Appendix A

TYPICAL OPERATING POLICIES AND PROCEDURES
(ref Chap 2, Sec. 2.5.2.1. and 2.5.3.2)

PROCEDURES FOR MANAGEMENT OF DOCUMENTATION

Document Management Manual
Document New, Merge and Revision Process
Operating Policies and Procedures Management System Guiding Principles and Policies
Procedure Template
Procedure Template Directions

GENERAL PROCEDURES

Assembling a Flanged Connection
Canadian Electrical Work Procedures
Communication Procedures
Compressed Gas Cylinders and Compressed Air
Contractor Employee Control Procedure
Crane and Rigging Use
Electric Motor Bearing Lubrication Guidelines
Field Planned Inspection Procedure
Fitness to Work
Flange Bolt Tightening
Guidelines for Venting of Sweet Natural Gas
High-Pressure Quick-Opening Closures Procedure
Hoisting, Lifting, Towing and Winching
Hydrates in Pipelines
Long-Term Standby Procedure
Machine Guarding Safety
Magnetic Particle Inspection Procedure
Motor Vehicle Operation
Natural Gas Flexible Hose Procedure
Natural Gas Leak Detection Procedure
One Call Procedure
Operation of Heavy Equipment
Operations Center Evacuation Procedure
Owner/User Inspection Program for Inspection and Maintenance of Pressure Equipment Including Repairs and Alterations
Pipeline Operation & Maintenance—A Practical Approach

Physical Security and Incident Reporting
Pile Driving Procedure
Portable Gas Detection of Atmosphere
Pre-job Procedure
Region Site Orientation Procedure
Release Response
Roadside Temporary Work Area Controls
Site-Specific Instructions Procedure
Unibolt Assembly and Connection
Use of Power and Hand Tools
Valve and Valve Operator Commissioning Procedure
Valve Operator Information
Valve Sealant and Sealant Guns Procedure
Vendor Service Bulletins—Document Management Process
Welder Qualification Procedure
Work Platforms, Scaffolds and Portable Ladders
Working Alone

HEALTH, SAFETY AND ENVIRONMENT

Asbestos Exposure Control
Checking for PCBs
Confined Space Entry
Construction Site Safety Inspection Procedure
Contaminant Identification and Management
Contractor’s Health and Safety Requirements
Dangerous Goods Guide for Welding Gases (Special Provision 42)
Dangerous Goods Guide to Shipping Small Quantities (Limited Quantities Exemption)
Disability Management
Disposal of PCBs
Documentation for Transporting Wastes, Hazardous Materials and Dangerous Goods
Emergency Management System Manual
Emergency Response during Natural Disasters
Employee/Visitor/Contractor/Health, Safety and Environment Orientation
Environmental Noise Complaint
Environmental Sampling and Testing
Ergonomic Hazard Control
Fall Protection
Fire and Safety System Protection Impairment Procedure
First Aid Injury/Illness Record
Hazard Advisories
Health, Safety and Environment Committee Roles and Responsibilities
Heat Stress Control
Hydrogen Sulfide (H2S) Exposure Control
Incident Management Process
Incident Reporting and Management
Integrated Public Awareness Program
Job Safety Analysis
Lockout/Tag-out Procedure
Manual Material Handling
Mercury Exposure Control
Nitrogen Foam Fire Fighting Troubleshooting Procedure
Occupational Exposure Limits Table
Occupational Injury and Illness Response
Occupational Noise Control
Overhead Powerlines Procedure
Personal Protective Equipment
Product/Chemical Approval and Handling Procedure
Safe Work Permits Procedure
Safety, Health and Environmental Policy
Screening/Investigation
System Emergency Response Procedure

PIPEDLINE

Aerial Pipeline Patrol
Brush Control Procedure
Discontinuation or Abandonment of Pipelines Procedure
Emergency Pipe Inventory
Excavation Procedure
Hydrostatic Failure Procedure
Inline Inspection (ILI) Procedure
Installation of Type A Reinforcement Steel Repair Sleeves
Installation of Type B Pressure Containing Steel Sleeves on Leaking Defects
Liquid Pipeline Isolation Procedure
Maximum Pressure for Exposing or Working on a Pipeline Containing Defects
Mueller Tee Retirement
Natural Gas Pipeline Isolation Procedure
Pentane Isolation, Handling and Storage Procedure
Pipeline Crossing and Encroachment Procedure
Pipeline Defect Assessment and Repair
Pipeline Defect Repair—Clock Springs Procedure
Pipeline Entry Procedure
Pipeline Hot Tap Procedure
Pipeline Liquids/Solids Sampling, Handling and Disposal
Pipeline Locating and Marking
Pipeline Operations (Gas Handling)
Pipeline Right-of-way
Piping Identification
Pressure Control of Leaking Pipelines
Railway Crossing With Heavy Equipment
Report Gas Used for Pipelines Procedure
Rodent Infestation and Hantavirus Exposure Control
Signage Procedure
COMPRESSION OR PUMPING STATION

Building Entry Procedure
Comp Station Limits and Settings
Compressor Limits (specific for each type)
Facility Isolation Procedure (possibly specific to each station)
Facility Safety System Bypass Procedure
Gas Turbine High Oil Consumption Procedure
Gas Turbine Installation Differences (specific for each type)
Gas Turbine Limits (specific for each type)
Gas Turbine Transportation Procedure (specific for each type)
Gas Turbine High Vibration Shutdown/Alarm
Guidelines for Engineering Staff Working at Unattended Compressor Stations
Guidelines for PLC Software Management
Ice Detection/Anti-ice System Operating Procedure
Lubricating Oil
PLC Software Control Procedure
Portable Transfer Compressor Tie-in Piping Pressurization and Leak Test Procedure
Remote Station Sequence Logic, Status and Alarm Management Procedure
Station Boiler and Heater Lighting Procedure

MEASUREMENT

Dew Point Chart Drawing
Flexible Hose Usage for Natural Gas Pressure Measuring Equipment
Flow Verification Procedure
Gas Flow Measurement Procedures
Gas Measurement Quality Assurance System Manual
Gas Quality Monitoring Procedure
Gas Quality Procedure Manual
Guidelines for Engineering and Technical Services Staff Working at Unattended Meter Stations
H2S Analyzer Commissioning Procedure (for each model)
H2S Contamination Procedure
Meter Station General Procedures
Meter Station Support Systems Procedure
The following troubleshooting information is presented in the form of a standard troubleshooting chart and has to be taken just as a typical example. Always consult the troubleshooting charts provided by most manufacturers.

There are three aspects to troubleshooting: The symptom describes what an operator might notice or detect during the operation of the engine. The probable cause lists the likely reasons for the symptom. The remedy makes recommendations on how the problem may be resolved.

TROUBLESHOOTING—STARTING

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Probable Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotor fails to rotate</td>
<td>Permissives not cleared</td>
<td>Address and clear permissives</td>
</tr>
<tr>
<td>Correct gas or hydraulic pressure not present</td>
<td>Check to ensure sufficient gas or hydraulic pressure</td>
<td></td>
</tr>
<tr>
<td>Starter motor inoperative</td>
<td>Repair or replace starter motor</td>
<td></td>
</tr>
<tr>
<td>Starter clutch not engaging</td>
<td>Repair starter clutch</td>
<td></td>
</tr>
<tr>
<td>Rotor is seized</td>
<td>If previous shutdown was recent and from full power, wait for several hours</td>
<td></td>
</tr>
<tr>
<td>Major internal problem</td>
<td>Contact manufacturer</td>
<td></td>
</tr>
<tr>
<td>Rotor rotates but fails to light off</td>
<td>Igniters not functioning</td>
<td>Check ignition system as per maintenance manual</td>
</tr>
<tr>
<td>Gas or liquid manifold pressure is not correct</td>
<td>Check fuel system as per maintenance manual</td>
<td></td>
</tr>
<tr>
<td>Rotor speed is not sufficient</td>
<td>Check starter system</td>
<td></td>
</tr>
<tr>
<td>Engine lights off but fails to reach idle speed</td>
<td>Air intake is obstructed</td>
<td>Clear intake obstructions</td>
</tr>
<tr>
<td></td>
<td>Fuel pressure is not adequate</td>
<td>Check fuel system as per maintenance manual</td>
</tr>
<tr>
<td></td>
<td>Control system setting is not correct</td>
<td>Check control system as per maintenance manual</td>
</tr>
<tr>
<td>Lube oil pump fails to switch over from pre-lube to main pump</td>
<td>Main oil pump pressure is not high enough</td>
<td>Check main oil pump regulator and pump performance</td>
</tr>
<tr>
<td></td>
<td>Control system setting is not correct</td>
<td>Check control system as per maintenance manual</td>
</tr>
<tr>
<td></td>
<td>Check valve between oil lines not operating properly</td>
<td>Verify proper operation</td>
</tr>
<tr>
<td>Loud bang is heard on start-up</td>
<td>Bleed valves not operating properly</td>
<td>Check bleed valves as per maintenance manual</td>
</tr>
<tr>
<td></td>
<td>Inlet guide vane not operating properly</td>
<td>Check IGV system as per maintenance manual</td>
</tr>
<tr>
<td></td>
<td>Engine compressor is fouled</td>
<td>Clean engine compressor using offline water wash</td>
</tr>
</tbody>
</table>
## TROUBLESHOOTING—RUNNING

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Probable Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed is unstable</td>
<td>Fuel pressure is not correct</td>
<td>Check to ensure sufficient gas or hydraulic pressure</td>
</tr>
<tr>
<td></td>
<td>Control system setting is not correct</td>
<td>Check control system as per maintenance manual</td>
</tr>
<tr>
<td></td>
<td>Speed probe or indicator is faulty</td>
<td>Repair or replace speed probe or indicator</td>
</tr>
<tr>
<td>Maximum power is not obtained</td>
<td>Control system setting is not correct</td>
<td>Check control system as per maintenance manual</td>
</tr>
<tr>
<td></td>
<td>Engine compressor is fouled</td>
<td>Clean engine compressor using offline water wash</td>
</tr>
<tr>
<td></td>
<td>Long-term engine deterioration</td>
<td>Perform borescope and if necessary, schedule major overhaul</td>
</tr>
<tr>
<td>Exhaust gas temperature spread is too high</td>
<td>Fuel nozzle is eroded</td>
<td>Check fuel nozzles</td>
</tr>
<tr>
<td></td>
<td>Fuel nozzle is plugged</td>
<td>Check fuel nozzles</td>
</tr>
<tr>
<td></td>
<td>Instrumentation problem</td>
<td>Check thermocouples, harness and connections</td>
</tr>
<tr>
<td>Sudden decrease in vibration</td>
<td>Problem with vibration transducer or wiring</td>
<td>Check vibration transducer or wiring</td>
</tr>
<tr>
<td>Sudden increase in vibration</td>
<td>If only one reading affected, problem with vibration transducer or wiring</td>
<td>Check vibration transducer or wiring</td>
</tr>
<tr>
<td></td>
<td>If more than one reading affected, engine mountings are tight or seized</td>
<td>Check engine mountings</td>
</tr>
<tr>
<td></td>
<td>If more than one reading affected, major engine problem or internal failure</td>
<td>Check vibration as per maintenance manual</td>
</tr>
<tr>
<td>Slow increase in vibration</td>
<td>Long-term engine deterioration</td>
<td>Perform borescope and if necessary, schedule major overhaul</td>
</tr>
<tr>
<td>Symptom</td>
<td>Probable Cause</td>
<td>Remedy</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-----------------------------------------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>Fuel pressure low</td>
<td>Fuel system leaks</td>
<td>Check for fuel system leaks</td>
</tr>
<tr>
<td></td>
<td>Fuel filter blocked</td>
<td>Check fuel filter</td>
</tr>
<tr>
<td>Vibration high</td>
<td>Problem with vibration transducer or wiring</td>
<td>Check vibration transducer or wiring</td>
</tr>
<tr>
<td></td>
<td>Alarm and shutdown levels not correct</td>
<td>Reset alarm and shutdown levels</td>
</tr>
<tr>
<td></td>
<td>Engine mounts too tight or seized</td>
<td>Check engine mountings</td>
</tr>
<tr>
<td></td>
<td>Major engine problem or internal failure</td>
<td>Perform borescope and if necessary, schedule repair</td>
</tr>
<tr>
<td>Loss of speed signal</td>
<td>Speed probe has failed</td>
<td>Check and replace speed probe</td>
</tr>
<tr>
<td></td>
<td>Problem with wiring and instrumentation</td>
<td>Check wiring and instrumentation</td>
</tr>
<tr>
<td>Lube oil supply pressure low</td>
<td>Tank level too low</td>
<td>Refill oil tank</td>
</tr>
<tr>
<td></td>
<td>Lube oil pump not supplying correct pressure</td>
<td>Check and replace lube oil pump</td>
</tr>
<tr>
<td></td>
<td>Regulator not set correctly</td>
<td>Check setting for regulator</td>
</tr>
<tr>
<td>Oil tank temperature too high</td>
<td>Tank level too low</td>
<td>Refill oil tank</td>
</tr>
<tr>
<td></td>
<td>Oil cooler thermostatic valve not operating properly</td>
<td>Check and reset thermostatic valve</td>
</tr>
<tr>
<td></td>
<td>Oil cooler is plugged</td>
<td>Repair oil cooler</td>
</tr>
</tbody>
</table>
Appendix C

SOURCEs OF INFORMATION ON PIPELINES, PIPING AND PETROLEUM

This material was first researched by Barboza and Triplehorn (2001).

Permission granted to use material previously developed by Ms. Kenyon Barboza and Ms. Triplehorn is hereby acknowledged. The material has been updated to 2004. Codes, Regulations, Standards Updated 2010.

TABLE OF CONTENTS

I. Basic References
   A. Corrosion and Cracking
   B. Design, Construction and Operation
   C. Economics and Environment
   D. Fluid Dynamics and Hydraulics
   E. General
   F. Historical
   G. Pigging
   H. Safety
   I. Slurry Pipelines
   J. Underwater Pipelines
   K. Rotating Equipment—General
   L. Rotating Equipment—Pumps
   M. Rotating Equipment—Compressors
   N. Rotating Equipment—Condition Monitoring
   O. Rotating Equipment—Maintenance and Reliability

II. Bibliographies
III. Codes, Regulations and Standards
IV. Conference Proceedings
V. Database and Indexes
VI. Dictionaries and Encyclopedias
VII. Directories
VIII. Handbooks and Manuals
IX. Journals
X. Maps
XI. Organizations
XII. Web Resources
I. Basic References

A. Corrosion and Cracking

(see also Handbooks and Manuals)


B. Design, Construction and Operation


C. Economics and Environment

(see also Bibliographies)

Appendix C


D. Fluid Dynamics and Hydraulics


E. General


Pipeline Industries Guild (Great Britain), 1994. Pipelines: All You Wanted to Know ... But Were Afraid to Ask, Pipeline Industries Guild, London, UK.


F. Historical


G. Pigging
(see also Conference Proceedings)


H. Safety


United States National Transportation Safety Board. Pipeline Accident Report, National Transportation Safety Board; Springfield, VA Irregular, Washington, D.C.


I. Slurry Pipelines

Faddick, R. R., 1979. The Environmental and Pollution Aspects of Coal Slurry Pipelines, Environmental Protection Agency, Office of Research and Development, Industrial Environmental Research Laboratory, Cincinnati, OH.


J. Underwater Pipelines
DeLaMare, R. F. 1985. Advances in Offshore Oil and Gas Pipeline Technology, Gulf Publishing, Houston, TX.

K. Rotating Equipment—General

L. Rotating Equipment—Pumps
Karassik, I. J., 1989. Centrifugal Pump Clinic, Marcel Dekker Inc.

M. Rotating Equipment—Compressors
Brown, R. Compressors: Selection and Sizing.
N. Rotating Equipment—Condition Monitoring


O. Rotating Equipment—Maintenance and Reliability

Modarres, M., 1993. What Every Engineer Should Know about Reliability and Risk Analysis, Marcel Dekker, New York, NY.

II. Bibliographies

American Society of Civil Engineers, 1989. List of Sources and Reference Material on Pipeline Design, American Society of Civil Engineers, New York, NY.


Buck, E. H. et al., 1978. Comprehensive Bibliography and Index of Environmental Information Along the Three Alternative Gas Pipeline Routes, Arctic Environmental Information and Data Center; Springfield, VA; Anchorage, AK.


Lai, N. W. et al., 1973. A Bibliography of Offshore Pipeline Literature, (NTIS Number: TAMU-SG-74-206), Department of Marine Resources Information, Center for Marine Resources, Texas A & M University College Station, TX.


III. Codes, Regulations and Standards
(see also Organizations)


American Petroleum Institute, 2008. Specification for Pipeline Valves (Gate, Plug and Check Valves), 23rd Ed., (API Spec 6D), American Petroleum Institute, Washington, D.C.


International Association of Plumbing and Mechanical Officials, 2009. *Uniform Plumbing Code*, International Association of Plumbing and Mechanical Officials, Walnut Creek, CA.


IV. Conference Proceedings


Proc., Int. Conf. on Offshore Mechanics and Arctic Engineering, 1982. Offshore Mechanics and Arctic Engineering Division, New York, NY. This conference is held annually.

Proc., Int. Conf. on Pipeline Protection, every 2 years. Mechanical Engineering Publications, Edmunds, London, UK.


Proc., Int. Deepwater Pipeline Technology Conf. and Exhibition, 1999. Clarion Technical Conferences, Houston, TX.

Proc., Int. Pigging Conf. and Exhibition, Annual. Clarion Technical Conferences and Scientific Surveys Ltd., Houston, TX.


Proc., Conf. on Pipelines in Adverse Environments II, 1983 Pickell, M. D., Pipeline Division, American Society of Civil Engineers, New York, NY.


V. Databases and Indexes

News from major worldwide publications on petroleum, petrochemical, natural gas and energy industries.

Available electronically.

Comprehensive coverage of literature pertaining to petroleum, petrochemical, natural gas and energy-related industries.


Available on CD-ROM, updated quarterly; available electronically.

Covers international English-language periodicals in the applied sciences and technology.


Worldwide multidisciplinary database from the Department of Energy and other agencies of basic, applied scientific and technology research on energy.


*Engineering Index, 1907* (updated monthly; superseded by annual volume). Engineering Information Inc., New York, NY; available electronically (see *Compendex*).


Worldwide literature in all aspects of fluid engineering.


Technical abstracts for U.S. government sponsored research, plus some summaries of state and local government agencies and some foreign government sponsored research.

*Petroleum Abstracts, 1961*. Petroleum Abstracts, University of Tulsa, Tulsa, OK: Petroleum Abstracts, University of Tulsa; available online (see Tulsa: *Petroleum Abstracts*).

Worldwide geotechnical literature for oil and gas exploration and production.


A unique partnership of journal publishers and the Department of Energy research community to provide the largest compendia of energy-related bibliographic citations available electronically.

Comprehensive database with abstracts on transportation topics from published articles, reports and research projects.


Worldwide geotechnical literature for oil and gas exploration and production.

**VI. Dictionaries and Encyclopedias**

*A Dictionary for the Petroleum Industry, 1991.* Petroleum Extension Service, University of Texas at Austin, Austin, TX.


**VII. Directories**

*Brown’s Directory of North American and International Gas Companies,* Annual. Edgell Communications, Dallas, TX.


*Pipeline Industry: Worldwide,* Annual. Midwest Register Inc., Tulsa, OK.

*Pipeline Personnel Directory,* Annual. Universal News Inc., Houston, TX.


**VIII. Handbooks and Manuals**


IX. Journals


X. Maps


*LPG/NGL Pipeline and Facilities Map of the United States and Canada, 1999.* Map: 48" X 70", PennWell Publishing Co., Tulsa, OK.


*Natural Gas Pipelines of Texas and Southeast New Mexico, 1997.* Map: 39" X 59", PennWell Publishing Co., Tulsa, OK.


*Offshore Gulf of Mexico Pipeline, 2000, Map: 76" X 45" PennWell Publishing Co., Tulsa, OK


The following are also available from PennWell Publishing Corp.

Refer to: http://store.yahoo.com/pennwell/dirmap.html

*Digital Pipeline Data*

*Iraq and Kuwait Energy Infrastructure Map*

*2002 IPE Africa Oil & Gas Map*

*Mexico Oil and Gas Energy Infrastructure Map*

*Oil & Gas Map of Southeast Asia*
XI. Organizations


American Society of Mechanical Engineers (ASME), Three Park Avenue, New York, NY 10016-5990; phone: 212-591-5267; fax: 212-591-7674; home page: http://www.asme.org.


American Welding Society (AWS), 550 NW LeJeune Road, Miami, FL 33126; phone: 800-443-9353 or 305-443-9353; home page: http://www.aws.org.


Gas Technology Institute (GTI), 1700 South Mount Prospect Road, Des Plaines, IL 60018-1804; phone: 847-768-0500; home page: http://www.gri.org.

Institute of Electrical and Electronics Engineers (IEEE), 1828 L Street, NW, Suite 1202, Washington, DC 20036-5104; phone: 202-785-0017; home page: http://www.ieee.org.

Instrument Society of America (ISA), 67 Alexander Drive, PO Box 12277, Research Triangle Park, NC 27709; phone: 919-549-8411; fax: 919-549-8288; home page: http://www.isa.org.


NACE International (NACE), PO Box 218340, Houston, TX 77218; phone: 713-492-0535; home page: http://nace.org.
XII. Web Resources

http://www.afms.org
Acadiana Flow Measurement Society

http://www.alyeska-pipe.com/
Aleyska Pipeline Service Co.; pipeline facts

http://www.apia.net.au/
Australian Pipeline Industry Association, Inc

http://www.aopl.org/accidents/markers.html
Association of Oil Pipelines

Bureau of Land Management, Interior Department

http://www.ceesi.com
Colorado Engineering Experiment Station

http://www.dresser-rand.com/e-tech/default.asp
Dresser-Rand Technical Papers

http://www.emersonprocess.com/daniel/
Emerson Process Management

http://www.osti.gov/energycitation/
Energy Citation Data Base
Pipeline Operation & Maintenance—A Practical Approach

http://www.eia.doe.gov/
**Energy Information Administration**, Energy Department

**Federal Energy Regulatory Commission**: Gas and Oil Pipelines

**Federal Register Environmental Documents**: Operation and Maintenance Procedures for Pipelines

http://www.flowcontrolnetwork.com  
Flow Control Network

http://www.flowresearch.com  
Flow and Measurement Articles

http://www.ftimeters.com  
FTI Flow Technology

http://www.fluidsealing.com  
Fluid Sealing Association

http://www.corrosioncost.com/infrastructure/gasliquid/  
Gas and Liquid Transmission Pipelines

http://www.gmrcc.org/gmrcc/index.html  
Gas Machinery Research Council

http://www.globalspec.com  
Global Spec—Standards

GE Reference Documents

http://www.gulfpub.com  
Gulf Publishing Company

http://www.pumps.org/  
Hydraulic Institute

http://www.iica.org.au  
Institute of Instrumentation and Control Australia

http://turbolab.tamu.edu  
International Pump Users Symposium and Turbomachinery Symposium

http://www.invensysenergy metering.com  
Invensys

http://www.maverickenergy.com  
Maverick Energy, Inc.

http://www.neb.gc.ca/  
National Energy Board of Canada
http://www.mcnallyinstitute.com/
McNally Institute—Pump and Seal Technical Information

http://www.saveballona.org/log.html
National Transportation and Safety

http://www.npc.org
National Petroleum Council, Advisory Committee to the Secretary of Energy.

http://www.npto.doe.gov/
National Petroleum Technology Office

http://www.naturalgasbrowser.com/
Natural Gas Browser, Research and Business Information Tool for the Natural Gas Transmission Industry

http://www.naturalgas.org/overview/overview.asp
Overview of Natural Gas

http://www.naturalgas.org/
Natural Gas Information and Educational Resources

http://www.ntsb.gov/
Office of Pipeline and Hazardous Materials, National Transportation Safety Board (NTSB)

http://www.oilandgasonline.com/content/homepage/default.asp?VNETCOOKIE=NO
Oil and Gas Online

http://ops.dot.gov
Office of Pipeline Safety, United States Department of Transportation

http://www.ptac.org/
Petroleum Technology Alliance Canada

http://www.findlinks.com/petrolinks.html
Petrolinks: sites of interest to the Petroleum Industry

http://www2.nrcan.gc.ca/mms/picon/main_e.asp
PICon

http://www.piggingassnppsa.com
Pigging Products and Services Association

http://www.pipeline101.com/
Pipeline 101: Source for Energy Pipeline Information

http://www.pipe-line.com
Pipe Line and Gas Industry

http://www.pipedir.com/default.cfm
Pipes and Pipelines International (UK)

http://www.pipemag.com
Pipes and Pipelines Magazine
REFERENCES


Triplehorn, J. H., 2001. Librarian, Keith B. Mather Library 2001 Geophysical Institute, International Arctic Research Center, Alaska Tel 907 747 7512
Appendix D

ACRONYMS, DEFINITIONS AND UNIT CONVERSIONS

ACRONYMS/ABBREVIATIONS

AC: Alternating current
A/D: Analog-to-digital
AFR: Air-fuel ratio
AGA: American Gas Association
API: American Petroleum Institute
APSC: Alyeska Pipeline Service Company
ASME: American Society of Mechanical Engineers
BBL: Barrel
BCF: Billion cubic feet
BCM: Billion cubic meter
BEP: Best efficiency point
BP: Base pressure
BPI: Base pressure index
BS: British Standard
BT: Base temperature
BV: Block valve
BVCS: Block valve communication system
BWR: Benedict-Webb-Rubin
Cc: Cubic centimeter
CCR: Central control room
CDM: Corrosion data management
CFR: Code of Federal Regulations
CMMS: Computerized maintenance management system
CMP: Comprehensive monitoring program
CP: Cathodic protection
CI: Compression ignition
CRO: Control room operator
LTSA: Long-term service agreement
LVB: Line volume balance
LVP: Low vapor pressure
M: Meter
MAOP: Maximum allowable operating pressure
MLU: Mainline unit
MMI: Man-machine interface
MNbbl: 1 million barrel
MOPICO: Motor pipeline compressor
MP: Milepost
MSCF: Thousand standard cubic feet (M represents 10³)
MSDS: Material safety data sheets
MSIMPP: Management system integrity monitoring program procedures
NEB: National Energy Board (Canada)
NGL: Natural gas liquids
Nox: Nitrogen Oxides
NPS: Nominal pipe size (measured, nominally, in inches)
NPSH: Net positive suction head
NPSHA: Net positive suction head available
NPSHR: Net positive suction head required
NSV: Net standard volume
OCC: Operations control center
OP: Operating procedure
OQ: Operator’s qualification
OSCP: Oil spill contingency plan
PCV: Pressure control valve
PD: Positive displacement
PJ: Petjoule = 1,015 Joules
PLC: Programmable logic controller
PLKP: Pipeline kilometer or milepost
PLMP: Pipeline milepost
PM: Preventive maintenance
PPE: Personal protective equipment
PS: Pump station
Psig/a: Pounds per square inch gauge/absolute
QA: Quality assurance
RAM: Random access memory
RCM: Reliability centered maintenance
ROGV: Remote-operated Gate Valve
ROM: Read-only Memory
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROW</td>
<td>Right-of-way</td>
</tr>
<tr>
<td>RTD</td>
<td>Resistive Temperature Device</td>
</tr>
<tr>
<td>RTM</td>
<td>Real-time measurement</td>
</tr>
<tr>
<td>RTU</td>
<td>Remote terminal unit</td>
</tr>
<tr>
<td>SCADA</td>
<td>Supervisory control and data acquisition</td>
</tr>
<tr>
<td>SCR</td>
<td>Silicon-controlled Rectifier</td>
</tr>
<tr>
<td>SDH</td>
<td>Synchronous digital hierarchy</td>
</tr>
<tr>
<td>SI</td>
<td>Spark ignition</td>
</tr>
<tr>
<td>SSDL</td>
<td>Station shutdown lockout</td>
</tr>
<tr>
<td>SSDR</td>
<td>Station shutdown restartable</td>
</tr>
<tr>
<td>T</td>
<td>Tonnes</td>
</tr>
<tr>
<td>TCF</td>
<td>Trillion cubic feet (1,012 cubic feet)</td>
</tr>
<tr>
<td>TSAT</td>
<td>Transformational satellite</td>
</tr>
<tr>
<td>TVB</td>
<td>Transient volume balance</td>
</tr>
<tr>
<td>UCP</td>
<td>Unit control panel</td>
</tr>
<tr>
<td>UHF</td>
<td>Ultra-high frequency</td>
</tr>
<tr>
<td>USL</td>
<td>Unit shutdown lockout</td>
</tr>
<tr>
<td>USR</td>
<td>Unit shutdown restartable</td>
</tr>
<tr>
<td>VFD</td>
<td>Variable frequency drive</td>
</tr>
<tr>
<td>VHF</td>
<td>Very high frequency</td>
</tr>
<tr>
<td>VPT</td>
<td>Volume pressure temperature</td>
</tr>
<tr>
<td>VVCP</td>
<td>Variable volume clearance pocket</td>
</tr>
<tr>
<td>VSAT</td>
<td>Very small aperture terminal satellite</td>
</tr>
<tr>
<td>VSV</td>
<td>Variable stator vanes</td>
</tr>
<tr>
<td>WAN</td>
<td>Wide area network</td>
</tr>
<tr>
<td>WO</td>
<td>Work order</td>
</tr>
<tr>
<td>Y or y</td>
<td>Year</td>
</tr>
</tbody>
</table>

**DEFINITIONS**

*Abandonment:* The process of abandoning a pipeline.

*Abandoned pipeline:* A pipeline that is physically separated from its source of supply and is no longer used.

*Access road:* A designated path leading to the pipeline or pipeline facilities.

*Active corrosion:* Continuing corrosion that, unless controlled, could result in a condition that is detrimental to safety.

*Actuator:* A device designed to open or close equipment or valve. Valve actuators on mainline transmission systems are primary operated by pushing a button at a control station.

*Alignment sheet:* A diagram, sketch or photograph showing the pipeline in perspective to the land.
Alternate current (AC): A current whose direction changes with time (e.g., commercial electricity used to run home appliances).

Ambient temperature: The temperature of the surrounding medium, usually ground or air

Anode: A positive electrode in an electrolytic system, such as applied in cathodic protection; the electrode at which oxidation or corrosion occurs.

API degrees: American Petroleum Institute—a measure of oil density.

Ball valve: A valve in which a pierced sphere rotates within the valve body to control the flow of fluids.

Batch: A quantity of petroleum product of like specifications moved through the pipeline as an identifiable, individual unit. A batch is measured in barrels.

Blasting: The act of using explosives to create a hole, trench pipeline ditch, etc.

Block valve: Valves are termed as emergency flow restrictive devices installed on mainlines and longer feeder laterals to isolate sections of pipe for ease in construction modifications or emergency shut-ins. They are complete shutoff valves (see Section 5).

Blowdown: A vertical outlet at the end of a section of pipeline designed to provide a means to depressurize the pipeline. The assembly includes vertical piping, a valve and an end closure. Blowdowns are normally adjacent to a block valve and are smaller in diameter than the pipeline.

Body bleed: A vent pipe that comes off of the body of the valve to depressurize the body itself (see Section Chapter 5).

Booster Station: A pump station used to increase the pressure of oil/products received through a main pipeline to pump it to the next station or terminal.

Breakout Tank: A tank used to relieve surges in a hazardous liquid pipeline system, or to receive and store hazardous liquid transported by a pipeline for re-injection and continued transportation by pipeline. (definition by D.O.T)

British thermal unit (BTU): The quantity of heat required to raise the temperature of one pound of water one degree Fahrenheit. It is used to express the heat content of petroleum products.

Bypass: A piping arrangement designed to route gas around instead of through a valve. Sometimes bypasses are installed around meter stations, compressors, check valves or other piping systems.

Casing: Larger pipe placed around carrier pipeline to help protect it. It is usually used under roads and railway crossings.

Cathode: A negative electrode in an electrolytic system.

Cathodic bond: A compensating bond attached between foreign pipelines or other metallic structures to reduce or eliminate stray current interference and whose failure would jeopardize protection of the structure.

Cathodic protection (CP): The use of direct current electricity from an external source to oppose the discharge of corrosion current from anodic areas.

Chainage: The measurement along a pipeline that shows the actual distance from either a reference point or the beginning of a pipeline.

Check valve: A valve that will allow gas to flow in only one direction. It closes if gas flow is reversed.

Cold cut: Cutting into a pipeline using a nonsparking device such as pipe cutters.

Combustion: The process of burning.

Common Carrier: Any transportation system available for use by the public for transporting oil. Almost all interstate pipelines are common carriers.

Condensate: A liquid mixture of pentane and heavier hydrocarbons that is recoverable from a gas well through a separation system.

Control Center: Pipeline systems are operated from highly computerized control centers which coordinate operations throughout the system - everything from rate of flow, to
pressure, to opening and closing valves. The control centers also monitor devices that can alert operators to abrupt changes in operating parameters, providing a detection mechanism for fast response to emergency conditions. Satellite and telecommunications links connect control centers with facilities along pipelines to assure rapid response and constant monitoring of pipeline conditions.

Corridor: A strip of land of variable width (1/2 to 3 km wide) that can accommodate one or more utilities

Crossover: A section of pipe connecting parallel pipelines or loops together so that the pipelines may operate as one. Crossovers are generally located at block valve sites.

Crude oil: A mixture of hydrocarbons that existed in the liquid phase in natural underground reservoirs and remains liquid at atmospheric pressure after passing through surface separating facilities.

Design life: The expected duration or useful life of a pipeline.

Destructive testing: Testing in which the part being tested is rendered unusable to prove the strength of the part being tested.

Direct current (DC): The opposite of AC; DC current stays constant over a period of time (e.g., a flashlight battery).

Direct/off-sales lateral: A pipeline that transports fluid to a large-volume customer such as a factory or power plant.

Discharge Pressure: Pressure of the fluid in the pipeline as it exits a pump/compressor station

Distribution line: A pipeline other than a gathering, lateral or transmission line.

Downstream: The direction to which the gas is flowing.

Electric flash welded pipe: Pipe having a longitudinal butt joint wherein coalescence is produced, simultaneously, over the entire area of abutting surfaces by the heat obtained from resistance to the flow of electric current between the two surfaces, and by the application of pressure after heating is substantially completed.

Electric fusion welded pipe: Pipe having a longitudinal butt joint wherein coalescence is produced in the performed tube by manual or automatic electric-arc welding. The weld may be single or double and may be made with or without the use of filler metal.

Electric resistance welded pipe (ERW): Pipe that has a longitudinal butt joint wherein coalescence is produced by the application of pressure and by the heat obtained from the resistance of the pipe to the flow of an electric current in a circuit of which the pipe is a part. It is produced in individual lengths, or in continuous lengths from coiled skelp, and subsequently cut into individual lengths.

Emergency response: An act of responding to emergency situations such as flooding, earthquake, fire, explosion etc.

Encroachment: Encroachment is to intrude on the owner’s right-of-way (ROW).

EPC: Engineering, procurement (purchasing) and construction.

Expel: Expelling displaces residual gas in the pipeline by drawing in fresh air.

Expeller: A device used to expel residual gas from pipeline after blowdown.

Exposed pipeline: A pipeline where the top of the pipe is protruding aboveground.

Explosive: Chemical material that can undergo a sudden and violent release of pressure and heat.

Fault (geologic): Break in the earth’s crust along which parallel slippage of adjacent material has occurred at some point in the past.

FERC: Federal Energy Regulatory Commission of the United States Department of Energy, or the agency succeeding to its regulatory functions.

Flammable: A substance that will burn readily or quickly.

Foreign crossing: When a person, group or company crosses or enters the pipeline owner’s right-of-way (ROW).
**Fusion:** A process of joining through the application of heat.

**Gas:** Natural gas, flammable gas or gas that is toxic or corrosive.

**Gate valve:** A full opening and closing valve depending upon deformation of mating surfaces for control (see Section Chapter 5).

**Gathering line:** A pipeline that transports gas from a current production facility to a transmission line or main.

**Globe valve:** A valve equipped with an orifice and a stem attached to a plug and matching circular seat. Shut-off is obtained by direct contact of the plug and the seat. Body of valve is normally spherical (see Section Chapter 5).

**Ground profile:** The vertical elevations plotted along the alignment of the pipeline centerline.

**Ground temperature:** The temperature of the earth at pipe depth.

**Half-cell (reference electrode):** A device used to measure the voltage potential at the junction of the metallic surface and the electrolyte (pipe surface to soil) with respect to that of the junction of the copper and the copper sulphate in the half-cell.

**Heating value:** The amount of heat obtained by the complete combustion of a unit quantity of a material.

**Holiday:** A discontinuity or break in the anti-corrosion coating protection on pipe or tubing that leaves the bare metal exposed to corrosive processes. It is an imperfection or bare spot in a coating of pipe that exposes the metal to corrosive processes.

**Hoop stress (Barlow’s formula):** The stress in a pipe wall acting circumferentially in a plane perpendicular to the longitudinal axis of the pipe and produced by the pressure of the fluid in the pipe.

Hoop stress calculation:

\[ S = \frac{PD}{2t} \]

- \( S \) = hoop stress (in psi)
- \( P \) = internal pressure
- \( D \) = outside diameter of the pipe (in inches)
- \( t \) = normal wall thickness (in inches)

**Hot cut:** Cutting into a pipeline with a flame while the line contains natural gas.

**Hot tap:** The process of making branch piping connections to operating pipelines, mains or other facilities while in operation. The connection of the branch piping to the operating line and the tapping of the operating line is done while it is under fluid pressure.

**Hot Zone:** Area where hazardous vapors and liquids are present. Working in a hot zone requires a special permit and personal protective equipment.

**Ignition temperature:** The minimum temperature required to ignite gas or vapor without a spark or flame being present.

**In-line inspection:** An inspection of the inside of the pipeline using pigs mounted with appropriate instrumentation.

**Interface:** The mixture which occurs during normal pipeline operations between adjacent batches of petroleum products or crude having different specifications. Also called “slop” or “transmix.”

**Joint:** Connection between two lengths of pipe.

**Lateral:** A lateral is a branch line. It is a pipeline that branches away from the central part of the transmission system or from another lateral.

**LEL:** Lower explosive limit is read from the CGI; it is the minimum amount of airborne chemical that must be present in the air-chemical mixture to make it explosive.

**Line segment:** A continuous run of transmission line between adjacent stations, between a station and storage facilities, between a station and a block valve, or between adjacent block valves.
**Linefill (liquid lines):** The volume of oil/products, usually measured in barrels, in the pipeline from the origin to the terminus. Linefill can also refer to the volume of oil/products contained in a given segment of the pipeline.

**Liquefied natural gas (LNG):** Gaseous at normal temperature and pressures, but held in the liquid state at very low temperatures to facilitate storage and transport.

**Liquefied petroleum gas (LPG):** A gas containing certain specific hydrocarbons that are gaseous under normal atmospheric conditions, but can be liquefied under moderate pressure at normal temperatures. Propane and butane are principal examples.

**LNG facility:** Any or all of the following when they are parts of a system to produce or transport LNG: the LNG liquefaction plant, gathering lines to that plant, loading and unloading facilities for LNG tankers, LNG tankers themselves and facilities to regasify the LNG.

**Local distribution company (LDC):** Purchases gas for resale.

**Looping:** A paralleling of an existing pipeline by another pipeline over the whole length or any part of it to increase capacity and efficiency.

**Low pressure distribution system:** A distribution system in which the gas pressure in the main is substantially the same as the pressure provided to the customer. This is restricted to residential and small commercial service only.

**Mainline:** A major transmission pipeline fed by smaller laterals. Mainlines all run to sales stations or border crossings.

**Manifold:** An arrangement of connected piping and valves used to provide links between a number of pumps/compressors, tanks, and/or pipelines (as applicable).

**Manometer:** A tube in the shape of a U, partially filled with liquid of suitable density.

**Maximum allowable operating pressure (MAOP):** The maximum pressure at which a pipeline or segment of a pipeline may be operated under the code.

**Merchantman:** An organic chemical compound having a distinctive odor used for motorization of gas streams.

**Methane gas:** The lightest in the paraffin series of hydrocarbons. It is colorless, odorless and flammable; it forms the major portion of natural gas, CH4 (see table).

**Natural gas:** A mixture of methane, ethane and up to 3% carbon dioxide.

**NEB:** National Energy Board of Canada.

**Parallel or common corridor:** A corridor that follows and/or overlaps existing facilities

**Petroleum:** A naturally occurring hydrocarbon or mixture of hydrocarbons. As oil or gas or in solution, it is widespread in Australian sedimentary rocks but major concentrations are generally rare.

**Pig:** An internal tool propelled through the pipeline, usually by natural gas flow, to perform cleaning or inspection functions.

**Pig-trap/Scraper-trap:** An aboveground and slightly larger diameter extension of a pipeline designed to load and unload pigs from the pipeline system.

**Pipeline System:** All parts of the physical facilities through which fluid is transported, including line pipe, valves, pumping/compressor units, metering stations and tanks (as applicable).

**Pressure Relief Valve:** A valve designed to open automatically to relieve pressure and keep it below a specified level.

**Pressure Spike:** A sudden, brief rise in pressure.

**Pressure Surge:** A pressure spike produced by a sudden change in velocity of the moving fluid that results from shutting down a pump station or pumping unit, closure of a valve or any other blockage of the moving stream. The pressure surge moves through the pipeline at sonic velocity and stops and reverses direction when it hits a closure in the pipeline such as a closed valve. Similar pressure rise can also occur in gas pipelines.
**Products:** Refined hydrocarbons made from crude oil. Gasoline, fuel oil, jet fuel, diesel fuel are typical petroleum products that are transported in pipelines.

**Probe:** A long, slender device (usually a steel rod) used to investigate unknown areas and to find pipe below ground.

**Purge:** The action of displacing air in the pipeline with natural gas before putting the pipeline in service.

**Rectifier:** A device that converts alternating current to direct current used for external corrosion control.

**Remote Block Valve:** A block valve that can be remotely controlled, as in from a pipeline control center, for the primary purpose of directing pipeline flow and isolating the pipeline into segments in the event of a pipeline break.

**Route:** A strip of land of varying width (300 to 400 m) wide within a corridor and in which a ROW for a pipeline could be located.

**ROW:** The pipeline owner's right-of-way.

**RVP:** Reed vapor pressure, the vapor pressure of liquid measured at 38 °C in a chamber that was initially filled with air. The unit of measurement is normally psi.

**SCADA (Supervisory Control and Data Acquisition System):** A comprehensive electronic surveillance system used to monitor and control an entire pipeline system and its operations from a pipeline control center. Pipeline operating data is remotely collected from transmitting devices located along the pipeline system. The data typically includes the pressures, volume and flow rate of each pipeline, and the operating status of all pumping equipment and remotely operated valves on each pipeline. This data is sent to the control center’s SCADA system and is used by the pipeline controller for the proper operation and control of each pipeline.

**Schematic:** An outline, systematic arrangement, diagram, scheme or plan of a pipeline system.

**Side valve:** A valve designed to isolate one connecting pipeline from another.

**Smart Pig:** An electronic internal inspection device placed inside the pipeline to provide data about the condition of the pipeline, such as measuring dents or locating corrosion.

**Station Block Valve:** A gate valve installed at the inlet (suction) side and the outlet (discharge) side of the pump station to isolate the pump station from the pipeline in the event of an emergency.

**Suction Pressure:** The pressure of the fluid in the pipeline as it enters a pump/compressor station.

**Swamper:** The person responsible for guiding the equipment operator in work such as digging with a backhoe or lifting with a side boom.

**Tank Farm:** A pipeline facility that contains a group of tanks connected to a pipeline or pipelines through which oil is moved.

**Trunk Line:** A main pipeline.

**Unibolts:** Top fitting on blowdown.

**Upstream:** The direction from which the gas flow originates.

**Water conveyance facilities:** Ditches, canals, pipelines and other such means of moving water.

**Yield Strength:** The stress level above which the pipe will yield/bend/stretch. The yield strength of the steel is determined by testing during the manufacture of the pipe. Yield strength is a parameter used in determining a pipeline’s maximum allowable operating pressure.
<table>
<thead>
<tr>
<th>Customary Unit</th>
<th>Define Unit</th>
<th>Symbol</th>
<th>Multiply By</th>
</tr>
</thead>
<tbody>
<tr>
<td>barrel per hour</td>
<td>liters per second</td>
<td>L/s</td>
<td>0.044 163</td>
</tr>
<tr>
<td>barrel per day</td>
<td>cubic meters per day</td>
<td>m³/d</td>
<td>0.158 987</td>
</tr>
<tr>
<td>MMBOD</td>
<td>cubic meters per day</td>
<td>m³/d</td>
<td>0.158 987 x 10⁶</td>
</tr>
<tr>
<td>Btu/second</td>
<td>kilowatt</td>
<td>kW</td>
<td>1.055 056</td>
</tr>
<tr>
<td>Btu/hour</td>
<td>watt</td>
<td>W</td>
<td>0.293 071</td>
</tr>
<tr>
<td>Btu/lbₜ</td>
<td>kilojoule per kilogram</td>
<td>kJ/kg</td>
<td>2.326</td>
</tr>
<tr>
<td>Btu/lbₜ°F</td>
<td>kilojoule per kilogram-kelvin</td>
<td>kJ (kg.K)</td>
<td>4.1868</td>
</tr>
<tr>
<td>Btu/lbₜ·mole⁻¹·R</td>
<td>joule per mole-kelvin</td>
<td>J/(mol.K)</td>
<td>4.1868</td>
</tr>
<tr>
<td>Btu/R</td>
<td>kilojoule per kelvin</td>
<td>kJ/K</td>
<td>1.8991</td>
</tr>
<tr>
<td>Btu/ft²-hr.</td>
<td>joule per sq. meter-second</td>
<td>J/(m².s)</td>
<td>3.154 591</td>
</tr>
<tr>
<td>Btu/ft·hr°F</td>
<td>joule per meter-second-kelvin</td>
<td>J/(m².s.K)</td>
<td>1.730 735</td>
</tr>
<tr>
<td>Btu/ft²·hr°F</td>
<td>joule per square meter-second kelvin</td>
<td>J/(m².s.k)</td>
<td>5.678 263</td>
</tr>
<tr>
<td>foot-pound force (ft. lbf)</td>
<td>joule</td>
<td>J</td>
<td>1.355 818</td>
</tr>
<tr>
<td>foot²</td>
<td>square meter</td>
<td>m²</td>
<td>0.092 903</td>
</tr>
<tr>
<td>foot³</td>
<td>cubic meter</td>
<td>m³</td>
<td>0.028 316 85</td>
</tr>
<tr>
<td>foot³/minute</td>
<td>liter per second</td>
<td>L/s</td>
<td>0.471 947</td>
</tr>
<tr>
<td>foot³/hour</td>
<td>cubic meter per day</td>
<td>m³/d</td>
<td>0.679 604</td>
</tr>
<tr>
<td>MMSCFD</td>
<td>cubic meter per second</td>
<td>m³/s</td>
<td>0.327 774</td>
</tr>
<tr>
<td>gallon/minute (GPM)</td>
<td>liter per second</td>
<td>L/s</td>
<td>0.063 090</td>
</tr>
<tr>
<td>inch²</td>
<td>square centimeter</td>
<td>cm²</td>
<td>6.451 600</td>
</tr>
<tr>
<td>inch³</td>
<td>cubic centimeter</td>
<td>cm³</td>
<td>16.387 064</td>
</tr>
<tr>
<td>kilowatt-hour (kWh)</td>
<td>megajoule</td>
<td>MJ</td>
<td>3.6</td>
</tr>
<tr>
<td>mile per hour</td>
<td>kilometer per hour</td>
<td>km/h</td>
<td>1.609 344</td>
</tr>
<tr>
<td>pound</td>
<td>kilogram</td>
<td>kg</td>
<td>0.453 592 37</td>
</tr>
<tr>
<td>pound force/foot² (psf)</td>
<td>pascal</td>
<td>Pa</td>
<td>47.880 258</td>
</tr>
<tr>
<td>pound mass/foot³ (lbₗ,ft³)</td>
<td>kilogram per cubic meter</td>
<td>kg/m³</td>
<td>16.018 463</td>
</tr>
<tr>
<td>pound mass/gallon</td>
<td>kilogram per liter</td>
<td>kg/L</td>
<td>0.119 826</td>
</tr>
<tr>
<td>pound mass/hour</td>
<td>kilogram per hour</td>
<td>kg/h</td>
<td>0.453 592</td>
</tr>
<tr>
<td>psi</td>
<td>kilopascal</td>
<td>kPa</td>
<td>6.894 757</td>
</tr>
<tr>
<td>psi/foot</td>
<td>kilopascal per meter</td>
<td>kPa/m</td>
<td>22.620 59</td>
</tr>
<tr>
<td>psi/mile</td>
<td>pascal per meter</td>
<td>Pa/m</td>
<td>4.284 203</td>
</tr>
<tr>
<td>watt-hour</td>
<td>kilojoule</td>
<td>kJ</td>
<td>3.6</td>
</tr>
<tr>
<td>yard²</td>
<td>square meter</td>
<td>m²</td>
<td>0.836 127</td>
</tr>
<tr>
<td>yard³</td>
<td>cubic meter</td>
<td>m³</td>
<td>0.764 555</td>
</tr>
<tr>
<td>Customary Unit</td>
<td>To Define Unit 1</td>
<td>Symbol</td>
<td>Multiply By</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>----------------------</td>
<td>--------</td>
<td>-------------</td>
</tr>
<tr>
<td>acre</td>
<td>square meter</td>
<td>m²</td>
<td>4,046.856</td>
</tr>
<tr>
<td>atmosphere (std)</td>
<td>kilopascal</td>
<td>kPa</td>
<td>101.325</td>
</tr>
<tr>
<td>barrel (42 gal)</td>
<td>cubic meter</td>
<td>m³</td>
<td>0.158 987</td>
</tr>
<tr>
<td>Btu (International Table)</td>
<td>kilojoule</td>
<td>kJ</td>
<td>1.055 056</td>
</tr>
<tr>
<td>calorie (thermochemical)</td>
<td>joule</td>
<td>J</td>
<td>4.184</td>
</tr>
<tr>
<td>degree F</td>
<td>degree Celsius</td>
<td>°C</td>
<td>5/9 (°F-32)</td>
</tr>
<tr>
<td>degree R</td>
<td>degree kelvin</td>
<td>K</td>
<td>5/9</td>
</tr>
<tr>
<td>foot</td>
<td>meter</td>
<td>m</td>
<td>0.3048</td>
</tr>
<tr>
<td>gallon (U.S. liquid)</td>
<td>liter</td>
<td>L</td>
<td>3.785 412</td>
</tr>
<tr>
<td>horsepower (U.S.)</td>
<td>kilowatt</td>
<td>kW</td>
<td>0.7457</td>
</tr>
<tr>
<td>inch (U.S.)</td>
<td>millimeter</td>
<td>mm</td>
<td>25.4</td>
</tr>
<tr>
<td>inch of mercury (60°F)</td>
<td>kilopascal</td>
<td>kPa</td>
<td>3.376 85</td>
</tr>
<tr>
<td>inch of water (60°F)</td>
<td>kilopascal</td>
<td>kPa</td>
<td>0.248 843</td>
</tr>
<tr>
<td>mil</td>
<td>micrometer</td>
<td>µm</td>
<td>25.4</td>
</tr>
<tr>
<td>mile (U.S. statute)</td>
<td>kilometer</td>
<td>km</td>
<td>1.609 344</td>
</tr>
<tr>
<td>ounce (U.S. fluid)</td>
<td>milliliter</td>
<td>mL</td>
<td>29.573 53</td>
</tr>
<tr>
<td>poise</td>
<td>pascal-second</td>
<td>Pa.s</td>
<td>0.1</td>
</tr>
<tr>
<td>stokes</td>
<td>square centimeter per second</td>
<td>cm²/s</td>
<td>1</td>
</tr>
<tr>
<td>ton, long (2,240 lbm)</td>
<td>ton</td>
<td>t</td>
<td>1.016 047</td>
</tr>
<tr>
<td>ton, short (2,000 lbm)</td>
<td>ton</td>
<td>t</td>
<td>0.907 184 74</td>
</tr>
<tr>
<td>ton of refrigeration</td>
<td>kilowatt</td>
<td>kW</td>
<td>3.516 853</td>
</tr>
<tr>
<td>yard (U.S.)</td>
<td>meter</td>
<td>m</td>
<td>0.9144</td>
</tr>
</tbody>
</table>
# INDEX

A  
Abbreviations, acronyms and, 693–696
Absolute viscosity, 377
Access roads, 136
Accuracy, 339
Acoustic beam, 113, 355
Acronyms, abbreviations and, 693–696
for instrumentation diagrams, 417–418
for organizations and topics, 41
AGA-33 flange taps, 276–278
Air patrol, 151–152
Alarm display, SCADA, 599, 600
Alarm management, SCADA, 595–598
Alerts, 546
Apportionment/proration, 98
Arc air gouging, 267
Arc burns removal, 267
Armor Plate pipe wrap repair, 173
Asset management, 48–62
Audits, 393
Automated ultrasonic inspection, 248, 249
Automatic line-break controls, 312–313
Automation, degree of, 36
system, see System automation
Availability, 633

B  
Back-welding, 267
Ball valves, 298–302
modes of failure, 327–330
Balloon plugs, 198–199
Batch cycle, 87
Batch injection, transportation and delivery, 89–90
Batch interface marking and position, 88
Batch optimization, multiproduct pipeline, 114
Batch planning schedule, 99
Batch reporting, 90
Batch sequencing, 86–90
Batch sizing, 90, 114
Batch tracking, 607
Batched product operational hydraulics, 103
Bathing, 85–86
Batching travel time, 87
Benchmarking, 59–60
Bernoulli's theorem, 10
Bias, 339
Bibliographies, 680–681
Blasting, maintenance and, 148–151
Block valve arrangement, 185
Block valve assemblies, 313–315
Blowdown size, 187–189
Blowdown time calculation, 184
Blowing down pipeline segment, 183–185
Body bleeds, 185, 296, 697
Bonnet leak, 332
Boolean algebra, 638
Border crossing stations, 700
Branch connections, joining, 274
Buffers, 88
Building maintenance, 508
Buried explosives, 148
Cable crossings, 140
Calibration equipment, 390–391
Canal crossings, 140–141
Carbon dioxide, 379
Cartridge filter, 113
Cathodic protection, 201–208
Cathodic protection rectifiers, 204
Cathodic protection trending plot, 209
Central Gas Control, 74–79
Centralized measurement data systems
data gathering, 367–368
data storage and retrieval, 369
data validation, 368
measurement data, editing and interpreting, 369
report generation, 369
trouble ticket generation, 369
Centrifugal compressors control systems, 480–490
dry seals, 482–484
magnetic bearings, 482
maintenance, 534–537
of bearings and oil system, 536
of compressor internals, 534–536
of seals and sealing system, 536–537
monitoring, 562–563
oil bearings and lube oil system, 480–482
operation, 480–490
performance characteristics, 484–485
start-up and shutdown, 489–490
surge control, 487–489
Centrifugal pumps controls internals, 542
maintenance, 539–544
avoidance of cavitation, 540–541
of bearings and oil systems, 541
elimination of vibration, 540
major, 543–544
operation, 498–503
performance characteristics, 501–502
Chart recorder, 34, 73–74, 349, 614
Check measurement, 370
Check meters, 391–392
Check valves, 304
Chilled mirror apparatus, 385–386
City-gate metering stations, 651–652
Clapper valve, 304
Cleaning pigs, 155, 156
Clock Spring repair, 170–171
Close interval survey, 207
CMMS (computerized maintenance management system), 45, 55–57
Coating defects, 200–201
Coating materials, 200
Codes and regulations and standards, 675 and standards, 41–42
Cold bending, 143–145
Cold-springing, 145–147
Colonial Pipeline systems, 65, 83
Column separation, slack line and, 114–116
Commercial aspects for gas pipelines, 617–618
for oil pipelines, 619–620
Commercial value of hydrocarbon products, 371
Commodity release alarms, 318
Community requirements, 36–37
Composite reinforced line pipe (CRLP), 18
Compressibility, 374, 375
Compression and pumping, 28–30
historical development, 7–12
maintenance elements, 29–30
operational elements, 28–29
Compression or pumping station procedures, 670
Compressor configuration parallel, 406
series, 406
Compressor costs, 61
Compressor performance monitoring, 606
Compressor/pump unit valves, 294
Compressor rings, leaking, 562
Compressor selection, 402–403
Compressor station overview, 398
Compressor station systems, 410–421
control system architecture, 415–418
fuel gas and start gas system, 420–421
high-pressure gas system, 418–420
instrument air system, 421, 423
instrumentation, 423–425
power gas system, 421, 422
protective trips, 416–417
shutdown control, 422
station auxiliary control, 414–415
station control system, 421–423
station process control, 412
unit control system, 415–418
Compressor vibration and pulsation, 552–553
Computational pipeline monitoring (CPM), 317
Computerized maintenance management system (CMMS), 45, 55–57
Condition-based maintenance, 389–390
Conditions of use, 630
Conference proceedings, 682–683
Configuring station recycle valve size, 323–324
Contaminated tube bundle, 344
Contracting of maintenance, 57–58
Control system architecture, system automation and, 571–574
Control systems, distributed, 367
Controlled liquid nitrogen, 194–195
Conversion table for common units, 702–703
Coriolis force meters, 357–358
application notes, 358
implementation, 357–358
operating principle, 357
Corporate organizational structure, 40
Corrective maintenance, 51
Corrosion control, 199–208
coatings, 200–201
operational aspects cathodic protection systems, 207–208
Corrosion control maintenance corrosion control, 200–208
corrosion mechanism, 199–200
Cover, depth of, 136
CPM (computational pipeline monitoring), 317
Cricondentherm, 375
Critical flow nozzles application notes, 362
implementation, 362
operating principle, 361–362
CRLP (composite reinforced line pipe), 18
Crude oil, 22–23
CTOOL, 156, 157
Custody transfer, 339, 340
Custody transfer/meter station valves, 294–295
Customer interfaces, 370–371
Customers, 36–37
Customer signals
check measurement, 370
customer interfaces, 370–371
operational considerations, 371
operational data, 370
Cutout repair, 167, 168
Cyclone filter, 113

D
Data acquisition, 575–576
Data gathering, 367–368
Data management, historical, 592
Data storage and retrieval, 369
Database management services, 592
Databases and indexes, 683–685
Data validation, 368
Defect assessment, 163–164
Definitions, 696–701
Densitometer, 425
Dependability, 625
Depth of cover, 136
Dew point, hydrocarbon, 379
Diaphragm meters, 361
application notes, 361
implementation, 361
principle of operation, 361
Diaphragm-type pressure relief valve, 306
Dictionaries and encyclopedias, 685
Differential pressure transmitters, 364
Dig preparation, 136
Discharge coefficient, 346
Distributed control systems, 367
Direct liquid nitrogen, 195
Directories, 685
Documentation, procedures for management of, 667
Documentation management system, 45–46
Downgrade strategies, 389
Drag reducers, liquid pipeline, 117–124
Drain-up process, 191
Dressing repair, 166
Drivers and driven equipment used on pipelines, 399
Dust filtration, 113
Dye penetrant inspection, 253–254
Dynamic viscosity, 377

E
EAM (enterprise asset management), 55
EFRD (emergency flow restricting devices), 293
Electric motors, 357–358
control system, 479–480
design, 472–475
hermetic compressors, 476–479
maintenance, 533–534
monitoring, 563–564
operation, 472–475
variable frequency drive, 475–476
Electric valve operators, 311, 312
Electrolysis, 386
Electronic flow measurement (EFM), 349
Electronic pulse trains, 363
Emergency flow restricting devices (EFRD), 293
Encyclopedias and dictionaries, 685
Energy, 372
Enterprise asset management (EAM), 55
Environmental protection, maintenance and, 131–132
Epoxy composition filled sleeve repairs, 169–170
Equipment replacement, 60–62
Equipment verification and calibration, 390–391
Erosion, velocity limit based on, 109–111
Erosional gas flow rate, 110–111
Erosional velocity, 116
Expert advisory systems, 613–614
Explosives, buried, 148

**F**

Failure data for pipeline systems components, 644–645
Failure investigation, troubleshooting and, 565
Failure rate data, 633, 645
Fault tree analysis, 635–638
gas pipeline reliability using, 650–663
Fiber optic systems, SCADA, 584
Fiber reinforced polymeric composites, 18–19
Field bending, 144–145
Field leak detection, 80
Filters, 381, 388
Flash-point test apparatus, 325
Flow calibration laboratory, 391
Flow computers, 366–367, 580–581
Flow computers, RTUs, and PLCs, 367
Flow conditioning, 342
Flow measurements, 604
Flow-through orifice, 346
Fluid contaminants, 347
Fluid properties, 371–372
Fluid property measurement, see Hydrocarbon measurement
Fluid temperature measurement, 347
Flux-cored arc welding (FCAW), 211, 225
Foam pigs, 155, 156
Foreign crossings, 139–143
Formaldehyde, 380
Freeze plugs, 193–194
Freeze time calculations, 197
Fuel valve, leaking, 561
Full encirclement split sleeve repair, 166, 167
Full-stream injections, 89
Function, 630
Fungible batches, 86

**G**

Gas chromatography, 382
field considerations, 384
implementation, 383–384
principle of operation, 382
Gas, expelling, 186
Gas controllers, 74
Gas cooler maintenance, 509
Gas day operations, 615–616
Gas detection setup, 190
Gas metering piping arrangement, 113–114
Gas pipeline reliability using fault tree analysis and probability theory, 650–663
using reliability block diagram and Monte-Carlo simulation, 645–650
Gas pipeline segment replacement, 182–190
Gas pipeline transportation, 69–82
Central Gas Control, 74–79
compression control, 72
contracts and services, 69–70
data acquisition, 73–74
field work, 79
gas control, 70–71
leak detection, 79–82
operations, 70–79
pipeline control, 71–72
system control, 70–71
system maintenance, 81–82
Gas pipelines commercial aspects for, 617–618
real-time management of, 604–606
Gas processing plants, 387
Gas quality specifications, 2
Gas transmission and distribution system, 19–21
Gas turbines, 357
aeroderivative, lube oil system, 440–441
air intake system, 432–433
anti-icing systems, 434
bearings, 438–440
component refurbishment, 522–523
compressor surge, 433
countrol system, 435–437
correction factors, 557
design, 430–432
deterioration, 556
dual fuel systems, 445–446
emission control, 446–447
engine compressor cleaning, 511–516
exhaust system, 434–435
fuel gas system, 442–444
heavy-duty, lube oil system, 441–442
instrumentation, 437
intermediate maintenance, 516
liquid fuel system, 444–445
lube oil systems, 437–442
maintenance, 509–523
major maintenance or overhaul, 516–522
monitoring, 556–558
operation, 430–452
performance characteristics, 451, 452
routine maintenance, 516
sample baselines, 556, 557
shutdown, 451
start-up, 447–451
troubleshooting chart for, 671–673
variable compressor geometry, 433–434
Gate valves, 295–298
modes of failure, 330–333
Gel pigs, 157
Geographic considerations, 36
Geotechnical requirements, 320
Globe valves, 305
GMAW (gas metal arc welding), 211, 224, 256
Grinding repairs, 166
Ground-bed materials, 203
Grounds maintenance, 508
Hand-wheel valve operators, 308
Handbooks and manuals, 685–686
Hardware architecture, 571–572
Hazardous pipelines, lifting/lowering in, 141–143
Hazardous pipelines, lifting/lowering in, 141–143
Hazardous pipelines, lifting/lowering in, 141–143
Hazardous pipelines, lifting/lowering in, 141–143
Hazards, 46
Headers, 388
Heat capacity and isentropic exponent, 376
Health, Safety and Environment (HSE) group, 40, 46–47
Health procedures, 668–669
Hermetic compressors, 476–479
Hexa-methyl benzene, 392
High-strength low-alloy steels (HSLA), 18
Historical data management, 592
Hoop stress, 15, 699
Hot tap welding, 179
Hot tapping, 176–182
Hot tapping anomalies, 179
Hot tapping attributes, 176, 177
Hot tapping machine, 178
HSE (Health, Safety and Environment) group, 40, 46–47
HSLA (high-strength low-alloy steels), 18
Human error, 391
Hydraulic profile, 608, 614
Hydrocarbon dew point, 379
Hydrocarbon dew point analysis, 372–373
Hydrocarbon gases (and liquids) commercially relevant properties density and compressibility factor, 374
energy, 372
heating value, 373–374
merchantability and interchangeability, 374–375
volume, 372–373
operationally relevant properties
heat capacity and isentropic exponent, 376
mass and mass density, 376
sound speed, 377, 378
thermal conductivity, 377–378
viscosity, 376–377
target enforcement purposes, 379
typical criteria, 379
Hydrocarbon measurement definitions, 339
facility design, 386–389
capacity, 388–389
load profiles, 387
security, 389
field measurement, purposes of custody transfer, 340
local process control, 341
operational cost recovery, 341
pipeline inventory management, 341
pipeline system control, 341
production allocation, 340
regulatory reporting, 341
transportation revenue generation, 340
fluid property measurement analysis, 382–386
properties measured, type of, 372–380
purposes, 371–372
sampling systems, 380–382
operations equipment verification and calibration, 390–391
maintenance strategies, 389–390
problems, see Problem avoidance and resolution
technician qualifications and training, 390
primary measurement devices, 341–363
Coriolis effect flow meters, 356–358
critical flow nozzles, 361
diaphragm meters, 361
meter performance, flow conditions and, 341–343
meter types, overview of, 363
orifice meters, 344–350
rotary positive displacement meters, 358–359
turbine meters, 350–354
ultrasonic flow meters, 354–356
vortex shedding, 359–361
scope, 339
secondary measurement devices process transmitters and transducers, 363–365
signal conditioning, 365–366
standards bodies, 393
purpose of, 393
tertiary measurement devices centralized measurement data systems, 367–369
control systems, SCADA and, 369–371
flow computers, RTUs, and PLCs, 366–367
Hydrostatic testing, valve, 334–335
Hydrovac excavation, 138
Ice plug formation, 195
ILI (in-line inspection) pigs, 155–157
In-line inspection (ILI) pigs, 155–157
In-service pipeline recoating, 175–176
Index and databases, 683–685
Inflatable-pneumatic plugs, 198
Information on pipelines, sources of, 675–692
Infrastructure, existing, 6–7
Inlet scrubbers, 404
Inspection technologies, 162–163
Instrumentation accuracy, 611
Instrument overrange condition detection, 368
Integrity assessment, 160–162
Integrity management programs, 173–175
Interchangeability, 371
merchantability and, 374–375
Internal combustion engines, 466, 490
Isentropic exponent, heat capacity and, 376
Jet mixer for cleaning tanks, 509, 510
Journals, 687
Kinematic viscosity, 377
KMP Product Pipelines, 65
Laboratory equipment, 391
Laminar flow, 93, 117
Leak detection, 79–82, 610–612
Leak size calculation, 320

Index

Leaking compressor rings, 562
Leaking fuel valve, 561
Lifting hazardous pipelines, 141–143
Line-break controls, 79–80 automatic, 312–313
Line current survey, 208
Line locator, 138, 139
Line-pack management, 75, 76
Line-pack monitoring, 605
Line-pack volume, 77
Line segment capacity, 104
Linear valve operator, 311
Liquid measurement
  rotary meter for, 359
turbine meter for, 352
Liquid nitrogen
  controlled, 194–195
direct, 195
Liquid pipeline control center, 102
Liquid pipeline drag reducers, 117–124
Liquid pipeline product velocity, 116–117
Liquid pipeline segment replacement, 182–199
Liquid pipeline transportation system, 22–23
Liquid pipeline valve spacing, 315–317
Liquid pipelines real-time management of, 606–610
  valve automation for, 317–320
Liquid sample cylinder, 383
Liquid transportation, 82–108
  batch sequencing, 86–90
  batching, 85–86
  operation and control, 96–108
types of, 82–85
Liquid turbine meter, 352
Load profile
delivery points, 387
gas processing plants, 387
pipeline system interconnects, 387
receipt points, 387
Lost and unaccounted for (LAUF), 339
Lowering in hazardous pipelines, 141–143
Lube oil condemning limits, 554
M
Magnetic flux leakage (MFL) tools, 161
Magnetic particle inspection, 252–253
Mainline block or sectionalizing valves, 294
Mainline rupture, full, 318–319
Mainline valve assembly and spacing, 314
Mainline valves, types of, 294
Maintenance, 127–284
  blasting and, 148–151
code requirements, 128–129
cold bending, 143
cold-springing, 145–147
contracting of, 57–58
corrosion control, 199–208
defect assessment, 163–164
definition of, 48–49
environmental guidelines, 132
environmental protection and, 131–132
field bending, 144–145
foreign crossings, 139–143
frequency, 129
inspection technologies, 162–163
integrity assessment, 160–162
integrity management programs, 173–175
locating pipelines, 138
major, 525–533
overview, 127–129
pigging, 153–160
pigging procedures, 159–160
pipeline extension/contraction, 147–148
pipeline patrol, 151–153
repair, 160–182
repair and rehabilitation techniques, 164–173
repair welding, 237, 267
right-of-way and site, 130–153
right-of-way requirements, 135–136
routine, 127, 297, 516
segment replacement, 182–199
gas pipeline, 182–190
liquid pipeline, 191–199
signs and markers, 132–134
site requirements, 136–137
surveillance program, 134–135
Maintenance enhancement, 52
Maintenance information systems, 55–57
Maintenance management, 50–52
Maintenance planning, 53–55
Maintenance programs, 52–53
Maintenance scheduling, 53–55
Maintenance strategy, 49–50
Major maintenance, 525–533
Management of documentation, procedures for, 667
Mandrel pigs, 156
Manual valve operators, 308
Manuals and handbooks, 685–686
Maps, 687–688
Markers, 132–134
Markov analysis, 644
Mass density, 376
Mass flow meter, 358
Material safety data sheets (MSDS), 46
Maximum operating pressure (MOP), 180, 306, 387
Mean time between failures (MTBF), 633
Mean time to restore (MTTR), 645
data, 645
Measurement, 339
Measurement data, 58–59
Measurement procedures, 670
Mechanical clamp to attach test leads, 206
Mechanical/vapor plugs, 192–193
Metallic media, SCADA, 583
Meter capacity, 388
Meter facility capacity
downgrade strategies, 389
headers, 388
meter capacity, 388
scrubbers and filters, 388
upgrade strategies, 388
yard piping and valves, 388
Meter performance, flow conditions and
  flow conditioning
    perforated plates, 343
tube bundles (straightening vanes), 342
fully developed flow, 342
low disturbances, causes and types of, 342
Meter provers, 358
Meter proving, 607
Meter stations, 652
  elements, 27
types of, 26–27
Metering, 23–24, 26–27
  fluid effects on, 341–343
  historical development, 12–15
  maintenance elements, 27
  operational control, 26–27
  standards, 13–15
  variety in, 13–15
weld process characteristics, 224–227

Pipeline welding techniques background, 208–210
pipe grade and welding, 212–213
pipe manufacture, 213–217
timeline, 210–212
weld microstructure and process, 217–219

Pipeline welding terms and definitions, 274–284

Pipelines background and history, 1–15
compression and pumping, see Compression and pumping
development, 3–6
drivers and driven equipment used on, 399
existing infrastructure, 6–7
gas, see Gas pipeline entries
general functions for, 33–35
liquid, see Liquid pipeline entries
maintenance, see Maintenance
monitoring and control, 570
oil, see Oil pipeline entries
operation and maintenance, see Operation and maintenance
organizational structure of, 37–40
origin, 2
sources of information on, 675–692
system automation, 30
system automation and control of, 569–570
system development trends, 15–19
system operation overview, 65–112
system technological advances, 20
transmission systems, see Transmission
typical organizational model, 38

Pipes of unequal wall thickness, joining, 271–273
Piping maintenance, 404
Piping vibration and pulsation, 552–553
PLC (programmable logic controller), 367, 580
Plug valves, 302–304
Polling methods, SCADA Host, 588–589
Power valve operators, 308–312

PPE (personal protective equipment), 47
Precision, 339
Preliminary cycle plan, 99
Pressure drop, 320–324
minimum, 108
Pressure point analysis, 612
Pressure regulators, 380–381
Pressure transducers, 363
Pressurizing pipeline segment, 186–190
Preventive maintenance, 51, 53
Probability, 630
Probability relations, basic, 637–638
Probability theory
gas pipeline reliability using, 650–663
in pipeline capability determination, 663–665
Problem avoidance and resolution audits, 393
check meters, 391–392
dispute resolution, 392
error, sources of, 391
witnessing, 392–393
Procedures, 47–48, 667–670
compression or pumping station, 670
general, 667–668
health, safety and environment, 668–669
for management of documentation, 667
measurement, 670
pipeline, 669
Process transmitters
differential pressure transmitters, 364
pulse output devices, 365
static pressure transmitters, 363
thermocouples, RTDs and, 364–365
Product batch management, 606–608
Product shipments, growth in number of, 98
Programmable logic controller (PLC), 367, 580
Proration/apportionment, 98
Protocols, SCADA Host, 589–590
PSP (pipe to soil potential) surveys, 208
Pulsation in piping flows, 552–553
Pulse output devices, 365
Pump and compressor stations, 397–565
control systems, 407–409, 411–415
design, 397–410
driver selection, 400–403
maintenance, 507–565
condition monitoring, 544–564
of centrifugal compressors and pumps, 562–563
of electric motors, 563–564
gas turbines, 556–558
general monitoring, 548
major maintenance actions, 547–548
monitoring and diagnostic techniques, 544–548
oil analysis, 553–555
of reciprocating engines and compressors, 559–562
of vibration, 549–555
site, 508–509
troubleshooting and failure investigation, 565
monitoring and control, 570
operation of centrifugal compressors and auxiliary systems, 480–490
operation of electric drivers, 472–480
operation of gas turbiners and auxiliary systems, 430–452
operation of pumps and auxiliary systems, 498–503
operation of reciprocating compressors and auxiliary systems, 490–498
operation of reciprocating engines and auxiliary systems, 452–472
pig launching, 425
piping layout, 403–407
safety systems, 409–410
unit selection, 400–403
Pump characteristic curve, 562
Pump selection, 402–403
Pump station piping layout, 407, 408
Pump station schematic display
SCADA, 601
Pump station systems
flare and sump system, 427–429
pump unit instrumentation, 425–426
shutdown control, 422
station and unit instrumentation, 423, 425
station control system, 421–423
station discharge control, 426–427
station electrical, 429–430
Pipeline Operation & Maintenance—A Practical Approach

Pump unit monitoring, 608
Purge pressure, 187–189
Purging pipeline segment, 186–190

Quality control, 104–105

Radio systems, SCADA, 532–534, 584–586
Radiographic inspection, 245
Random error, 339
Rapid valve closure, 320–321
Rateability, 97–98
RBDs, see Reliability block diagrams
RCM (reliability centered maintenance), 48, 547, 634–635
Reader-Harris/Gallagher (RG) equation, 346
Real-time data acquisition, SCADA Host, 591–592
Real-time management of gas pipelines, 604–606
of liquid pipelines, 606–610
Real-time measurement (RTM), 341, 604
Real-time transient analysis, 612
Receipt meter stations, 19, 22
Reciprocating compressors control systems, 496–498
lubrication system, 495–496
performance characteristics, 496
start-up and shutdown, 489–490
Reciprocating engines, 438
air intake scavenging and turbocharging, 454–456
cooling systems, 466
design, 452–454
engine control system, 456–457
fuel gas system, 459–466
fuels, 459–461
ignition systems, 464–465
lube oil system, 457–459
maintenance, 523–533
major maintenance, 525–533
of cooling system, 530
of cylinder heads, 526–528
of fuel and ignition system, 532–533
of intake and exhaust system, 531
of lubrication system, 531
of pistons and cylinders, 528–530
of prelube and starting system, 533
of rods, crankshaft, camshaft and bearings, 529–530
of turbocharger system, 533
monitoring, 559–560
routine maintenance, 523–525
shut down, 471–472
start-up, 466–471
Redundancy, 631
References, basic, 676–680
Regional organizational structure, 38–39
Regulations, codes and standards, 41–43
Regulatory documents, 42–43
Regulatory requirements, 36–37, 42–43
Rehabilitation techniques, 164–173
Relative density (RD), 374
Reliability, 49
defined, 623, 632
gas pipeline, see Gas pipeline reliability safety and, 630–631
Reliability analysis, fundamentals, 632–633
Reliability assessment, 565–583, 623
applications, 625–629
computer tools for, 631
fundamentals and techniques, 629–635
reasons for, 624
techniques, 631–632
Reliability block diagrams (RBDs), 630
gas pipeline reliability using, 645–650
modeling, 639
technique, 638–641
Reliability centered maintenance (RCM), 48, 547, 634
Reliability modeling, principles of, 631
Reliability standards, applicable, 567–571, 625–629
Relief valve sizing, 306–307
Relief valves, 305–306
Remote telemetry units, 367
Remote terminal units (RTUs), 575–581
Repair, 160–182
and rehabilitation techniques, 164–173
Repair welding, 237–244
Repeatability, 339
Replacement, equipment, 60–62
Report generation, 369
Reproducibility, 339
Resistance coefficient values for pipeline valves, 322
Rest potential, 207
Reynold’s number, 342
pipe, 92, 93, 94
Right-of-way (ROW), 130–131
Right-of-way requirements, maintenance, 135–136
Risk, 633–634
Road crossings, 140
Rolls Royce RB211, 431, 433
Rotary meters, 299–303
operating principle, 358
operation in practice, 358–359
Rotary piston valve operator, 311
Rotary positive displacement meters application notes, 358–359
implementation, 358
operating principle, 358
Rotary vane valve operators, 310
Routine maintenance, 129, 297, 301, 516
ROW (right-of-way), 130–131
RTM (real-time measurement), 604–610
RTUs (remote terminal units), 575–581
Rupture disk, 306
Ruptured pipeline, 317, 645
Safety, reliability and, 630–631
Safety equipment maintenance, 509
Safety procedures, 668–669
Sample cylinders and cans, 381
Sample equipment, 382
Sample probes, 380
Samplers, 382
Sampling systems in fluid property measurement
continuous sampling
flow triggered, 382
proportional to flow, 382
proportional to time, 381–382
purpose of, 380
sample equipment, 382
samplers, 382
spot samples, 382
system components
filters, 381
pressure regulators, 380–381
sample cylinders and cans, 381
sample probes, 380
tubing, 381
Satellite system and SCADA, 586–587
SCADA (supervisory control and data acquisition), 574–603
calculations, 577
control loops, 577
control outputs, 576–577
data acquisition, 575–581
fiber optic systems, 581, 584
flow computers, 580–581
hardware architecture, 571, 572
metallic media, 583
network configuration, 582–583
programmable logic controllers, 580
radio systems, 584–585
remote terminal units, 575–581
RTU hardware, 578–579
RTU/Host communications, 577
satellite system and, 586–587
station control system/DCS, 580
telecommunication and, 581–588
transmission media, 583–587
SCADA and control systems
reliability, 369–370
status alarms, 370
SCADA Host, 535–546, 588–606
alarm management, 593–598
alarms, 599–600
hardware configurations, 601–603
historical data management, 592
polling methods, 588–589
protocols, 589–590
real-time data acquisition, 591–592
reporting, 600
scan time, 590–591
supervisory commands, 598
system configuration and maintenance, 601
Scan time, SCADA Host, 590–591
Scavenging, 454
Schedule-based maintenance, 389
Scrubbers, 388
Sealant injection leakage, 332
Sealing pigs, 155
Seat leakage, valve, 330–331
Secondary refrigerant technique, 194
Security, 389
Segregated batches, 86
Seismic crossings, 140
Senior Daniels orifice plate fitting, 346, 347
Separators, 421
Series compressor configuration, 406
Series systems, 631
Shielded metal arc welding (SMAW), 211, 224–227
Shipper nominations, 97
Shippers, 36–37
Shuttle valve, 304
Side-stream injections, 89
Side/takeoff valves, 313
Signal conditioning, 365–366
Signs, 132–134
Single-path ultrasonic meter signal configuration, 354
Slack line, column separation and, 114–116
Slug/batch train, 87
SMAW (shielded metal arc welding), 211, 224–227
Software architecture, 572–574
Solar Centaur 50, 432, 433, 434
Sonic nozzles, 388
Sound speed, 377, 378
Specific gravity (SG), 374
Spill volume calculation, 318–320
Spin test, 354
Spot samples, 382
Spring-back, 144–145
Spring-loaded pressure relief valve, 306
Standards and codes, 41–42
regulations and codes, 681–682
Standby units, 641
Static pressure transmitters, 363
Station alarms, 73
Station shutdowns, 73
Station tie-ins, 313
Station valves, 294
Stamp alarms, 370
 Stem leakage, valve, 330
Stop and bypass, 167–169
Stoppage fittings, 168, 169
Storage pool monitoring, 606
Straightening vanes, 342
Stress corrosion cracking, 164, 282
StrongBack composite wrap repair, 172–173
Stub installation, 180–182
Sulfur content problems, 91, 379
Supervisory control and data acquisition, see SCADA entries
Surveillance program, 134–135
System architecture, control, system automation and, 571–574
System automation, 569–620
advanced applications, 603–618
and control of pipelines, 569–570
control system architecture and, 571–574
expert advisory systems, 613–614
gas measurement and accounting, 614–618
leak detection, 610–612
liquids measurement and accounting, 618–620
pipeline simulation, 612–613
real-time management of gas pipelines, 604–606
real-time management of liquid pipelines, 606–610
System management tools, 573–574

T
Tanks
jet mixer for cleaning, 509, 510
maintenance of, 509
Tariff enforcement, 371, 379
Technical support organizational structure, 39–40
Technician qualifications and training, 390
Telecommunication, 581–588
trends in, 587–588
Temporary leak clamp repairs, 165–166
Terminal control, 101
Terminal maintenance, oil, 509
Terminals, design of, 410
Test leads, 204, 205, 206
for cased crossings, 134, 205
at insulation flanges, 206
for mainlines, 700
mechanical clamp to attach, 206
TFI (transverse field inspection) tools, 151, 206
Thermal conductivity, 377–378
Thermocouples, 365
RTDs and, 364–365
Thermography, 534
Time interval, 630
Torsional vibration, 551–552
Total sulfur, 379
TransCanada pipelines, 67
Transducers, 27, 283, 363
Transient analysis, real-time, 612
Transmission, 19–24
gas, 19–21
gas pipeline, see Gas pipeline transportation
liquid, see Liquid transportation
Transmission pipeline valve spacing, 315
Transmitters
differential pressure (dP), 364
pressure, 363, 419, 423
temperature, 419, 423
Transportation, see Transmission entries
Transverse field inspection (TFI) tools, 163
Trend analysis, 546–547
Trend display, SCADA, 600
Trouble ticket generation, 369
Troubleshooting and failure investigation, 565
installation, 333–334
Troubleshooting chart for gas turbines, 671–673
Tubing, 381
Turbine meter(s)
application notes, 351–354
implementation, 351
operating principle, 350
Turbine meter nose cone, 353
Turbulent flow, 117
Turbine meter(s)
application notes, 351–354
implementation, 351
operating principle, 350
Turbine meter nose cone, 353
Turbulent flow, 117
U
Ultrasonic flow meters
application notes, 355–356
implementation, 355
operating principle, 354–355
Ultrasonic inspection, automated, 248–249, 283
Ultrasonic measurement, 564
Ultraviolet light absorption, 385
Unavailability, 574, 633, 659, 661, 662
Uncertainty, 339
Unit alarms, 73
Unit shutdowns, 73
Units, common, conversion table for, 702–703
Upgrade strategies, 388
Utility pigs, 154–155
V
Valve assemblies, 313–317
Valve automation for liquid pipelines, 317–320
Valve body bleed, 185
Valve characteristics, 320–324
Valve closure rapid, 320–321
Valve flow coefficient during, 321
Valve failures, modes of, 327–336
Valve flow coefficient calculations, 321
for different types of valve and sizes, 322–323
during valve closure, 323
Valve handling, 333
Valve installation, 333
Valve labeling acronyms, 326
Valve maintenance, 296–297
Valve maintenance requirement, 325–336
Valve operators, 307–312
Valve seat leakage, 330–331, 335
Valve spacing liquid pipeline, 315–317
 transmission pipeline, 315
Valve stem leakage, 330
Valves, 289–336
 application notes, 292–293
 application ranking and identification, 324–325
 automatic line-break controls, 312–313
 ball, see Ball valves
 check, 304
coding and color, 325–326
gate, see Gate valves
 general and history, 289–292
 globe, 305
 hydrostatic testing, 334–335
 inspection and schedule, 326–327
 monitoring and control, 570
 plug, 302–304, 325
 relief, 305–307
 resistance coefficient values, 322
 side/takeoff, 313
 standards, 292–293
 station tie-ins, 313
 types for pipeline applications, 293–307
 types of, 294–295
 Valves, yard piping and, 388
 Vapor plugs, 192
 Vapor pressure of batched products, 103
 Variable flow coefficient, 323
 Variable frequency drives (VFD), 9, 475–476
 Variance, 339
 VECTRA MFL metal loss tool, 157
 Velocity, liquid pipeline product, 116–117
 Velocity limit, 108, 109–110, 111
 based on erosion, 109–110
 based on indirectly defined damage, 111
 VFD (variable frequency drives), 9, 475–476
 Vibration frequency chart, 550
 Viscosity, 376–377
 Volume out calculation, 318–319
 Vortex shedding
 application notes, 360–361
 implementation, 360
 operating principle, 360
 W
Water, 379
 Water-wash cart, 513
 Water-wash fluids, 511
 Watercourse crossings, 140–141
 Warped orifice plate, 346
 Web resources, 689–692
 Weld anatomy, 229–232
 Weld defects, 254–266
 limitations on imperfections in, 261
  macrographs of, 255, 257
 Weld deposition, 166
 Weld inspection techniques, 244
 avoiding defects, 258
 film cataloguing procedure, 248
 film identification marking, 248
 influencing factors on weld defects, 261–266
 limits on weld defects, 258–261
 liquid dye penetrant inspection, 253–254
 magnetic particle inspection, 252–253
 marking of welds, 247–248
 operation, 250–252
 radiographic equipment, 245–246
 radiographic equipment and supplies, 247
 radiographic inspection, 245
 radiographic inspector responsibilities, 247
 radiographic procedure qualification, 246–247
 radiographic quality, 247
 radiography of repair welds, 247
 radiography using x ray and ray on welds, 245
 ultrasonic inspection, 248–249
 ultrasonic inspection characteristics, 249–250
 weld imperfections/defects, 254–258
 Weld qualification and weld quality assurance
 development and qualification of welding procedures, 237–239
 double-jointing, 239
 mechanized welding, 240
 typical equipment crew, 239–240
typical mechanized welding crew, 240
   typical SMAW welding crew, 239
   welders qualification record, 244
   welding inspection, 241
   welding procedures, 241–244
Weld repairs, 266–267
Weld stress calculations
   application of Mohr’s circle for a simple tensile test, 268
   principles of stresses in welding, 267–268
   T weld design, 269–270
   weld design principles, 269
   Welders qualification, 238
   Welding cost, pipe thickness and, 270–271
   Welding positions/orientation, 232–235
   Welding rod designation, 235–237
   typical electrodes for pipeline welding applications, 237
   Welding terms/types, 222
   Witnessing, 392–393
Wobbe number, 375
Work practices, 47–48

Y
Yard piping, 388

Z
Zero-hour overhaul, 516