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American Petroleum Institute
UNITED STATES
Hydraulic Fracturing and Onshore Oil and Natural Gas Development: Industry Standards for Safe and Responsible Development

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American Petroleum Institute
API History

• 1919: API founded as non-profit national trade association, New York City
  • Three initial priorities – taxes, statistics, and equipment standards
• 1969: API relocates to Washington, DC
  • Heightened interest in advocacy issues
• Over 600 Members
Global Industry Services

- Standards
- Statistics
- Certification Program
- Training and Education

Headquartered in Washington, D.C. with sales and marketing offices in Houston, Beijing, Dubai, and Singapore.
API Standards

- Over 600 technical standards covering all aspects of the oil and natural gas industry
- Fully accredited by the American National Standards Institute (ANSI), which accredits many national laboratories
- National Technology Transfer and Advancement Act (NTTAA) requires Federal Agencies to use voluntary consensus standards, encourages participation
  - API standards are cited in regulations by agencies including OSHA, EPA, DOT and BSEE
  - 100 API standards are cited over 270 times in the U.S. Code of Federal Regulations

- API Standards also widely cited by States
  - 184 API standards are cited over 3300 times in state regulations
Standards

600+ Industry Standards and Technical Reports covering:

- Exploration & Production
- Refining
- Marketing
- Pipeline
- Measurement
- Safety and Fire Protection
- Petroleum E-Commerce
Robust System of Regulations, Industry Standards, and Operational Integrity = Safety and Environmental Protection
Key state regulations include:

- Review and approval of permits
- Well design, location and spacing
- Drilling operations
- Stimulation
- Water management and disposal
- Air emissions
- Wildlife impacts
- Surface disturbance
- Worker health and safety
- Inspection and enforcement of day-to-day oil and gas operations
Strong permitting is paramount.

SOME of the permits required for a well in Pennsylvania are:

- Well drilling permit (w/ well location plat, casing and cementing plan, PNDI for threatened or endangered species, landowner/water well owner notifications, coal owner or operator notification and gas storage field owner notification)
- Water management plan for Marcellus Shale wells
- Proposed alternate method of casing, plugging, venting or equipping a well
- Bond for Oil and Gas Well(s) (individual or blanket, various bond types allowed)
- Waiver of distance requirements from spring, stream, body of water, or wetland (to put the well closer than 200 feet)
- Variance from distance restriction from existing building or water supply (to put the well closer than 100 feet)
- Proposed alternate method or material for casing, plugging, venting or equipping a well
- Approval for alternative waste management practices
- Approval of a pit for control, handling or storage of production fluids
- Use of alternate pit liner
- NPDES GP-1 for discharges from stripper oil wells
- Water Quality Management Permit for treatment facilities
- Alternative pit liners
- Inactive status
- Roadspreading plan approval
- Transfer of well permit or registration
- Orphan well classification
- Off-site solids disposal
- Residual waste transfer stations and processing facilities
- Transportation of residual waste
- Road use permit – construction of access to state roadway
- Road use bond (PennDOT or municipality)
- Surface use permit (if in the Allegheny National Forest)
- PASPGP-3 or PASPGP-4 for pipelines crossing streams (if < 1 acre)
- Water Obstruction – Encroachment – US Army Corps of Engineers Section 404 Joint Permit
- Dam permit for a centralized impoundment dam for Marcellus Shale gas wells
- GP-11 for non-road engine air emissions
- GP-05 for natural gas compression facilities emissions
- Earth disturbance permit (if > 5 acres)
- Erosion and sedimentation control permit (if > 25 acres)
- NPDES storm water for construction activities
- Water allocation (SRBC, DRBC or DEP for Ohio River basin)
- GP-3 for bank rehabilitation, bank protection, and gravel bar removal
- GP-4 for intake and outfall structures
- GP-5 for utility line stream crossings
- GP-7 for minor road crossings
- GP-8 for temporary road crossings
- GP-11 Maintenance, Testing, Repair, Rehabilitation or Replacement of Water Obstructions and Encroachments
Key federal regulations governing shale development include:

- Clean Water Act
- Clean Air Act
- Safe Drinking Water Act
- National Environmental Policy Act
- Resource Conservation and Recovery Act
- Emergency Planning and Community Right to Know Act
- Endangered Species Act
- Occupational Safety and Health Act
Industry Standards for Onshore Operations

Overview of Industry

Guidance/Best Practices Supporting Hydraulic Fracturing (HF)

API Spec 12F
Drilling and Well Servicing Structures
API Spec 6A
Wellhead and Christmas Tree Equipment
API Spec 7K
Drilling Equipment
API Spec 6B
Hosing Equipment (Inspection and Maintenance)
API Spec 16A
Chokes and Kill Systems
API Spec 6D
Control Systems for Drilling Well Control Equipment
API Spec 12T
Cased Tubing Well Control Equipment Systems
API Spec 53
Blowout Prevention Equipment Systems
API Spec 52U
Underbalanced Drilling Operations
API Std 69B
Reliability/Maintenance Data
API Spec 62
QMS Requirements for Service Organizations for the Petroleum and Natural Gas Industry
API Spec 12B
Production Liquid Storage Tanks (Billets)
API Spec 12D
Production Liquid Storage Tanks (Field Welded)
API Spec 12F
Production Liquid Storage Tanks (Shop Welded)
API Spec 12J
Oil and Gas Separators
API Spec 12K
Hazardous Type Offshore Systems
API Spec 12L
Vertical and Horizontal Emulsion Testers
API RP 12N
Flame Ablation Operations, Testing, and Maintenance

API Spec 12P
Flanged Reinforced Plastic Tanks
API RP 12RI
Production Service Tanks (Inspection and Maintenance)
API RP 2560
Storage Tanks, Girth Weld Inspection
API Pub 4663
Drilling Equipment
API Bull 018
Split Flow Control and Containment Systems
API RP 49
Drilling and Bonding Wells
API Spec 58
Drilling Operations Occasional Safety
API RP 55
Gas Processing Involving Hydrogen Sulfide
API RP 59
Well Control Operations
API Spec 64
Diverting Systems Equipment and Operations
API RP 67
Oilfield Explosives Safety
API RP 68
Oil and Well Servicing and Workover Operations
API RP 74
Inducing Hydrogen Sulfide
API RP 75
Production Operations Occasional Operations
API RP 79
Safety and Environmental Management Systems
API RP 110-1
Contractor Safety Management
API RP 110-2
Incident Management Team Operations
API RP 110-3
Annual Aiming Pressure For Onshore Wells
API RP 110-4
Well Integrity and Fracture Containment
API RP 110-5
Environmental Impact Related to Onshore Operations
API RP 110-6
Environmental Protection Natural Gas Processing Plant Fractions
API RP 110-7
Environmental Protection for Operations

energy
API

API is the world’s leading standard-developing organization for the oil and natural gas industry.

Since 1919, API has developed standards for oil and natural gas operations.

API’s formal consensus process is accredited by the American National Standards Institute (ANSI), the same institute that accredits U.S. national laboratories for their science and technology processes.

API standards are developed in an open process that requires regular review of its more than 800 standards covering all segments of the industry.

Nearly 200 API standards are cited over 3300 times in state regulations, and more than 100 standards are cited 270 times in federal regulations.

www.api.org
Good well construction and careful operations protect groundwater.

- **API RP 100-1 (Well Construction) and Standard 65-2 (Zonal Isolation)**
- **Well construction:** material selection, performance, evaluation
- **Well integrity:** isolate internal conduit of well from surface & subsurface environment
  - Protect groundwater through a combination of redundant steel casing and cement sheaths, mechanical isolation devices
- **Well logging and other testing:** data gathering tools for formation evaluation, well design and construction
API Recommended Practice 100-2

Covers:
- Baseline Water Sampling
- Source Water Management
- Material Selection
- Transportation of Materials and Equipment
- Storage and Management of Fluids
- Management of Wastes
- Air Emissions
- Site Planning
- Training
- Noise
Hydraulic fracturing fluid is 99.5% water and sand.

### Fracturing Fluid Components

<table>
<thead>
<tr>
<th>Compound</th>
<th>Purpose</th>
<th>Common application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acids</td>
<td>Helps dissolve minerals and initiate fissure in rock (pre-fracture)</td>
<td>Swimming pool cleaner</td>
</tr>
<tr>
<td>Sodium Chloride</td>
<td>Allows a delayed breakdown of the gel polymer chains</td>
<td>Table salt</td>
</tr>
<tr>
<td>Polyacrylamide</td>
<td>Minimizes the friction between fluid and pipe</td>
<td>Water treatment, soil conditioner</td>
</tr>
<tr>
<td>Ethylene Glycol</td>
<td>Prevents scale deposits in the pipe</td>
<td>Automotive anti-freeze, deicing agent, household cleaners</td>
</tr>
<tr>
<td>Borate Salts</td>
<td>Maintains fluid viscosity as temperature increases</td>
<td>Laundry detergent, hand soap, cosmetics</td>
</tr>
<tr>
<td>Sodium/Potassium Carbonate</td>
<td>Maintains effectiveness of other components, such as crosslinkers</td>
<td>Washing soda, detergent, soap, water softener, glass, ceramics</td>
</tr>
<tr>
<td>Glutaraldehyde</td>
<td>Eliminates bacteria in the water</td>
<td>Disinfectant, sterilization of medical and dental equipment</td>
</tr>
<tr>
<td>Guar Gum</td>
<td>Thickens the water to suspend the sand</td>
<td>Thickener in cosmetics, baked goods, ice cream, toothpaste, sauces</td>
</tr>
<tr>
<td>Citric Acid</td>
<td>Prevents precipitation of metal oxides</td>
<td>Food additive; food and beverages; lemon juice</td>
</tr>
<tr>
<td>Isopropanol</td>
<td>Used to increase the viscosity of the fracture fluid</td>
<td>Glass cleaner, antiperspirant, hair coloring</td>
</tr>
</tbody>
</table>
FracFocus: A searchable, online database for the contents of fracturing fluids. Currently there are 23 states that allow companies to use FracFocus as the disclosure method to meet state requirements.

As of April 28, 2016 – 5 years in operation
Companies:
1,384 participating
1,037 reporting
over 112,000 wells
### What FracFocus Discloses

Like other industries:
- Ingredients, not a recipe
- Trade secrets protected

Key disclosures for 3rd party products available through other resources like MSDS sheets available to health care providers

#### Hydraulic Fracturing Fluid Product Component Information Disclosure

<table>
<thead>
<tr>
<th>Trade Name</th>
<th>Supplier</th>
<th>Purpose</th>
<th>Ingredients</th>
<th>Chemical Abstract Service Number (CAS #)</th>
<th>Maximum Ingredient Concentration (by mass)</th>
<th>Maximum Ingredient Concentration (in HF Fluid by mass)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>WATER</td>
<td>CUSTOMER</td>
<td>WATER</td>
<td>WATER</td>
<td>7732-18-5</td>
<td>100.00%</td>
<td>68.864196%</td>
<td></td>
</tr>
<tr>
<td>BREAKER-500L</td>
<td>EES</td>
<td>LIQUID ENZYME BREAKER</td>
<td>Enzyme</td>
<td>57-50-1</td>
<td>50.00%</td>
<td>0.000000%</td>
<td></td>
</tr>
<tr>
<td>GL-57</td>
<td>EES</td>
<td>CLAY CONTROL</td>
<td>WATER</td>
<td>773-15-2</td>
<td>34.00%</td>
<td>0.940767%</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>T-MAC</td>
<td>75-77-0</td>
<td>33.00%</td>
<td>0.330566%</td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>METHANOL</td>
<td>64-17-5</td>
<td>33.00%</td>
<td>0.000000%</td>
<td></td>
</tr>
<tr>
<td>CO2</td>
<td>PRAXAIR</td>
<td>CARBON DIOXIDE</td>
<td>CARBON DIOXIDE</td>
<td>124-38-9</td>
<td>100.00%</td>
<td>34.000000%</td>
<td></td>
</tr>
<tr>
<td>MAY-J</td>
<td>INTERNATIONAL</td>
<td>FRAG GEL</td>
<td>GUAR</td>
<td>5000-30-0</td>
<td>100.00%</td>
<td>0.150184%</td>
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</tr>
<tr>
<td>MAVICIDE II</td>
<td>WEATHERFORD</td>
<td>N-OCTOXYL-1</td>
<td></td>
<td>1022-01-2</td>
<td>100.00%</td>
<td>0.000000%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>HCLI</td>
<td>INDUSTRIAL CHEMICAL</td>
<td>ACIDIZE THE FORMATION</td>
<td>HCL</td>
<td>7647-01-0</td>
<td>7.50%</td>
<td>0.000000%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>WATER</td>
<td>7732-18-5</td>
<td>92.10%</td>
<td>0.001818%</td>
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<tr>
<td>MAYHEB 3</td>
<td>EES</td>
<td>ACID INHIBITOR</td>
<td>N-METHYLMORAMIDE</td>
<td>68-12-2</td>
<td>0.10%</td>
<td>0.000000%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Propionic Acid</td>
<td>107-21-1</td>
<td>0.10%</td>
<td>0.000000%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>METHANOL</td>
<td>64-17-5</td>
<td>0.10%</td>
<td>0.000000%</td>
<td></td>
</tr>
<tr>
<td>S-1</td>
<td>EES</td>
<td>SURFACTANT</td>
<td>AROMATOPHENYL</td>
<td>127087-67-0</td>
<td>25.00%</td>
<td>0.015317%</td>
<td></td>
</tr>
</tbody>
</table>
Community Engagement

API Bulletin 100-3

Principles:
• Integrity
• Safety and Environmental Responsibility
• Communicating Effectively
Community Engagement

API Bulletin 100-3

Five Phase Model:
• Entry
• Exploration
• Development
• Operations/Production
• Exit
Occupational Safety for Oil and Gas Well Drilling and Servicing Operations

API Recommended Practice 54

Recommends practices and procedures for promotion and maintenance of safe working conditions for personnel engaged in drilling operations and well servicing operations, including special services.
Occupational Safety for Oil and Gas Well Drilling and Servicing Operations

API Recommended Practice 54

Covers:
• Injuries and First Aid
• PPE
• Operations
• Fire Prevention/Protection
• Flammable Liquids
• Drilling and Well Servicing Rig Equipment
• Drilling and Well Servicing Rig Electrical Systems

• Pumping Units
• Special Services
• Wireline Service
• Stripping and Snubbing
• Drill Stem Testing
• Acidizing and Fracturing
• Cementing Operations
• Gas, Air or Mist Drilling
• Hot Tapping and Freezing
• Hotwork and Welding
Chapter 4. Safety

Safety is an essential part of crude oil trucking operations both on roadways and during custody transfer. API MPMS Chapter 18.1 was developed for applications where access to lease tanks to perform the associated measurement and quality tasks was not restricted and where the settling and weathering of crude oil prior to custody transfer was possible. There are many applications today where these conditions cannot be met. Opening thief hatches of storage tanks can lead to the rapid release of high concentrations of hydrocarbon gases and vapors. Be aware that these may result in very low oxygen levels and toxic and flammable conditions around and over the hatch. This standard was developed to encourage uniform, technically defensible measurement and testing practices for crude oil gathered from lease tanks when access to the tank’s thief hatch may be restricted.
Additional Recent and Ongoing Standards Development Related to Occupational Safety

API Recommended Practice 77, Risk-based Approach for Managing Hydrocarbon Vapor Exposure during Manual Tank Gauging and Sampling of Onshore Production Facilities (under development)

• Hazard Identification
• Hazard and Risk Assessment
• Mitigation
• Personnel Training and Hazard Communication
• Operator and Contractor Interface
• Recordkeeping
Shale Energy Production is Driving Energy Security and Environmental Benefits
US Crude Oil Production

Average 2008: 5.0 MMbbl/d
Average 2015: 9.4 MMbbl/d

Peaked in 1970

+4.4 MMbbl/d (+90%)

Source: EIA
U.S. Crude Oil Net Imports vs. Production

Source: EIA

![Bar chart showing U.S. Crude Oil Net Imports vs. Production from 2006 to 2015.](chart.png)
US Natural Gas Marketed Production

Billion Cubic Feet per Day

World Dry Gas Production in 2013 was 121 Tcf. The US accounts for over 20% of World natural gas production.
Natural gas generates cleaner power

<table>
<thead>
<tr>
<th>Tons per year per thousand households</th>
<th>Biomass (Wood)</th>
<th>Coal</th>
<th>Natural Gas</th>
<th>Nuclear &amp; Renewables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Monoxide (CO)</td>
<td>11</td>
<td>7.2</td>
<td>0.3</td>
<td>0.0</td>
</tr>
<tr>
<td>Carbon Dioxide (CO2)</td>
<td>14,264</td>
<td>9,832</td>
<td>4,076</td>
<td>0.0</td>
</tr>
<tr>
<td>Nitrogen Oxides (NOx)</td>
<td>5.9</td>
<td>2.9</td>
<td>0.3</td>
<td>0.0</td>
</tr>
<tr>
<td>Particulate Matter</td>
<td>0.73</td>
<td>0.48</td>
<td>0.17</td>
<td>0.0</td>
</tr>
<tr>
<td>Volatile Organic Compounds (VOC)</td>
<td>0.15</td>
<td>0.14</td>
<td>0.17</td>
<td>0.0</td>
</tr>
<tr>
<td>Sulfur Dioxide (SO2)</td>
<td>0.0</td>
<td>4.77</td>
<td>0.03</td>
<td>0.0</td>
</tr>
<tr>
<td>Mercury</td>
<td>0.0</td>
<td>0.0001</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Source: R.W. Beck

Natural gas is clean burning
U.S. Energy Related CO2 Emissions Are Down Because of Natural Gas
The EIA projects U.S. energy-related CO2 emissions will be lower in 2040 than when they peaked in 2007.

Source: EIA
Natural gas generates more electricity from less land than other power sources.

Acres of land needed to produce the fuel and generate enough electricity to serve 1,000 households for one year

- Natural Gas: 0.3
- Coal: 0.4
- Biomass: 0.8
- Nuclear: 1.2
- Wind: 6
- Solar: 6

Source: R.W. Beck and Black and Veatch for NGSA
Water intensity for various power generation technologies

Gas-fired combined cycle power plants use much less water than thermal power plants with only a small contribution from gas production.


* Assumes closed loop cooling tower
** Other use includes water for other process uses such as emissions treatment, facilities
More Information

To learn more about the oil and natural gas industry, from policy and regulation to the science behind our operations, visit us online, engage with us via social media and ask us questions.

• Stay informed by following Energy Tomorrow on Twitter and Facebook:
  • https://www.facebook.com/EnergyTomorrow
  • https://twitter.com/energytomorrow

• The Energy Tomorrow e-newsletter provides the latest in American energy development, regulatory, legislative and industry news. Sign up to be in-the-know.
  • www.EnergyTomorrow.org/StayInformed
America and the World are Fueled by Oil and Natural Gas
The U.S. will require 12 percent more energy in 2040 and more than 60 percent of it will be met by oil and natural gas.

Source: EIA
Most energy analysts agree that sustaining even modest economic growth worldwide for the next several decades will require massive new investments in oil and natural gas.
Figure 2
Exploration and Production vs. Mining (2005-2014)
Injuries and Illnesses Incidence Rates

![Graph showing incidence rates for Exploration and Production vs. Mining (2005-2014). The graph compares the incidence rate per 100 Full-Time Workers for different sectors over the years. The rates are presented for the U.S. Private Sector - Mining, U.S. Oil and Natural Gas Industry - Exploration and Production, and U.S. Offshore (Exploration and Production).]