maintain a number of plans for safe operation of the pipeline. Therefore, all information relative to work performed on gas distribution pipelines installed on DoD installations must be provided to the responsible operator through the design and construction process in order to support the ongoing planning and reporting efforts required from that responsible operator. The Department of Public Works (DPW)/Base Civil Engineer (BCE), a Utility Privatization (UP) contractor, or a gas supplier is typically the responsible operator of gas distribution pipelines located on DoD installations and should provide information on the distribution pipeline as it exists and must receive complete information on all work performed.

The plans required from a distribution pipeline operator are listed below to indicate the necessary thoroughness of the information that must be made available. Requirements for developing these plans and reporting the information contained in the plans are defined in 49 CFR 192.

- Operations and Maintenance (O&M) Plan: Subparts L and M, consist of 27 procedures covering all aspects of installing, operating and maintaining each pipe segment and component. These procedures include, but are not limited to, the following:
  - Making construction documents available to operating personnel.
  - Gathering data needed for reporting incidents.
  - Corrosion control.
  - Continued surveillance and damage prevention: §192.613 and 614.
  - Emergency Plan: §192.615.
  - Public Awareness Plan: §192.616.
  - Leak Survey: §192.723.
- Operator Qualification Plan: Subpart N.
- Distribution Integrity Management Plan: Subpart P, consists of 7 required elements.

The information necessary to develop these required plans mostly originates during design and construction of each segment of the pipeline. Therefore, the construction plans and specifications developed by the Designer of Record (DoR) must include appropriate system design and testing parameters as well as requirements for the installing contractor to submit all information necessary, including location, materials, equipment, installation procedures, procedure and personnel qualification, and testing results, for the DoD installation to develop and maintain the required plans and procedures.

## **1-5 ORGANIZATION OF 49 CFR 192.**

49 CFR 192 is divided into Subparts, each describing a specific area of concern. The following sub-parts are not retroactive and apply to pipelines readied for service after 12 March 1971, or were replaced, relocated, or changed after 12 November 1970:

Subpart B – Materials  
Subpart C – Pipe Design  
Subpart D – Design of Pipeline Components  
Subpart E – Welding of Steel in Pipelines  
Subpart F – Joining of Materials other than by Welding  
Sub part G – General Construction Requirements for Transmission Lines  
Subpart H – Customer Meter, Services, Regulators, and Service Lines  
Subpart J – Test Requirements  
Subpart N – Qualification of Pipeline Personnel

The following subparts are retroactive and apply to all existing pipelines regardless of date of construction:

Subpart A – General  
Subpart I – Requirements for Corrosion Control  
Subpart K – Uprating  
Subpart L – Operations  
Subpart M – Maintenance  
Subpart O – Gas Transmission Pipeline Integrity Management  
Subpart P – Distribution Integrity Management

## **1-6 USE OF ASME B31.8.**

Pipelines on DoD installations must comply with the requirements of 49 CFR 192. A comparable industrial standard is ASME B31.8, Gas Transmission and Distribution Piping Systems. Although ASME B31.8 may appear to be an acceptable piping code for compliant natural gas pipeline construction, it allows materials, components, and construction practices that do not comply with 49 CFR 192. §192.7 specifies that use of ASME B31.8 is approved only as referenced in §192.112(b) and §192.619(a).

As an industry standard, ASME B31.8 provides additional detail that is not found in the Code of Federal Regulations (CFR). Therefore, ASME 31.8 is a very good reference document and is recommended to help the reader better understand the material and construction practices available from the natural gas industry. But 49 CFR 192 is the defining requirements document and any decision made from information presented in ASME B31.8 must be confirmed to comply with the requirements of 49 CFR 192.

## **1-7 GLOSSARY.**

APPENDIX B contains acronyms, abbreviations, and terms.

## **1-8 REFERENCES.**

APPENDIX C contains a list of references used in this document. The publication date of the code or standard is not included in this document. Unless otherwise specified, the most recent edition of the referenced publication applies.



## CHAPTER 2 DISTRIBUTION PIPELINE DESIGN

### 2-1 SYSTEM PLANNING.

#### 2-1.1 System Layout.

Gas distribution pipelines will be planned carefully with due consideration for economy, safety, and uniformity of pressure. The lines will be well-looped within the main area and in all outlying areas whenever practicable and economically feasible to do so. It is not always practicable to loop a supply line to an outlying area and then back into the main system, but in such cases the objectionable effects of dead ends can often be relieved to some extent by looping such line around the area it serves and then back into itself.

#### 2-1.2 Pipeline Location.

Gas distribution pipelines will never be installed under a building. They will not be laid in the same trench with other utilities to preclude the possibility of leaking gas following along or collecting in other conduits and creating an explosion hazard. For the same reason, gas lines will be above other utilities whenever they cross, if practicable. Underground gas pipelines must be installed with the minimum clearance from other underground structures as is specified in §192.325. Gas lines will not be laid under paved streets or in other locations subject to heavy traffic whenever practicably avoidable. Whenever it is necessary to locate gas lines in such locations, the lines will be protected in accordance with (IAW) 49 CFR 192. Sufficient clearance must be maintained between plastic mains and steam, hot water, power lines, and other sources of heat, to avoid temperatures in excess of the rated temperature and pressure combination of the pipe.

#### 2-1.3 Location Classification.

49 CFR 192, §192.5 classifies the location of a gas pipeline based on its proximity to occupied buildings or frequently occupied outdoor locations. The location classification ranges from Class 1 to Class 4 and signifies the level of risk and consequence to human life in the event of pipeline failure. As population density increases, so the location class number increases. The location classification is used in defining several regulatory requirements for a given pipe segment.

The Designer of Record (DoR) of any project that modifies any segment of a gas distribution pipeline on a DoD installation must obtain existing location classifications, verify that the class meets §192.5, and identify the proper location class for all pipeline segments modified or connected to in the project. Design drawings must indicate the location classification for each pipe segment in the distribution pipeline. For projects on DoD installations, all new or modified distribution pipeline must be location Class 3 to minimize the impact that future building construction projects may have on existing pipelines. Where connection is made to a pipe segment designed for a location class other than Class 3, the drawings must identify the location of the change in class.

The pipeline operator is responsible for maintaining the proper location classification for each segment of pipe as additional buildings are constructed on the DoD installation. Therefore, the DoR must coordinate the intended location classification with appropriate DoD installation personnel.

## **2-2 ENGINEERING ANALYSIS, PLANS, AND SPECIFICATIONS.**

The DoR must provide an engineering analysis, plans, and specifications that define the work to be performed and all of the information that the installing contractor is required to provide to the Government for a complete and functional installation that meets the regulatory requirements of 49 CFR 192 and provides the Government Operator with all information needed for proper reporting to the regulatory agency, for example PHMSA, State agency.

### **2-2.1 Engineering Analysis.**

Engineering analysis will be presented in diagram form showing all connected loads, design flow rate, locations of valves, pressure regulators, and other pipeline devices, actual operating pressure before and after each regulator, and any other appurtenance required to control downstream pressure, relieve downstream pressure, or prevent excess flow. A complete set of supporting calculations will be prepared.

### **2-2.2 Plans.**

The plans will include a layout drawing showing the entire distribution system and detail drawings clearly showing pipe sizes, the location of gas mains, service connections, details for abandoning gas piping, mechanical couplings, valves, service taps, regulators, and other appurtenances. ASME B31.8 requires that abandoned gas lines be physically disconnected from gas sources. Shutoff valves are not an acceptable means of disconnect.

### **2-2.3 Specifications.**

#### **2-2.3.1 Required Specifications.**

The DoR must use UFGS 33 51 15 Natural-Gas / Liquefied Petroleum Gas Distribution Pipelines to specify gas distribution pipeline work from the gas source (gas purveyor's meter and regulator) and LPG storage tank where applicable, to the point of connection to building fuel gas piping. Be aware that UFGS 23 11 25 Facility Gas Piping specifies the requirements from the point of connection to the distribution system to the appliances.

#### **2-2.3.2 Submittal Description (SD)-11 Close-Out Submittals Required.**

Close-out submittals, SD-11, typically include items such as the as-built set of drawings and specifications, test results, and project acceptance documents. Close-out submittals for construction of distribution pipelines are required to include a complete display of all information obtained during the construction process in order to support

the ongoing efforts of the DoD Installation to comply with the documentation and reporting tasks required by 49 CFR 192.

The following is a list of information that must be submitted at project close-out in order to support the DoD Installation in obtaining and retaining information pertinent to construction of distribution pipelines for which the DoD Installation is the operator:

- As-built Layout Drawings – Submit drawings that show the geographic information system (GIS) location each newly installed pipe segment, each connection to existing pipe, and each abandoned pipe segment. The drawing must include pipe size, material type, design gas flow capacity, and maximum allowable operating pressure as defined by the operator and specified by the DoR.
- Pipe Materials – Submit for each pipe segment the pipe material specification number (for example ASTM D2513), name of manufacturer, manufacturer's item or part number, length of segment purchased, lot number, date manufactured, and date installed. These material submittals must be keyed to the layout drawing.
- Mechanical Couplings – Submit for each mechanical coupling installed the name of manufacturer, manufacturer's part number, serial number, date manufactured, and date installed. Each mechanical coupling must be keyed to the layout drawing so as to identify the exact location of the particular serial number installed.
- Piping Joints – Layout drawings must identify the GIS location of each joint made in every segment of distribution pipeline. A pipe joint, as used here, is defined as any connection made to join a pipe to another pipe, a fitting, a piece of equipment, or any other appurtenance. The following information regarding each pipe joint must be correlated to the pipe joints shown on the layout drawing.
  - Manufacturer's written procedure for making the identified connection.
  - Name and identifying mark of the person making that connection.
  - Qualification certificate for the person who made the connection.
- Leakage and strength test results.

Geographic Information System (GIS) coordinates must be submitted for the pipeline including all joints in the pipeline, all taps and tee, and all mechanical fittings.

## **2-3 DISTRIBUTION PIPELINE DESIGN.**

The design for any new or modified gas pipeline must comply with 49 CFR 192, Subpart C. For LPG (petroleum gas) pipelines, 49 CFR 192, §192.11 states that the requirements of NFPA 58 prevail in case of conflict.

Subpart C – Pipe Design, prescribes the minimum requirements for pipe design. Pipe must be designed with sufficient wall thickness to withstand the internal pressure of the gas without failure. The wall thickness must be increased or the pipe must be installed with adequate protection to withstand the anticipated external forces and loads without failure.

### **2-3.1 Load Diversity.**

The design of a gas distribution pipeline installed on a DoD Installation will be based on the sum of rated gas load of all connected appliances to the distribution pipeline in the following proportions:

- Natural gas, more than 15 buildings: More than 80 percent of the full connected appliance load.
- Natural gas, 15 buildings or fewer: 100 percent of the full connected appliance load.
- LPG, vapor phase: 100 percent of the full connected appliance load regardless of the system size.

### **2-3.2 Design Pressure for Steel Pipe.**

#### **2-3.2.1 Design Pressure.**

The DoR must determine the design pressure of each pipe segment in accordance with 49 CFR 192, Subpart C.

Steel pipe design pressure is calculated using the equation presented in §192.105. This equation uses the basic hoop stress equation with reduction factors for increased temperature, type of longitudinal joint, and location classification. Each of the variables used in the equation are defined in §192.107 through 115.

#### **2-3.2.2 Yield Strength.**

The yield strength of pipe is defined in the pipe specifications that are listed in 49 CFR 192, Appendix B, and is the Specified Minimum Yield Strength (SMYS) stated in the Appendix B specification list for the pipe material used. Because pipe specifications not listed in Appendix B are not allowed on Government DoD installations, alternative means of determining yield strength are not allowed for new construction. These alternative means may, however, be required for evaluating the design pressure existing pipe.

Class 3 location is the minimum class allowed for all distribution pipelines on a DoD Installation.

### **2-3.3 Design Pressure for Plastic Pipe.**

The DoR must determine the design pressure of each pipe segment in accordance with 49 CFR 192, Subpart C.

Plastic pipe design pressure is calculated using the equation presented in §192.121. This equation is a modified version of the basic hoop stress equation that uses terms common in the plastic piping industry. The yield strength is the Hydrostatic Design Basis (HDB) at or above the operating temperature of the pipe. The HDB is typically found in the pipe specification that defines the particular type of plastic pipe.

### **2-3.3.1 Standard Dimension Ratio (SDR).**

The maximum allowed Standard Dimension Ratio (SDR) for plastic pipe installed on a DoD installation is SDR-11. The SDR is the diameter of the pipe divided by the wall thickness. SDR-11 represents the minimum wall thickness allowed on DoD installations.

A design factor of 0.32 reduces the design pressure of polyethylene (thermoplastic) and reinforced epoxy resin (thermosetting) pipe. A design factor of 0.40 reduces the design pressure of polyamide-11 (PA-11) pipe.

### **2-3.3.2 Maximum Design Pressure.**

Maximum design pressure for plastic pipe is limited by §192.121. 49 CFR 192 limits the design pressure of plastic pipe to 100 pounds per square inch gauge (psig) with exceptions in specific piping materials to allow higher pressures. These exceptions must be thoroughly investigated and documented prior to providing plastic pipe in systems with greater than 100 psig.

Note that ASTM F2945 for PA-11 states that heat fusion joining of PA-11 pipe and fittings is not allowed to pipes and fittings made from any other thermoplastic materials. Therefore, care should be taken when specifying a different type of plastic than has been previously installed because of the complexity in connecting different plastic materials.

### **2-3.4 Maximum Allowable Operating Pressure (MAOP).**

The MAOP of the distribution pipeline is controlled by the responsible operator of that distribution system, in accordance with 49 CFR 192. The DoR must obtain the MAOP for the existing distribution system from this responsible operator prior to designing work on the distribution pipeline. The MAOP must be included in the design calculations and on the design drawings for each pipe segment connected to or installed in the project.

Maximum Allowable Operating Pressure (MAOP) for steel and plastic pipelines is determined from the requirements stated in §192.619 thru 623, which prescribe the MAOP for distribution mains and service lines respectively. MAOP, as determined under §192.619 thru 623, is generally associated with the lowest of the design pressure or a fraction of the test pressure that the pipe segment was initially tested to after installation. The test pressure for Class 3 locations is 1.5 times the MAOP. Every pipe segment must be tested IAW 49 CFR 192, Subpart J in order to substantiate the MAOP determined under §192.619. It is recommended that new pipe be tested at the highest pressure that is safely practical to set the MAOP of that pipe segment as high as safely possible to prevent having to uprate in the future.

MAOP for distribution mains is limited to 60 psig unless every service line connecting to the distribution main contains devices installed for the purpose of protection against over-pressurization IAW §192.197(c). These devices must limit the inlet pressure to the service regulator by pressure regulation, flow relief, or isolation. ASME B31.8, para. 845 may be used as reference, as this reference provides additional information on these overpressure devices, and all devices listed are included in 49 CFR 192.

### **2-3.5 Increasing the MAOP by Uprating.**

Pipelines may have their pressure increased above a previously determined MAOP by following the requirements of 49 CFR 192, Subpart K and logically determining a new MAOP IAW §192.619. All pipe segments to be uprated must be tested to the requirements of a new pipe of the same material installed in the same location.

The process required by 49 CFR 192, Subpart K is quite detailed, requiring much research and field work before the pipeline pressure increase is allowed. Therefore, it is recommended to initially test all pipelines to the highest test pressure that is safely practical in order to prevent the need for uprating in the future.

### **2-3.6 Alternative MAOP.**

Although 49 CFR 192.619 allows for determining alternative MAOP, this method is difficult to implement due to the vast amount of information necessary to apply the method. An acceptable alternative is to utilize §192.620 which provides the requirements for determining and using an alternative MAOP. §192.620(b) (2) requires that the pipeline segment that uses an alternative MAOP be constructed to meet the additional design requirements of § 192.112. This section stipulates that only pipe manufactured to API SPEC 5L may use the alternative MAOP. The requirements further mandate several documented quality control manufacturing processes, which are typically not available for existing systems and not cost effective for new systems.

### **2-3.7 Test Requirements.**

Every pipe segment must be tested IAW 49 CFR 192, Subpart J in order to substantiate the MAOP determined under §192.619. Tests are required to prove that the pipeline does not leak and in specified cases must be strength tested for a specified duration. For safety reasons, hydrostatic testing is preferred; however, 49 CFR 192 allows air, inert gas, and even the natural gas source to be used under specific constraints. 49 CFR 192 does not allow the use of LPG in the vapor phase, a.k.a. petroleum gas, to be used as a test media.

LPG pipelines operating under 49 CFR 192 must comply with the testing requirements of 49 CFR 192, rather than testing described in NFPA 58.

#### **2-3.7.1 Test Pressure for Steel Pipelines.**

The test pressure that applies to most distribution pipelines installed on DoD installation are defined in the 2018 revision of 49 CFR 192 as follows:

- §192.507 for steel pipelines operating at 100 psig or higher and less than 30% SMYS: Leak test between 100 psig and the pressure that creates stress of 20% SMYS. Strength test at leak test pressure for duration of 1 hour.
- §192.509 for steel distribution mains operating below 100 psig: A minimum leak test pressure of 90 psig for operating pressures of 1 psig or greater. A minimum leak test pressure of 10 psig for operating pressures less than 1 psig.
- §192.511 for steel service lines with operating stress less than 20% SMYS: A minimum leak test pressure of 50 psig for operating pressures from 1 to 40 psig. A minimum leak test pressure of 90 psig for operating pressures greater than 40 psig.
- §192.513 for plastic distribution mains and service lines: Leak test pressure at least 150% of the maximum operating pressure. Not less than 50 psig. Refer to §192.513 for further restrictions during testing. Pneumatic leak testing must be performed IAW ASTM F2786. Hydrostatic testing must be performed IAW ASTM F2164

For steel pipelines that operate at or above 100 psig, with a hoop stress less than 30% of the SMYS, the rules presented in §192.507 must be applied using an appropriate test pressure and inspection that discovers all leaks in the segment being tested. In the rare case that a steel distribution pipeline operates with a hoop stress above 30% of the SMYS, the reader should follow §192.505 for hydrostatic strength testing and leak testing requirements.

Please refer to these 49 CFR 192 sections for updates to the required test pressures and more detail of the required tests.

### **2-3.7.2 Test Pressure for Polyethylene Pipelines.**

#### **2-3.7.2.1 Leak Testing.**

49 CFR 192 §513 requires that leak test on plastic distribution mains and service lines be performed at a pressure at least 150% of the maximum operating pressure, but not less than 50 psig. Refer to §192.513 for further restrictions during testing.

Leak testing of polyethylene and other plastic pipelines must be specified and performed with an understanding of the effects that pressure has on the plastic material. Pneumatic leak testing of polyethylene pipelines must be performed IAW ASTM F2786. Hydrostatic testing of polyethylene pipelines must be performed IAW ASTM F2164. Both of these documents prescribe procedures that limit the maximum test pressure to 1.5 times the design pressure of the weakest component. This limitation is in contrast 49 CFR 192 §513, which states that the maximum test pressure must not exceed 3 times the design pressure calculated in §192.121. This is because the two documents define 'design pressure' differently.

### **2-3.7.2.2 Hydrostatic Design.**

49 CFR 192 §121 uses the Hydrostatic Design Basis (HDB) of the particular material at the testing temperature and a design factor of 0.32 to reduce the pipeline design pressure.

ASTM F2786 uses the Hydrostatic Design Stress (HDS) of the particular material to calculate the pressure rating of the pipeline and a temperature reduction factor to reduce the pipeline maximum test pressure. ASTM F2164 uses the terms 'design pressure' and 'pressure rating' synonymously.

### **2-3.7.2.3 Pressure Testing.**

It is recommended that the maximum test pressure be determined using the methods presented in ASTM F2786 for pneumatic testing or ASTM F2164 for hydrostatic testing. Although the ASTM and CFR methods produce the same maximum test pressure when the pipe temperature is at 73° F, as the pipe temperature increases, 3 times the design pressure as specified in 49 CFR 192 §513 exceeds the maximum test pressure calculated from the ASTM methods.

Because pipe strength reduces with increasing pipe temperature, it necessary to monitor the pipe temperature during testing. Pipe temperature increases during pneumatic testing due to the heat of compression in the compressible test media, sunlight exposure, and ambient temperature. Contact the manufacturer of pipe, fitting, and components for guidance during pneumatic testing. The cooler temperature and higher heat capacitance of a hydrostatic test media helps to reduce the temperature of the test section.

In both pneumatic testing per ASTM F2786 and hydrostatic testing per ASTM F2164, the length of time that the pipeline is pressurized above its MAOP is limited to 8 hours. Therefore, from the start of pressurizing the pipeline, through the test phase, and ending at depressurization of the pipeline, the total time duration must not exceed 8 hours. If retesting is necessary, the pipeline must be allowed to relax at a pressure less than the operating pressure for a duration of 8 hours before restarting the test.



## CHAPTER 3 MATERIALS AND COMPONENTS

### 3-1 LPG STORAGE CONTAINERS.

Containers used for storage of LPG in the liquid phase must comply with NFPA 58 requirements. Where piping systems are to be designed for filling LPG storage tanks, please refer to UFC 3-460-01 for guidance in design of these specialized, LPG liquid piping systems.

LPG storage containers must be designed, fabricated, tested, and marked in accordance with the regulations of the department of transportation (DOT), ASME Section VIII "Rules for the Construction of Unfired Pressure Vessels, or API-ASME Code for Unfired Pressure Vessels for Petroleum Liquids and Gases. Storage containers having 4,000-gallon water storage capacity or less must include all appurtenances as required by NFPA 58, paragraph 5.9 to include, but not limited to, the following:

- Vapor shutoff valve
- Liquid shutoff valve
- Pressure relief valve
- Fixed maximum liquid level gauge
- Filler valve
- Overfilling protection device
- Actuated liquid withdrawal excess-flow valve for 25-gallon water capacity or more
- Float gauge for 125-gallon water capacity or more

Please refer to NFPA 58, paragraph 5.9.4.2 for connection and appurtenance requirements that apply to LPG storage containers having storage capacity greater than 4,000 gallons of water capacity. Container appurtenances must have a minimum service pressure rating of 250 psig.

### 3-2 PIPE MATERIAL SELECTION.

Pipe materials used in LPG distribution pipelines installed on a DoD installation must comply with the material specifications listed in NFPA 58, with the exceptions of DoD installations below.

Pipe materials used in natural gas and manufactured gas distribution pipelines installed on a DoD installation must comply with the material specifications listed in 49 CFR 192, Subpart B and Appendix B, with the following exceptions:

#### 3-2.1 Exceptions of DoD Installations.

The following are exceptions to the materials listed in Appendix B of 49 CFR 192:

- It is recommended that steel pipe not be installed below grade due to corrosion. Where a fuel gas compressor is installed on the user's fuel gas supply piping, governed by NFPA 54, a steel service line may be necessary to withstand the forces caused by pressure pulsation and vibration. See API RP 686, ASME B31.8, and 49 CFR 192 for guidance. Steel pipe installed below grade must be coated and cathodically protected from corrosion.
- Polyethylene (PE) piping, ASTM D2513, must be installed below grade, SDR-11 or thicker wall.
- Polyamide-11 (PA-11), SDR-11 or thicker wall, can be installed below grade only to connect to existing PA-11 piping because heat fusion of PA-11 to any other plastic is not qualified. Recommend using ASTM F2945 for specifying PA-11 piping because this material was moved from the PE piping ASTM after 1999.
- Plastic pipe that passes through vaults or is otherwise uncovered by soil, the plastic pipe must be encased in ASTM A53/A53M minimum schedule 40 steel pipe that is properly protected from corrosion and vented. Materials and installation must comply with 49 CFR 192.
- Although ASTM D2517, Standard Specification for Reinforced Epoxy Resin Gas Pipe and Fittings, for example thermosetting plastic, is included in the Appendix B list. Thermosetting plastic material should not be specified unless the existing distribution pipeline is also constructed of this material.
- For LPG, NFPA 58 does not allow ASTM D2517, thermosetting plastic pipe to be used.

### **3-2.2 Restricted Materials.**

Cast iron and ductile iron are restricted materials within 49 CFR 192. Cast and ductile iron should not be used in natural or manufactured gas distribution pipelines on DoD installations. Where existing cast iron or ductile iron pipe is installed, the DoR must make every effort to know all details of its installation and any rehabilitation that has been performed. The construction documents created by the DoR that connect to the existing cast iron or ductile iron pipe must require the installing contractor to perform all inspections and tests and make all necessary enhancements or take all necessary precautions required by 49 CFR 192. The following information is identified from the 2018 revision of 49 CFR 192, but is not inclusive of all restrictions. NFPA 58 does not allow cast iron pipe or pressure containing components constructed from cast iron to be used in LPG pipelines. NFPA 58 does not allow ductile iron pipe to be used in LPG pipelines, but does allow metallic fittings and pressure containing components to be constructed from ductile iron that meets ASTM A395/A395M.

The following apply to existing cast iron or ductile iron natural or manufactured gas pipelines as stated:

- §192.621 limits the operating pressure of cast iron pipe segment with unreinforced bell and spigot connections to 25 psig.
- §192.753 (a) requires all bell and spigot connections in pipe segments operating at pressures higher than 25 psig to be sealed with mechanical leak clamps or equivalent. For pipe segments operating at 25 psig or below, the connection must be sealed IAW §192.753. (b) if the connection is exposed for any reason.
- Existing cast iron connections that are sealed with a gasket and retained by a follower ring are qualified under §192.275 but are restricted in MAOP.
- Cast iron flanges must be cast integrally into the pipe, fitting, or valve and must conform to ASME B16.1.
- Neither cast iron nor ductile iron pipe that is less than 6" nominal pipe size (NPS) may be used as a service line, per §192.373.
- Requirements of §192.557 must be met before the operating pressure of a cast iron or ductile iron pipe segment is increased above its previously established MAOP.
- Ductile iron components are typically allowed to operate at 80% of their rated pressure at temperature.

In addition, §192.489 requires the replacement of cast and ductile iron piping that shows general graphitization might cause the pipe to fracture or leak. Only localized graphitization may be repaired. Several other paragraphs throughout 49 CFR 192 place requirements on construction practices that may be required when modifying a distribution pipeline that is constructed from cast iron or ductile iron. The reader is cautioned to pay particular attention to all design elements when modifying an existing pipeline constructed of these materials.

### **3-3 DESIGN OF PIPELINE COMPONENTS.**

Components installed in distribution pipelines must comply with the requirements of 49 CFR 192, Subpart D, which prescribes the qualification of all valves, fittings, pressure regulators, and other devices installed in a natural gas pipeline.

#### **3-3.1 Fittings.**

Fittings used on steel pipe must be butt welded or flanged and be rated for the operating pressure and temperature of the distribution pipeline. Butt weld fittings should be factory made wrought steel per ASME B16.9 with butt weld ends per ASME B16.25. Flanges should comply with ASME B16.5 and MSS SP-44.

##### **3-3.1.1 Threaded Fittings.**

Threaded fittings complying with ASME B1.20.1 may be used above ground only, due to the corrosion potential when installed underground. Threaded fittings must have at least the minimum metal thickness required for the operating pressure and temperature of the system.

Threaded fittings may be used on LPG pipelines to connect piping to equipment or appurtenances that are provided from the manufacturer with threaded connections. The proper type of threaded fitting must be specified to make connection to the manufacturer's equipment or appurtenance. Butt weld fittings are preferred to connect lengths of pipe in all sizes. Threaded fittings should not be used to connect lengths of pipe, but where this type of connection is necessary in the construction, specify schedule 80 pipe and back weld at the threaded connection.

### **3-3.1.2 Socket Weld Fittings.**

Socket weld fittings must not be used in natural gas, manufactured gas, or LPG distribution pipelines installed on DoD installations for the reasons listed hereinafter. Socket weld fittings are connected by a fillet weld, which is not a full penetration weld and cannot be confirmed by nondestructive testing to meet pull-out requirements. The socket weld fitting also contains a void between the pipe and fitting that can be a site for contaminant, corrosion, natural gas, and petroleum distillate to reside, undetected.

### **3-3.1.3 Branch Connections.**

Branch connections must be designed for both pressure and temperature requirements and mechanical strength. Tee fittings should be used for branch connections where practical. Welded branch connection must be designed and constructed to ensure that the strength of the pipeline system is not reduced, taking into account the stresses in the remaining pipe wall due to the opening in the pipe or header, the shear stresses produced by the pressure acting on the area of the branch opening, and any external loadings due to thermal movement, weight, and vibration.

### **3-3.1.4 Mechanical Fittings.**

Mechanical fittings used to make a hot taps must be qualified to withstand the maximum anticipated operating pressure and temperature of the pipeline.

### **3-3.1.5 Mechanical Compression Joints.**

Mechanical compression joints are allowed to connect plastic pipe only in locations where other fitting types are not feasible. When compression joints are utilized, they must be installed in accordance with the requirements of 49 CFR § 192.281(e). Proof of satisfying the design requirements must be provided by a knowledgeable third party such as a representative of the compression joints manufacturer. The manufacturer of the mechanical compression fitting must certify that the fitting is intended for the specific gas service, that the gasket is compatible with the type of plastic specified, and that a rigid tubular internal stiffener, not split tubular, is incorporated in the design. The manufacturer must provide the part number, serial number and year made for each mechanical fitting used on a DoD installation and the contractor must submit this information along with the GIS Location and date of installation for the Government's permanent record.

### **3-3.2 Valves.**

Steel valves installed in natural and manufactured gas distribution pipelines must comply with API SPEC 6D. Although ASME B16.34 is the basis for all valves specified in API SPEC 6D, §192.145 mandates that all steel valves in a natural gas pipelines comply with the requirements of API SPEC 6D, which adds substantial additional features and testing over and above the requirements of ASME B16.34. Metallic valves installed in metallic distribution pipelines conveying LPG must comply with UL 125. Valves installed in polyethylene distribution pipelines that convey natural gas, manufactured gas, or LPG must comply with ASTM D2513 and ASME B16.40. Valves installed in polyamide distribution pipelines that convey natural gas, manufactured gas, or LPG must comply with ASTM F2945 and ASME B16.40.

#### **3-3.2.1 Restricted Valve Materials.**

Cast iron, malleable iron, and ductile iron are restricted materials for use in natural or manufactured gas pipelines within 49 CFR 192 and should not be used in valve shell construction on Government DoD installations. Although these materials have been used in the past, and may qualify under certain conditions, these materials should not be used in new natural gas pipelines installed on Government DoD installations. These materials are not qualified for use at compressor stations.

#### **3-3.2.2 Valve Locations.**

Valves must be installed in the distribution pipeline in the locations required by 49 CFR §192.181 and as described below:

- Each high-pressure distribution system must have valves spaced so as to reduce the time to shut down a section of main in an emergency. The valve spacing is determined by the operating pressure, the size of the mains, and the local physical conditions.
- An isolation valve must be installed on the inlet piping to each regulator station that controls the flow or pressure of gas in a distribution system. This isolation valve must be installed at a safe distance from the regulator station sufficient to permit the operation of the valve during an emergency that prevents access to the station.
- Service line operating or emergency shut-off valve must be installed upstream of regulator/meter, must be readily accessible, outside of the building, and in a covered valve box if installed below grade.

Valve locations must be compliant with all requirements of the current edition of 49 CFR §192.181.

### **3-3.3 Control of Gas Pressure and Over Pressure Protection.**

Where a gas source that is at higher pressure than the MAOP of a distribution pipeline, and is connected to that distribution pipeline, a pressure regulator is required and a pressure relieving device or pressure limiting device that meets the requirements of

§192.199 and §192.201 is required to protect the distribution pipeline from over pressurization that could result from failure of the upstream pressure control or of failure of some other type.

### **3-3.3.1 Natural and Manufactured Gas Pressure Regulators and Relief/Limiting Devices.**

The pressure of gas delivered from a high-pressure distribution system must be controlled IAW 49 CFR §192.197. This section differentiates pressure regulation and protection requirements for pipelines operating at pressures 60 psig or less from those required for pipelines operated at pressures greater than 60 psig. It is recommended that distribution pipelines installed on DoD installations must apply the “greater than 60 psig” pressure regulation and protection requirements to allow flexibility in future uprating of MAOP.

Four different types of pressure regulators are used in the design of a natural gas or manufactured gas systems, which are as follows:

- Appliance regulator: allowed in the fuel gas piping defined by NFPA 54, but not qualified to operate in a 49 CFR 192 distribution pipeline.
- Line regulator: allowed in the fuel gas piping defined by NFPA 54, but not qualified to operate in a 49 CFR 192 distribution pipeline.
- Main regulators: supplied by a qualified manufacturer of regulators intended for use in a distribution system.
- Service regulator: qualified by AGA ANSI B109.4 to be installed at the end of service line, with an isolation valve.

Each service regulator installed on a service line intended to regulate the pressure of fuel gas supplied to a consumer must comply with §192.197(c)(3). This paragraph requires that a pressure relief device be installed to protect the piping system connected to the low-pressure side of the regulator. This pressure relief device may be built into the service regulator or may be a separate relief valve installed downstream of the service regulator. The relief device must be capable of relieving downstream pressure, at the rated regulator flow, to prevent over pressurization of the consumer’s fuel gas piping. Even though §192.197(a) allows regulators with specified characteristics, but having no pressure relief, to be installed on distribution systems that operate at 60 psig or less, this practice is not recommended for DoD installations because future pressure increases would require major infrastructure rehabilitation.

### **3-3.3.2 Natural and Manufactured Gas Pressure Relief and Limiting Devices.**

Where the distribution pipeline pressure exceeds 60 psig, a pressure relieving or pressure limiting device is required by §192.197(c) to ensure that the MAOP of the downstream pipeline or service line and appurtenances is never exceeded. The devices required are listed below:

- Pressure relief valve, spring loaded or weight loaded.

- Pilot loaded, back-pressure regulator that acts as a relief device to maintain the inlet pressure of the primary regulator to a specified set point. A pilot senses the pressure downstream from the back-pressure regulator (inlet to the primary regulator) and vents to atmosphere to ensure the inlet pressure to the primary regulator never exceeds the specified set point. This vent must discharge in a safe manner to a non-hazardous location.
- An automatic shut off device installed in series with the primary regulator with manual reset.
- A second regulator installed upstream of the primary or service regulator, set to limit the inlet pressure of the downstream regulator to 60 psig or less, and a device set to relieve the pressure between the two regulators in the event that the upstream regulator fails.
- A monitoring regulator installed upstream of a primary or service regulator. In this arrangement, a sensing line is connected downstream of the primary or service regulator to allow the monitoring regulator to sense the pressure downstream of the primary or service regulator. If the downstream regulator fails, then the monitoring regulator takes over the pressure control. The set point of the monitoring regulator is slightly higher than the set point of the working regulator, but never higher than the MAOP of the downstream pipeline. During normal operation, the monitoring regulator is fully open.
- A service regulator with internal pressure relief or separate relief valve installed downstream of the service regulator, as long as the inlet pressure does not exceed 125 psig.

These devices are more clearly described by trade name in ASME B31.8, para 845, which may be used as a reference.

The pressure relieving or limiting device must be designed IAW §192.199. The capacity of the pressure relieving and limiting device must be IAW §192.201. In all cases where natural gas is vented from a pressure relieving or limiting device to the atmosphere, the vent must be constructed to prevent blockage by rain, snow, ice, insects, or vermin and must discharge safely to the environment without undue hazard.

### **3-3.3.3 LPG Pressure Regulators and Relief Devices.**

The pressure of LPG in the vapor phase must be reduced and regulated when leaving the LPG liquid container in accordance with NFPA 58, paragraph 5.10. This pressure regulator must be one of the two stage regulator combinations specified in NFPA 58, paragraph 5.10, and must contain the required pressure relief device or overpressure shutoff device. The regulators used in an LPG distribution pipeline must comply with UL 144. Do not use line pressure regulators per ANSI Z21.80, or appliance regulators per ANSI Z21.18 in an LPG distribution pipeline. Line and appliance regulators belong in the fuel gas piping system as specified in NFPA 54 with specific reference to NFPA 58.

A summary of regulator combinations qualified to be installed in an LPG distribution pipeline are as follows:

- Automatic changeover regulator incorporating an integral two stage regulator, with integral pressure relief to limit second stage outlet pressure to 2 psig when seat disc is removed, and inlet pressure is 15 psig or overpressure shutoff with manual reset on the outlet of the second stage regulator. This regulator is for use on multiple cylinder installation.
- Integral two-stage regulator with means to determine the outlet pressure of the high-pressure regulator, and with integral pressure relief to limit second stage outlet pressure to 2 psig when seat disc is removed, and inlet pressure is 15 psig or overpressure shutoff with manual reset.
- High pressure regulator installed on the LPG container with integral relief valve, and a first stage regulator, with integral pressure relief, installed downstream of the high-pressure regulator to serve multiple second stage regulators. Second stage regulators must have integral pressure relief to limit second stage outlet pressure to 2 psig when seat disc is removed, and inlet pressure is 15 psig or overpressure shutoff with manual reset on the outlet of the second stage regulator.
- First stage regulator, 10 psig maximum outlet pressure, with integral pressure relief, and a second stage regulator with integral pressure relief to limit second stage outlet pressure to 2 psig when seat disc is removed, and inlet pressure is 15 psig or overpressure shutoff with manual reset.
- 2 psig regulator system including a first stage regulator, 10 psig maximum outlet pressure, with integral pressure relief, and a 2 psig regulator, 2.5 psig maximum outlet pressure with integral pressure relief to limit 2 psig regulator outlet pressure to 5 psig when seat disc is removed and inlet pressure is 15 psig or overpressure shutoff with manual reset.
- Or an integral 2 psig service regulator meeting the design intent of the 2 psig regulator system but manufactured into one assembly.

Automatic changeover, integral two stage, high pressure, first stage, and integral 2 psig regulators must be installed in compliance with NFPA 58, paragraph 6.10.1, either on the LPG storage tank vapor service valve or connected to the vapor discharge valve using a flexible metallic connector that is qualified for LPG service. The regulators must be installed so that weather elements do not affect their operation. The relief vent discharge must be located in compliance with NFPA 58 such that the termination point presents little hazard, is a minimum of 3 horizontal feet from any building opening and 5 feet from sources of ignition, mechanical air intake, or direct vented gas appliance.

### **3-3.4 Customer Meters, Regulators and Service Lines.**

Customer meters, service regulators and service lines must comply with the requirements of 49 CFR 192, Subpart H. This subpart addresses the allowed locations for installation, the requirement for protection against damage, and the elimination of stress on the piping system.



DoD installations require, in most cases, adherence to an Advanced Metering Program. Each branch of military service has written its own specific requirements that guide the design of advanced metering systems and their electronic reporting system. Cybersecurity and on-board memory are necessary elements of each program. Please refer to the requirements of the specific DoD installation for guidance on specifying the required metering systems and connectivity.

#### **3-3.4.1 Meters.**

§192.359 requires that all new meters be tested by the manufacturer at a shell pressure of not less than 10 psig. Meters may not be operated at a pressure higher than 67% of the manufacturer's shell test pressure. A rebuilt or repaired tinned steel meter may not be operated at more than 50% of the pressure used to test the meter after rebuilding or repairing. Gas meters that comply with AGA ANSI B109 are qualified for natural gas, manufactured gas and LPG in the vapor phase, but the manufacturer must know which gas will be metered. LPG in the vapor phase may or may not require metering when it is supplied from a distribution pipeline to multiple customers on a DoD installation. Please coordinate with the contracting officer of the project to determine the Government's desire for metering of LPG.

#### **3-3.4.2 Regulators.**

The service regulator that reduces the natural or manufactured gas pressure to the meter and the customer's fuel gas piping system are described in paragraph 3-2.3 of this UFC. Refer to NFPA 54 for specific usage of line pressure regulators that reduce 2 psig gas supply to appliance regulator inlet pressure and appliance regulators.

The term 'service regulator' does not apply to LPG distribution pipelines. Required regulators are described in paragraph 3-2.3 of this UFC. Refer to NFPA 58 and NFPA 54 for specific usage of line pressure regulators that reduce 2 psig LPG vapor supply to appliance regulator inlet pressure and appliance regulators.

#### **3-3.4.3 Service Lines.**

Each steel service line to be operated at less than 100 psig must be constructed of pipe designed for a minimum of 100 psig. Additional requirements are defined in §192.361 through §192.379. Exception to §192.375 is that a plastic service line may not be exposed above grade level on a DoD installation. An anode less riser must be used to bring a plastic service line from below grade to a steel pipe serving the isolation valve, service regulator, and meter.

#### **3-3.5 Excess Flow Valve (EFV).**

An EFV must be installed on all new or replaced single and branched service lines that serve single-family residences where the service line operates at 10 psig or greater. EFVs are also required to be installed on multifamily residences, and small commercial entities consuming gas volumes not exceeding 1,000 standard cubic feet per hour (SCFH). The EFV must comply with the requirements of §192.381 and close upon detection of flow in excess of the anticipated maximum flow through the service line.

Sizing an EFV requires knowing the maximum gas demand of all the appliances connected to the service line. The potential for adding future gas burning equipment should also be considered.

**3-3.6           Vaults.**

Vaults must be structurally sound, designed to minimize entrance of water, and must not be drained to any other underground structure. Vaults serving as access to natural gas distribution pipelines must comply with §192.183 through §192.189. Where plastic pipe passes through a vault must be encased in ASTM A53/A53M minimum schedule 40 steel pipe that is properly protected from corrosion and vented.

## CHAPTER 4 CONSTRUCTION OF DISTRIBUTION PIPELINES

### 4-1 QUALIFICATION OF PROCESSES.

Methods used to install natural gas distribution pipelines must be proven to provide a durable, gas-tight system. All pipe joints made in the system must be made in accordance with qualified written procedures and by personnel qualified by training and testing that have been proven by test or experience to produce strong, gas-tight joints.

The DoD installation must include these qualified written procedures and personnel qualifications in its operations and maintenance manual. It is therefore required that the installing contractor provide a qualified written procedure and personnel qualifications for each joint made in the distribution pipeline.

### 4-2 WELDING OF STEEL PIPE.

Welding of steel pipelines must comply with the requirements of 49 CFR 192, Subpart E.

#### 4-2.1 Welding Procedures for Steel Pipe.

The installing contractor must submit for Government approval, a written procedure for welding steel pipe and fittings installed in the distribution pipeline. Welding procedures must be qualified under API STD 1104, Section 5, Section 12, or Appendix A or under the ASME/BPVC SEC IX as written in §192.225. The contractor must make sure that welding is performed in accordance with these established written welding procedures that have been qualified and tested to produce quality welds.

#### 4-2.2 Welder Qualifications.

Welders must be qualified IAW API STD 1104, Section 6, Section 12, or Appendix A or under the ASME/BPVC SEC IX as written in §192.227. The contractor must submit to the Government, proof of each welder's current certification of qualification. Welders qualifications must further comply with the limitations specified in §192.229, which include qualification intervals and methods of qualification.

Welders of pipe segments and components intended to serve natural gas compressors must be qualified under the destructive test requirements of the applicable API STD 1104 sections.

#### 4-2.3 Inspection and Testing of Welds.

All welds must be inspected by a person that is qualified by training and experience to ensure welding is performed by certified welders, using a qualified written procedure, and has produced acceptable welds under API STD 1104, Section 9 or Appendix A, which will not be used to accept cracks. In accordance with §192.243, and minimum location class 3 for DoD installations, 100% of welds on pipelines and components operating at a hoop stress of 20% or more of the SMYS must be nondestructively tested.

## **4-3 HEAT FUSION JOINING OF PLASTIC PIPE.**

### **4-3.1 Written Joining Procedures.**

The installing contractor must submit for Government approval, a qualified, written procedure for joining plastic materials obtained from the manufacturer of the plastic pipe and fittings installed in the system. The procedure must have been proven to make strong, gas-tight joints by passing the tests specified in §192.283. Vendors who cannot provide this qualified joining procedure must be disqualified from supplying materials for the work. The contractor must make sure that each joint is made in accordance with these Government approved procedures. Any contract that purchases plastic pipe for use in the natural gas distribution system must disallow the purchase of plastic pipe from any manufacturer or supplier that does not certify qualified joining procedures for the pipe. It is the DoD installation's responsibility to verify that the contractor follows these written joining procedures for each type of pipe and fitting used.

### **4-3.2 Joint Maker Qualifications.**

The contract documentation must require the contractor to train, test, and qualify each person performing work on the natural gas distribution system located on a DoD installation in accordance with 49 CFR 192, Subpart F. No person may make a plastic pipe joint unless that person has been qualified under the pipe manufacturer's written joining procedure by making a specimen joint that passes inspection and test. The specimen joint used to qualify the joiner must be visually examined during and after joining and found to have the same appearance as a joint or photograph of a joint that is acceptable under the procedure. In the case of heat fusion, the specimen must be cut into at least three longitudinal straps, each of which is:

- Visually examined and found not to contain voids or discontinuities on the cut surfaces of the joint area;
- Deformed by bending, torque, or impact, and if failure occurs, it must not initiate in the joint area.

Each person joining plastic in a distribution pipeline must be re-qualified under the applicable procedure §192.285(c), or after any production joint is found unacceptable by testing under §192.513. A person that is qualified by appropriate training or experience to evaluate the acceptability of the joint must inspect each joint installed in a gas piping system. This inspection may be performed by the person installing the joint if so qualified.

## **4-4 PIPELINE INSTALLATION AND REPAIR.**

All pipelines must be installed IAW 49 CFR 192. Joining of new pipe to existing pipe must be in a manner approved in 49 CFR 192.

Where a distribution pipeline passes under a roadway or a railroad, the pipeline must be encased in steel pipe that protected from corrosion. If the casement is not vented it must be sufficiently strong to contain the operating pressure of the gas without

exceeding the stress levels presented in §192.323. Vented casements must be protected from the weather. Distribution pipeline must be installed with sufficient underground clearance from other buried items to allow for proper maintenance and to protect against damage caused by those buried items.

Distribution mains must have minimum cover of 24" or be otherwise protected from external loads and excavation damage. In accordance with §192.361, the part of the service line installed in a public right-of-way must have minimum cover of 18". This service line is allowed to have a minimum cover of 12" once it has passed onto private property. For DoD installations, it is recommended that the 12" cover apply only to single family dwellings but could be safely expanded to duplexes and quad-plexes. A minimum 18" cover is required for service lines serving any other type of building on a DoD Installation.

#### **4-4.1 Plastic Pipe Installation.**

Plastic pipe installed in a distribution pipeline must be installed below grade and must be continuously supported in suitable compacted soil to prevent movement after installation. Ensure that the installation has sufficient slack to prevent pullout due to thermal contraction. Inspect pipe and fittings for damage prior to backfilling. If the pipe has a scratch or cut that exceeds 10% of the wall thickness, it must be replaced.

Plastic pipelines must be installed with sufficient clearance from any item that may increase the temperature of the plastic pipe segment, to prevent degradation of the pipe strength. These items may include, but are not limited to, hot water piping, steam piping, condensate piping, and electrical equipment. Where proximity cannot be avoided, the DoR must design adequate protection to prevent pipe temperature increase. Where temperature increase of the plastic pipe cannot be avoided, the DoR must reduce the design pressure of the plastic pipe by using a Hydrostatic Design Basis value for a temperature that is higher than the actual anticipated temperature.

#### **4-4.2 Steel Pipe Installation.**

Aboveground steel pipe must be securely supported and protected from vehicular collisions. Steel pipe must be painted for corrosion protection.

Where steel pipe is required for below grade installations the pipe must be coated with an approved anti corrosion coating and must be cathodically protect IAW 49 CFR 192, Subpart I. The pipe must be continuously supported by properly compacted material.

Where connections are made to existing underground steel pipe, the contractor must inspect the existing pipe for corrosion and take remedial action IAW 49 CFR 192 Subpart I if corrosion is found.

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## CHAPTER 5 CONTROL OF CORROSION

### 5-1 METALLIC PIPELINES.

Metallic pipelines installed underground must be protected from corrosion IAW 49 CFR 192, Subpart I, which includes both an approved anti corrosion coating per §192.461 and a cathodic protection system in compliance with the requirements of §192.463.

### 5-2 DISTRIBUTION PIPELINE INTEGRITY MANAGEMENT PLAN.

The distribution pipeline operator is required to maintain a Distribution Pipeline Integrity Management Plan that details, among other items, all aspects of metallic pipeline installed underground, methods used to protect against corrosion, and inspections to determine the efficacy of the corrosion control program. A complete listing of information required to be maintained can be found in Chapter IX “Guidance Manual for Operators of Small Natural Gas Systems”, current edition, DOT Pipeline and Hazardous Materials Safety Administration.

The DoR for any project installing or connecting to existing underground metallic pipe must support the distribution pipeline operator’s efforts to control corrosion through proper design and requiring the installing contractor to do the following:

- Perform corrosion inspection and report on inspections of any underground metallic natural gas pipe that is uncovered during construction.
- Provide mill coating on steel pipelines installed below grade.
- Properly install and backfill coated pipe without damage to the coating.
- Properly field coat all connection and components.
- Thoroughly inspect and test the coatings for holidays.
- Properly install and test new cathodic protection systems.
- Properly install test stations for new cathodic protection systems.
- Electrically isolate protected pipelines from other, unprotected below grade metal and all above grade pipeline connections.
- Hire a corrosion control expert to help solve known corrosion problems.
- Obtain the operator’s acceptance of the installation before backfill.

Where corrosion is found, remedial methods described in §192.487 and §192.489 should be employed.

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## CHAPTER 6 NATURAL GAS COMPRESSORS

### 6-1 COMPRESSOR STATIONS PER 49 CFR 192.

Compressor Stations are not defined but are only described within 49 CFR 192. 49 CFR 192 and ASME B31.8 provide the following specific requirements for piping that connects to compressor stations:

- Steel pipe from the gas distribution main to the compressor, 49 CFR 192 §192.229 and ASME B31.8, 843.4.
- Cast iron components must not be used in compressor station piping systems, 49 CFR 192 §192.145 (e) and ASME B31.8, 831.1.
- Welders must be qualified based on destructive test requirements of API 1104. 49 CFR 192 §192.229 and ASME B31.8, 823.2.2.
- Butt welds must be 100% tested by non-destructive methods such as radiography, 49 CFR 192 §192.243, ASME B31.8, 826.3.

### 6-2 FUEL GAS BOOSTER COMPRESSORS.

It is rare that a compressor station as described by 49 CFR 192 is installed in the pipeline that is operated by a DoD installation. It is quite common, however, that a fuel gas booster compressor be installed on a distribution service line in order to boost pressure and gas flow to a local, point-of-use piece of equipment such as a gas turbine. Although the 49 CFR 192 and ASME B31.8 code requirements would not seem to apply to the connection of a point-of-use fuel gas booster compressor, the engineering precautions necessary to ensure safe operation do apply. The booster compressor has the potential to transmit vibration and pressure pulsation to the service line, which can cause the service line to fail. It is recommended that the service line be welded steel pipe, constructed and inspected in accordance with 49 CFR 192. Where alternative methods are used, the Designer of Record must ensure the installation and pipe connections comply with the requirements of the compressor manufacturer, state and local codes. Analysis must also be performed and submitted to the government showing that the vibration and pulsation load and cycle will not cause the pipe to fail. It is recommended that fuel gas piping that connects to the discharge of a booster compressor be welded steel, but this piping is beyond the scope of this UFC as it is downstream from the demarcation between 49 CFR 192 and NFPA 54. There are codes that apply to specific fuel gas using equipment that also place requirements on the fuel gas supply piping. NFPA 37 is an example of code that places requirements on the fuel gas piping system from the discharge of the booster compressor to a gas turbine.

Requirements for construction of natural gas compressors are defined in the following American Petroleum Institute (API) documents:

- API STD 617 Axial and Centrifugal Compressors and Expander Compressors

- API STD 618 Reciprocating Compressors for Petroleum, Chemical, and Gas Industry Services
- API STD 619 Rotary-Type Positive-Displacement Compressors for Petroleum, Petrochemical, and Natural Gas Industries

Recommended practices for installing these compressors can be found in API RP 686 – Recommended Practices for Machinery Installation and Installation Design. This reference requires a vibration analysis, pulsation analysis and a mechanical piping analysis to ensure that pressure limits of the piping system are not exceeded. It further places requirements on pipe arrangement and components, supports and anchors, places restrictions on branch connections, and identifies the need for pulsation and vibration dampeners.

## APPENDIX A BEST PRACTICES

Appendix A identifies background information and practices for accomplishing certain design and engineering services. The Designer of Record (DoR) is expected to review and interpret this guidance and apply the information according to the needs of the project. If a Best Practices document has guidelines or requirements that differ from the UFGS or Unified Facilities Criteria, the UFGS and the UFC must prevail. If a Best Practices document has guidelines or requirements that are not discussed in the Unified Facilities Guide specification (UFGS) or UFC, the DoR must submit a list of the guidelines or requirements being used for the project with sufficient documentation to the Government Project Manager for review and approval prior to completing design.

### A-1 WHOLE BUILDING DESIGN GUIDE.

The [Whole Building Design Guide](#) provides additional information and discussion on practice and facility design, including a holistic approach to integrated design of facilities.

The WBDG provides access to all Construction Criteria Base (CCB) criteria, standards and codes for the DoD Military Departments, National Aeronautics and Space Administration (NASA), and others. These include, Unified Facilities Criteria (UFC), Unified Facilities Guide Specifications (UFGS), Performance Technical Specifications (PTS), design manuals, and specifications. For approved Government employees, it also provides access to non-government standards.

### A-2 GUIDANCE.

#### A-2.1 DOT Manual for Operators of Small Natural Gas Systems.

In absence of installation specific directive instructions and guidance, follow gas pipeline safety regulations defined in the DOT manual as it applies to natural gas systems and operators of natural gas master meter systems. The pipeline safety regulations require operators of natural gas systems to: deliver gas safely and reliably to customers; provide training and written instruction for employees; establish written procedures to minimize the hazards resulting from natural gas pipeline emergencies; and, keep records of inspection and testing.

#### A-2.2 State Compliance.

Designers and operators should check with the pipeline safety agency in their state to determine:

- Whether a state agency has safety jurisdiction;
- Whether the state agency has pipeline safety requirements that exceed the federal regulations
- The inspection and enforcement procedures of the state agency.

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## APPENDIX B GLOSSARY

### B-1 ACRONYMS

AFCEC	Air Force Civil Engineer Center
AGA	American Gas Association
ANSI	American National Standards Institute
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
BCE	Base Civil Engineer
BIA	Bilateral Infrastructure Agreement
CCB	Construction Criteria Base
CCR	Criteria Change Request
CFR	Code of Federal Regulations
DoD	Department of Defense
DoR	Designer of Record
DOT	Department of Transportation
DPW	Department of Public Works
EFV	Excess Flow Valve
GIS	Geographic Information System
HDB	Hydrostatic Design Basis
HDS	Hydrostatic Design Stress
HQUSACE	Headquarters, U.S. Army Corps of Engineers
HNFA	Host Nation Funded Construction Agreements
IAW	in accordance with
ICC	International Code Council
LPG	Liquefied Petroleum Gas

MAOP	Maximum Allowable Operating Pressure
MMO	Master Meter Operators
MMS	Master Meter Systems
NAVFAC	Naval Facilities Engineering Command
NFPA	National Fire Protection Association
NPS	Nominal Pipe Size
O&M	Operations and Maintenance
PA-11	Polyamide-11
PE	Polyethylene
PHMSA	Pipeline and Hazardous Material Safety Administration
psig	pounds per square inch gauge
PTS	Performance Technical Specifications
SCFH	Standard Cubic Feet per Hour
SD	Submittal Description
SDR	Standard Dimension Ratio
SMYS	Specified Minimum Yield Strength
SOFA	Status of Forces Agreements
UFC	Unified Facilities Criteria
UFGS	Unified Facilities Guide Specifications
UP	Utility Privatization
U.S.	United States

## APPENDIX C REFERENCES

### AMERICAN GAS ASSOCIATION (AGA)

[www.aga.org](http://www.aga.org)

AGA ANSI B109.4, *Self-Operated Diaphragm-Type Natural Gas Service Regulators for Nominal Pipe Size 1¼ inches (32 mm) and Smaller with Outlet Pressures of 2 psig (13.8 kPa) and Less*

### AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

[www.ansi.org](http://www.ansi.org)

ANSI Z21.18, *Gas Appliance Pressure Regulators*

ANSI Z21.80, *Line Pressure Regulators*

### AMERICAN PETROLEUM INSTITUTE (API)

[www.api.org](http://www.api.org)

API RP 686, *Recommended Practice for Machinery Installation and Installation Design*

API SPEC 5L, *Line Pipe*

API SPEC 6D, *Specification for Pipeline and Piping Valves*

API STD 617, *Axial and Centrifugal Compressors and Expander-Compressors*

API STD 618, *Reciprocating Compressors for Petroleum, Chemical, and Gas Industry Services*

API STD 619, *Rotary-Type Positive Displacement Compressors for Petroleum, Petrochemical, and Natural Gas Industries*

API STD 1104, *Welding of Pipelines and Related Facilities*

API-ASME Code, *Unfired Pressure Vessels for Petroleum Liquids and Gases*

### AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

[www.asme.org](http://www.asme.org)

ASME B1.20.1, *Pipe Threads, General Purpose (Inch)*

ASME B16.1, *Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250*

ASME B16.5, *Pipe Flanges and Flanged Fittings*

ASME B16.9, *Factory Made Wrought Steel Butt Welding Fittings*

ASME B16.25, *Butt Welding Ends*

ASME B16.34, *Valves – Flanged, Threaded, Welding End*

ASME B16.40, *Manually Operated Thermoplastic Gas Shutoffs and Valves in Gas Distribution Systems*

ASME B31.8, *Gas Transmission and Distribution Piping Systems*

ASME Section VIII, *Rules for the Construction of Unfired Pressure Vessels*

ASME/BPVC SEC IX, *ASME Boiler and Pressure Vessel Code, Section IX*

### **ASTM INTERNATIONAL (ASTM)**

[www.astm.org](http://www.astm.org)

ASTM A53/A53M, *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless*

ASTM A395/A395M, *Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures*

ASTM D2513, *Standard Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings*

ASTM D2517, *Standard Specification for Reinforced Epoxy Resin Gas Pressure Pipe, Tube, and Fittings*

ASTM F2945, *Standard Specification for Polyamide 11 Gas Pressure Pipe, Tubing, and Fittings*

ASTM F2164, *Standard Practice for Field Leak Testing of Polyethylene (PE) and Crosslinked Polyethylene (PEX) Pressure Piping Systems Using Hydrostatic Pressure*

ASTM F2786, *Standard Practice for Field Leak Testing of Polyethylene (PE) Pressure Piping Systems Using Gaseous Testing Media Under Pressure (Pneumatic Leak Testing)*

### **MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)**

<http://msshq.org>

MSS SP-44, *Steel Pipeline Flanges*



**NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)**

[www.nfpa.org](http://www.nfpa.org)

NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*

NFPA 54, *National Fuel Gas Code*

NFPA 58, *Liquefied Petroleum Gas Code*

**PIPELINE AND HAZARDOUS MATERIALS SAFETY ADMINISTRATION (PHMSA)**

[www.phmsa.dot.gov](http://www.phmsa.dot.gov)

*Guidance Manual for Operators of Small Natural Gas Systems*

**UNDERWRITERS LABORATORIES (UL)**

[www.ul.com](http://www.ul.com)

UL 125, *UL Standard for Safety Flow Control Valves for Anhydrous Ammonia and LP-Gas*

UL 144, *UL Standard for Safety LP-Gas Regulators*

**UNIFIED FACILITIES CRITERIA (UFC)**

<https://www.wbdg.org/ffc/dod/unified-facilities-criteria-ufc>

UFC 3-460-01, *Design: Petroleum Fuel Facilities*

**UNIFIED FACILITIES GUIDE SPECIFICATIONS (UFGS)**

<https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs>

UFGS 23 11 25, *Facility Gas Piping*

UFGS 33 51 15, *Natural-Gas / Liquefied Petroleum Gas Distribution Pipelines*

**U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)**

[www.archives.gov](http://www.archives.gov)

49 CFR 192, *Transportation of Natural and Other Gas by Pipeline: Minimum Safety Standards*