Liquid Process Piping

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Module 1: Introduction

Learning Objectives

By the end of this section, you will be able to:

- **Identify** the specific systems and applications that fall under the scope of liquid process piping design criteria.
- **Determine** the appropriate measurement system (SI vs. IP) and standard dimensions for project design compliance.
- **Evaluate** the necessity for cathodic protection in underground ferrous piping systems based on regulatory mandates.

Executive Summary: This course establishes the mandatory design criteria for liquid process piping systems used in pumping, storage, and treatment units, emphasizing the required shift toward SI (metric) units and the absolute requirement for cathodic protection on all underground ferrous lines.

Purpose

This module provides the engineering framework and essential information for the design of liquid process piping systems.

Applicability

Liquid process piping systems include all pipe and appurtenances used to convey liquids to, from, and between:

- Pumping units
- Storage units
- Treatment units

⚠️ **Safety Constraint:** This criterion applies only to piping that is **not** integral to a unit (i.e., not factory-furnished). Specific systems excluded from this course that must follow alternate regulations include:

- **Plumbing:** Governed by TM 5-810-5.
- **Potable Water:** Governed by TI 814-03.
- **Sewage:** Governed by TI 814-10.
- **Other Exclusions:** Storm drainage, fuel supply, and lubricant supply piping.

References

Required and related references for these design standards are listed in detail in Appendix A.

Design Scope and Fundamental Principles

This course includes criteria for the design of component parts and assemblies of liquid process piping systems.

- **Compliance:** Compliance requires that fundamental design principles be followed.
- **Materials:** Materials and practices not prohibited by this course or its basic references should also be considered.
- **Industry Standards:** Where special conditions are not specifically addressed, follow acceptable industry standards.
- **Modifications:** Modifications or additions to existing systems solely for the purpose of meeting criteria in this course are not authorized.

Cathodic Protection

⚠️ **Safety Constraint:** All underground ferrous piping should be cathodically protected. For additional guidance, refer to TM 5-811-7 (Army) and MIL-HDBK-1004/10 (Air Force).

Metrics and Measurement Systems

Both the International System of Units (SI) and the Inch-Pound (IP) ("English") system of measurement are used in this course.

- **Standard Dimensions:** Pipe and appurtenances are provided in standard dimensions, either in **ISO** sizes (SI-based) or ANSI sizes (IP-based).
- **Comparison:** Table 1-1 compares these systems. Standard sizes under the two systems are close, but not equivalent.

Brand Names

The citation of brand names of commercially available products does not constitute official endorsement or approval.

Table 1-1: Standard Pipe Dimensions

Table 1-1 Standard Pipe Dimensions					
ANSI		ISO			
Nominal Pipe Size (in)	Actual D_o (in)	Nominal Pipe Size (mm)	Nominal Pipe Size (in)	Actual D_o (mm)	Actual D_o (in)
⅛	0.405	6	(0.236)	10	(0.394)
¼	0.540	8	(0.315)	12	(0.472)
⅜	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					

Course Organization

The course progresses from general design and engineering calculations (Modules 2-3) to specific material requirements and equipment (subsequent modules).

Fluid/Material Matrix

Appendix B contains a matrix comparing pipeline material suitability for various process applications based on temperature, pressure, and carrier fluid.

Checkpoint Quiz

1. **Which of the following piping systems is covered by the criteria in this course?**
   a) Potable water piping
   b) Sewage piping
   c) Piping between a storage tank and a treatment unit
   d) Fuel and lubricant supply piping

Answer (c). Section 1-2 defines liquid process piping as systems conveying liquids to, from, and between pumping, storage, and treatment units. Potable water, sewage, and fuel systems are explicitly excluded and covered by other specific regulations.

2. **True or False: All underground ferrous piping must be cathodically protected.**
   a) True
   b) False

Answer (a). Section 1-5a mandates that all underground ferrous piping will be cathodically protected to mitigate corrosion risks and ensure system longevity.

3. **When an industry has committed to a "hard" metric product, what is the design requirement for USACE projects?**
   a) Use IP products with a soft conversion
   b) Use the hard metric product
   c) Use whichever is more cost-effective
   d) Revert to ANSI standards

Answer (b). Section 1-6a states that USACE must specify and use "hard" metric products when the industry has committed to them, in accordance with ER 1110-1-4, to ensure alignment with construction industry standards.

Module 2: Design Strategy

Learning Objectives

By the end of this section, you will be able to:

- **Evaluate** the components of a comprehensive design analysis, including engineering calculations and system descriptions.
- **Distinguish** between Process Flow Diagrams (PFDs) and Piping and Instrumentation Diagrams (P&IDs) in terms of content and application.
- **Calculate** environmental loading conditions, including wind, snow, ice, and earth loads, for piping systems.
- **Analyze** piping layouts to ensure efficiency, accessibility, and compliance with pump and valve installation standards.

Executive Summary: Effective piping design requires a systematic strategy that moves from schematic system descriptions to detailed physical layouts. Engineers must integrate rigorous calculations for sustained and occasional loads (wind, seismic, etc.) with practical layout considerations like pump efficiency and valve accessibility.

Design Analyses

The design analysis serves as the documented proof of the piping system's integrity. It incorporates applicable codes, standards, and environmental constraints.

Calculations

Engineering calculations are the backbone of the design. They define:

- Process flow rates
- System pressure and temperature
- Pipe wall thickness
- Stress and pipe support requirements

🧮 **Calculation Note:** Computations must be clear and include all assumptions, data sources, and references (manuals, handbooks, etc.). While computer-aided programs are useful, they do not replace the engineer’s fundamental understanding of the design process.

System Descriptions

System descriptions outline the function and features of each major system. They provide the necessary baseline to develop PFDs and P&IDs.

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