Liquid Process Piping

Course Number: ME-02-340

PDH: 12

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Chapter 1
Introduction

1-1. Purpose

This course provides information for the design of liquid process piping systems.

1-2. Applicability

Liquid process piping systems include all pipe and appurtenances which are used to convey liquids to, from and between pumping, storage and treatment units and which are not integral to any unit (i.e., piping that is furnished as a part of the unit). Plumbing is covered by TM 5-810-5, potable water piping is covered by TI 814-03, sewage piping is covered by TI 814-10, storm drainage, and fuel and lubricant supply piping are excluded.

1-3. References

Required and related references are listed in Appendix A.

1-4. Distribution

This course is approved for public release; distribution is unlimited.

1-5. Scope

This course includes criteria for the design of component parts and assemblies of liquid process piping systems. Compliance with these criteria requires only that fundamental design principles be followed. Materials and practices not prohibited by this course or its basic references should also be considered. Where special conditions and problems are not specifically addressed in this course, acceptable industry standards should be followed. Modifications or additions to existing systems solely for the purpose of meeting criteria in this course are not authorized.

a. Cathodic Protection

All underground ferrous piping will be cathodically protected. TM 5-811-7 (Army) and MIL-HDBK-1004/10 (Air Force) contain additional guidance pertaining to cathodic protection of underground pipelines.

1-6. Metrics

Both the International System of Units (SI) (the Modernized Metric System) and the Inch-Pound (IP) ("English") system of measurement are used in this course. Pipe and appurtenances are provided in standard dimensions, either in International Organization for Standardization (ISO) sizes which are SI based, or in American National Standards Institute (ANSI) sizes which are IP based. Table 1-1 compares the standard sizes of the measurement systems. Standard sizes under the two systems are close, but not equivalent. A similar table is included in the Tri-Service CADD Details Library.

a. SI Design Requirement

In accordance with ER 1110-1-4, where feasible, all project designs for new facilities after 1 January 1994 must be developed using the SI system of measurement. The USACE metric conversion has been closely coordinated with that of the construction industry. Where the industry has committed to a "hard" metric product, USACE must specify and use that product in its designs. Where the industry is as yet undecided, IP products should be used with a "soft" conversion when design efficiency or architectural treatments are not compromised. The limited availability of some metric products may require additional investigation, may result in more complex procurement, and may alter scheduling during construction.

1-7. Brand Names

The citation in this course of brand names of commercially available products does not constitute official endorsement or approval of the use of such products.

1-8. Accompanying Guidance Specification

This course is intended to be used in conjunction with CEGS 15200, Liquid Process Piping.

Table 1-1
Standard Pipe Dimensions

ANSI		ISO			
		Nominal Pipe Size		Actual D_o	
Nominal Pipe Size (in)	Actual D_o (in)	(mm)	(in)	(mm)	(in)
χ	0.405	6	(0.236)	10	(0.394)
¼	0.540	8	(0.315)	12	(0.472)
δ	0.675	10	(0.394)	16	(0.630)
½	0.840	15	(0.591)	20	(0.787)
¾	1.050	20	(0.787)	25	(0.984)
1	1.315	25	(0.984)	32	(1.260)
1¼	1.660	32	(1.260)	40	(1.575)
1½	1.900	40	(1.575)	50	(1.969)
2	2.375	50	(1.969)	63	(2.480)
2½	2.875	65	(2.559)	75	(2.953)
3	3.500	80	(3.150)	90	(3.543)
4	4.500	100	(3.937)	110	(4.331)
5	5.563	125	(4.921)	140	(5.512)
6	6.625	150	(5.906)	160	(6.299)
8	8.625	200	(7.874)	225	(8.858)
10	10.75	250	(9.843)	280	(11.024)
12	12.75	300	(11.81)	315	(12.402)
14	14.00	350	(13.78)	356	(14.00)
16	16.00	400	(15.75)	407	(16.00)
18	18.00	450	(17.72)	457	(18.00)
20	20.00	500	(19.69)	508	(20.00)
--	--	550	(21.65)	559	(22.00)
24	24.00	600	(23.62)	610	(24.02)
--	--	650	(25.59)	660	(25.98)
28	28.00	700	(27.56)	711	(27.99)
30	30.00	750	(29.53)	762	(30.00)
32	32.00	800	(31.50)	813	(32.00)
--	--	850	(33.46)	864	(34.02)
36	36.00	900	(35.43)	914	(35.98)
40	40.00	1000	(39.37)	1016	(40.00)
--	--	1050	(41.34)	1067	(42.00)
44	44.00	1100	(43.31)	1118	(44.00)
48	48.00	1200	(47.24)	1219	(48.00)
52	52.00	1300	(51.18)	1321	(52.00)
56	56.00	1400	(55.12)	1422	(56.00)
60	60.00	1500	(59.06)	1524	(60.00)

Note: D_o = Outer Diameter

1-9. Course Organization

Chapter 2 of this course provides basic principles and guidance for design. Chapter 3 presents engineering calculations and requirements for all piping systems, regardless of construction material. Subsequent chapters address engineering requirements for specific materials of construction, valves, ancillary equipment, and corrosion protection.

a. Fluid/Material Matrix

Appendix B contains a matrix that compares pipeline material suitability for different process applications. Design for specific process applications should consider temperature, pressure and carrier fluid. The use of Appendix B is addressed in Chapter 3.

Chapter 2
Design Strategy

2-1. Design Analyses

The design analyses include the design of the process piping systems. The design criteria include applicable codes and standards, environmental requirements, and other parameters which may constrain the work.

a. Calculations

Engineering calculations included in the design analyses document the piping system design. Combined with the piping design criteria, calculations define the process flow rates, system pressure and temperature, pipe wall thickness, and stress and pipe support requirements. Design calculations are clear, concise, and complete. The design computations should document assumptions made, design data, and sources of the data. All references (for example, manuals, handbooks, and catalog cuts), alternate designs investigated, and planned operating procedures are included. Computer-aided design programs can be used but are not a substitute for the designer's understanding of the design process.

b. System Descriptions

System descriptions provide the functions and major features of each major system and may require inputs from mechanical, electrical and process control disciplines. The system description contains system design bases, operating modes and control concepts, and both system and component performance ratings. System descriptions provide enough information to develop process flow diagrams (PFDs), piping and instrumentation diagrams (P&IDs), and to obtain any permits or approvals necessary to proceed. Table 2-1 lists the typical contents of a system description.

2-2. Specifications

Piping specifications define material, fabrication, installation and service performance requirements. The work conforms to ER 1110-345-700, Design Analysis, Drawings and Specifications. In addition, the project design must adhere to general quality policy and principles as described in ER 1110-1-12, Quality Management.

Table 2-1
System Description

1. Function
2. Bases of Design
   - Environmental
   - Safety
   - Performance Requirements
   - Codes and Standards
3. Description
   - General Overview
   - System Operation
   - Major Components

2-3. Drawings

Contract drawings include layout piping drawings, fabrication or detail drawings, equipment schedules, and pipe support drawings. Isometric drawings may also be included and are recommended as a check for interferences and to assist in pipe stress analyses. A detailed pipe support drawing containing fabrication details is required. Piping supports can be designed by the engineer or the engineer may specify the load, type of support, direction and degree of restraint.

a. Drawings Requirements

The requirements and procedures for the preparation and approval of drawings shall meet ER 1110-345-700, Design Analysis, Drawings and Specifications. This regulation addresses the stages of design and construction, other than shop drawings.

b. Process Flow Diagram (PFD) Content

PFDs are the schematic illustrations of system descriptions. PFDs show the relationships between the major system components. PFDs also tabulate process design values for different operating modes, typically normal, maximum and minimum. PFDs do not show piping ratings or designations, minor piping systems, for example, sample lines or valve bypass lines;

instrumentation or other minor equipment, isolation valves, vents, drains or safety devices unless operable in a described mode. Table 2-2 lists the typical items contained on a PFD, and Figure 2-1 depicts a small and simplified PFD.

Table 2-2
PFDs

1. Major Equipment Symbols, Names, Identification Number
2. Process Piping
3. Control Valves and Other Valves that Affect Operations
4. System Interconnections
5. System Ratings and Operational Variables

   maximum, average, minimum flow
   maximum, average, minimum pressure
   maximum, average, minimum temperature
6. Fluid Composition

c. Piping and Instrumentation Diagram (P&ID) Content

P&IDs schematically illustrate the functional relationship of piping, instrumentation and system equipment components. P&IDs show all of the piping, including the intended physical sequence of branches, reducers, and valves, etc.; equipment; instrumentation and control interlocks. The P&IDs are used to operate the process systems. Table 2-3 lists the typical items contained on a P&ID, and Figure 2-2 depicts a small and simplified P&ID.

d. Piping Sketches

Major piping sketches may be included in a preliminary design submittal. Sketches of the major piping systems may be overlaid on preliminary equipment locations and structural plans to indicate new pipe runs and provide data input for a cost estimate.

Table 2-3
P&IDs

1. Mechanical Equipment, Names and Numbers
2. All Valves and Identification
3. Instrumentation and Designations
4. All Process Piping, Sizes and Identification
5. Miscellaneous Appurtenances including Vents, Drains, Special Fittings, Sampling Lines, Reducers and Increasers
6. Direction of Flow
7. Class Change
8. Interconnections
9. Control Inputs/Outputs and Interlocks

2-4. Bases of Design

The bases of design are the physical and material parameters; loading and service conditions; and environmental factors that are considered in the detailed design of a liquid process piping system to ensure a reasonable life cycle. The bases of design must be developed in order to perform design calculations and prepare drawings.

a. Predesign Surveys

Predesign surveys are recommended for the design of liquid process piping for new treatment processes and are a necessity for renovation or expansion of existing processes. A site visit provides an overview of the project. Design requirements are obtained from the customer, an overall sense of the project is acquired, and an understanding of the aesthetics that may be involved is developed. For an existing facility, a predesign survey can be used to evaluate piping material compatibility, confirm as-built drawings, establish connections, and develop requirements for aesthetics.

Purchase this course to see the remainder of the technical materials.