

Overview of the Design, Construction, and Operation of Interstate Liquid Petroleum Pipelines

Environmental Science Division

About Argonne National Laboratory

Argonne is a U.S. Department of Energy laboratory managed by UChicago Argonne, LLC under contract DE-AC02-06CH11357. The Laboratory's main facility is outside Chicago, at 9700 South Cass Avenue, Argonne, Illinois 60439. For information about Argonne, see www.anl.gov.

Availability of This Report

This report is available, at no cost, at <http://www.osti.gov/bridge>. It is also available on paper to the U.S. Department of Energy and its contractors, for a processing fee, from:

U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
phone (865) 576-8401
fax (865) 576-5728
reports@adonis.osti.gov

Disclaimer

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor UChicago Argonne, LLC, nor any of their employees or officers, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of document authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof, Argonne National Laboratory, or UChicago Argonne, LLC.

Overview of the Design, Construction, and Operation of Interstate Liquid Petroleum Pipelines

by

T.C. Pharris¹ and R.L. Kolpa²

¹Decision and Information Sciences Division

²Environmental Science Division

Argonne National Laboratory

November 2007

CONTENTS

NOTATION	vii
1 INTRODUCTION	1
1.1 U.S. Pipeline Network	1
1.2 Fluids Handled	2
1.3 Types of Line Pipe	4
1.4 System Components.....	5
1.4.1 Tankage.....	5
1.4.2 Piping Types	6
1.4.3 Pumping Stations	8
1.4.4 Metering Stations.....	8
1.4.5 Valve Manifolds.....	8
1.4.6 Piping Manifolds.....	8
1.4.7 Pigging Stations	9
1.4.8 Supervisory Control and Data Acquisition Systems.....	9
1.4.9 Telecommunication Towers.....	9
1.4.10 Mass Flow Meters.....	10
1.4.11 Valves	10
1.4.12 Corrosion Control Systems	10
2 PIPELINE DESIGN	13
2.1 Factors Influencing Pipeline Design.....	13
2.1.1 General Pipeline Design Considerations	13
2.1.2 Safety	13
2.1.3 Industry Codes and Standards.....	14
2.1.4 Pipeline Coating.....	17
2.1.5 Sizing	19
2.1.6 Pressure.....	19
2.1.7 Product Qualities.....	20
2.1.8 Other Design Considerations	24
2.1.9 Leak Detection	29
2.1.10 Overpressure Protection.....	31
2.1.11 Valve Spacing and Rapid Shutdown.....	31
2.1.12 Pumps and Pumping Stations.....	32
2.1.13 Pigging Devices and Pig Launching/Receiving Facilities	34
2.1.14 Distribution Terminals	34
2.1.15 Measurement and Flow Control.....	34
2.1.16 Risk of Natural Hazards and Human Threats	38
2.2 Colocation Issues in Corridors.....	38
2.2.1 Fire Hazards	39
2.2.2 Coincident Construction	39
2.2.3 Electrical Interference.....	39

CONTENTS (Cont.)

3	PIPELINE CONSTRUCTION	45
3.1	Scheduling.....	46
3.2	Preconstruction Activities.....	46
3.2.1	Survey and Mapping.....	46
3.2.2	Staging Areas.....	48
3.2.3	Soil and Geology Studies.....	48
3.3	Construction.....	48
3.3.1	Movement and Staging of Pipeline Components and Construction Equipment.....	51
3.3.2	Clearing and Grading.....	51
3.3.3	Stringing Pipe Joints along the ROW.....	53
3.3.4	Ditching.....	55
3.3.5	Pipe Bedding Material	56
3.3.6	Welding.....	57
3.3.7	Pipe Bending.....	60
3.3.8	Pipe Coating.....	60
3.3.9	Lowering the Pipeline into the Ditch.....	61
3.3.10	Backfilling the Ditch.....	61
3.3.11	Hydrostatic Testing.....	62
3.3.12	Final Grading and Reclamation	64
3.3.13	Special Conditions	65
4	PIPELINE OPERATIONS	79
4.1	Inspections and Markers	79
4.1.1	Inspections during Excavation.....	79
4.1.2	ROW Inspections.....	79
4.1.3	Pipeline Markers and Aboveground Facilities.....	80
4.1.4	Change in Operating Rate.....	80
4.2	Pipeline Repairs	80
4.2.1	Moving and Lowering Hazardous Liquid Pipelines	81
4.2.2	Remedial Action for Corrosion Deficiencies.....	81
4.3	Pigging Activities.....	81
4.4	Chemical Additives.....	82
4.5	Pipeline Security	82
4.6	Waste Management.....	82
4.7	Cathodic Corrosion Protection.....	83
4.8	Leak Detection.....	84
4.9	Integrity Assesments.....	85
4.9.1	Metal-Loss Tools	86
4.9.2	Crack-Detection Tools.....	86
4.9.3	Geometry Tools	86

CONTENTS (Cont.)

4.9.4	Mapping Tools	87
4.10	Pipeline Repair Techniques	87
5	Decommission and Demolition	89
6	Emergencies and Off-Normal Events	91
7	References.....	93

FIGURES

2.1-1	Coating Newly Installed Pipe for Corrosion Control	18
2.1-2	Examples of the Types of Pigs in Use Today	35
2.1-3	Pig Launcher/Receiver.....	36
3.3-1	Typical ROW with Topsoil Segregation.....	49
3.3-2	Typical ROW with Adjacent Pipeline	50
3.3-3	Typical ROW Maintenance in Forested Areas	51
3.3-4	Pipe Segments Arriving at Rail Off-loading Area.....	52
3.3-5	Pipe Segments in a Material Laydown Area.....	52
3.3-6	Sample Road Entrance to a Pipeline ROW.....	54
3.3-7	Stringing Pipe along the ROW	54
3.3-8	Delivering Pipe Segments to the Construction Site in Rugged Terrain May Require Special Equipment	55
3.3-9	Pipeline Ditching	56
3.3-10	Welding Pipe.....	58
3.3-11	Pipe Bending Machine	60
3.3-12	Applying Coating to Pipeline.....	61
3.3-13	Lowering Pipe into Trench	62
3.3-14	Backfilling Pipeline	63
3.3-15	Final Contouring of Pipeline ROW	64

FIGURES (Cont.)

3.3-16	Revegetated Pipeline ROW	65
3.3-17	Trenched Road Crossing.....	66
3.3-18	Bored Road/Railroad Crossing	67
3.3-19	Typical Waterbody Crossing	68
3.3-20	Dam-and-Pump River Crossing with Two Pipelines.....	69
3.3-21	Flume Water Crossing with Two Pipelines	70
3.3-22	Typical Directional Drilling under Waterway	71
3.3-23	Waterbody Crossing Containing a Second Pipeline	72
3.3-24	Saturated Wetland Crossing.....	73
3.3-25	Concrete-Coated Pipe in a Wetland.....	75
3.3-26	Crude Oil Pipeline Pump Station.....	78
3.3-27	Typical Pipeline Breakout Station at a Petroleum Terminal	78

TABLES

1.2-1	Characteristics of Liquid Hydrocarbons	3
2.1-1	Live Loads	26
2.1-2	Impact Factors for Highways and Railroads Versus Depth of Cover.....	26
2.1-3	Degree of Component Vulnerability to Damage or Disruption from Natural Hazards and Human Threats	40

NOTATION

The following is a list of the acronyms, initialisms, and abbreviations (including units of measure) used in this document. Acronyms and abbreviations used only in tables and figures are defined in the respective tables and figures.

ACRONYMS, INITIALISMS, AND ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
AC	alternating current
ACEC	areas of critical environmental concern
ALA	American Lifelines Alliance
ANSI	American National Standards Institute
AOPL	Association of Oil Pipe Lines
API	American Petroleum Institute
AREA	American Railway Engineering Association
AREMA	American Railway Engineering Maintenance-of-Way Association
ASCF	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWS	American Welding Society
BTEX	benzene, toluene, ethylbenzene, and xylene
CDPD	Cellular Digital Packet Data
CFR	<i>Code of Federal Regulations</i>
CPS	cathodic protection system
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EIA	Energy Information Administration (DOE)
EPA	U.S. Environmental Protection Agency
FEMA	Federal Energy Management Agency
FERC	Federal Energy Regulatory Commission
GPS	global positioning system
HDD	horizontal directional drilling
IAPMO	International Association of Plumbing and Mechanical Officials
IEEE	Institute of Electrical and Electronic Engineers, Inc.

LNG	liquefied natural gas
LPG	liquefied petroleum gas
MAOP	maximum allowable operating pressure
MFL	magnetic flux leakage
MOP	maximum operating pressure
MTU	master terminal unit
NACE	National Association of Corrosion Engineers
NDT	nondestructive testing
NORM	naturally occurring radioactive materials
OPS	Office of Pipeline Safety (DOT)
OSHA	Occupational Safety and Health Administration
RCRA	Resource Conservation and Recovery Act
ROW(s)	right(s)-of-way
RP	Recommended Practice
RTU	remote thermal unit
SCADA	supervisory control and data acquisition
TAPS	Trans-Alaska Pipeline System
UHF	ultrahigh frequency
VHF	very high frequency

UNITS OF MEASURE

cSt	centistoke
°F	degree(s) Fahrenheit
lb	pound(s)
ppm	part(s) per million
psi	pound(s) per square inch
psia	pound(s) per square inch absolute
psig	pound(s) per square inch gauge