Hydraulic Fracturing 101

Bob Garland
Senior Technical Advisor
Universal Well Services
Outline

Responsibility
What is the Marcellus
Stimulation
Additives
Responsible:
A trait of being accountable
(answerable) to someone or some organization
Who are we Responsible To?

- EPA@40
- OSHA
- US Army Corp of Engineers
- PENNDOT
- Delaware River Basin Commission
- SRBC
Who else are we responsible to?

- Ourselves
- Environment
- Employees
- Citizens of the States
- Township and Communities
- HSE
- Industry
WHAT WE DO AND HOW WE DO IT ON A DAILY BASIS REALLY DOES MATTER!
The Industry is at a Confluence of two challenges

1. Produce enough O&G to meet the world demand.
2. At the same time reduce the perceived environmental impact of responsibly producing Marcellus Shale Gas.
Marcellus Fairway
What is the Opportunity?

• 2008
  – 195 Marcellus Wells
  – Non-Marcellus 3,997 Wells

• 2009
  – 768 Marcellus Wells
  – Non-Marcellus 1,775 Wells

In 2010 it is estimated that 1,400 to 1,750 MARCELLUS wells will be drilled in PA.

For every $1 spent by Industry in PA $1.90 is produced in Economic Production.
A MEMORANDUM OF AGREEMENT

Between

The United States
Environmental Protection Agency

And

BJ Services Company,
Halliburton Energy Services, Inc., and
Schlumberger Technology Corporation

Elimination of Diesel Fuel in Hydraulic Fracturing Fluids Injected into Underground Sources of Drinking Water During Hydraulic Fracturing of Coalbed Methane Wells

12 December 2003
Public Comment and Response Summary for the Study on the Potential Impacts of Hydraulic Fracturing of Coalbed Methane Wells on Underground Sources of Drinking Water

FINAL
Michael Paque, Executive Director  
Ground Water Protection Council  
13308 North MacArthur Boulevard  
Oklahoma City, OK 73142  

Dear Mr. Paque:

I am the program manager for Pennsylvania’s Ground Water Protection Program in the Pennsylvania Department of Environmental Protection (DEP). I have been concerned about press reports stating extensive groundwater pollution and contamination of underground sources of drinking water in Pennsylvania, as a result of hydraulic fracturing to stimulate gas production from deep, gas bearing rock formations. DEP has not concluded that the activity of hydraulic fracturing of these formations has caused wide-spread groundwater contamination.

After review of DEP’s complaint database and interviews with regional staff that investigate groundwater contamination related to oil and gas activities, no groundwater pollution or disruption of underground sources of drinking water has been attributed to hydraulic fracturing of deep gas formations. All investigated cases that have found pollution, which are less than 10% in over 15 years of records, have been primarily related to physical drilling through the aquifers, improper design or setting of upper and middle well casings, or operator negligence.

If you have any questions or concerns, you may contact me by e-mail at joseph.lee@state.pa.us or by telephone at 717-772-4048.

Sincerely,

Joseph J. Lee, Jr., P.G., chief  
Source Protection Section  
Division of Water Use Planning
Therefore, the injected fluid does not come into contact with groundwater; it is, in fact, injected into and recovered through a wellbore that has been specifically constructed to safely convey hydrocarbons under pressure to the surface without negatively impacting fresh water aquifers. The Department has no record of any documented instance of groundwater contamination caused by hydraulic fracturing for gas well development in New York, despite the use of this technology in thousands of wells across the state during the past 50 or more years.

New York State Department of Environmental Conservation
Division of Mineral Resources
Bureau of Oil and Gas Regulation

Environmental Impact Statement
on the Oil, Gas and Solution Mining Regulatory Program

Well Permit Issuance for Horizontal Drilling and High-Volume Hydraulic Fracturing to Develop the Marcellus Shale
(2.1.2 Hydraulic Fracturing, pg. 10)
Typical Casing Design
“...no groundwater pollution or disruption of underground sources of drinking water has been attributed to hydraulic fracturing of deep gas formations.”
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History of Hydraulic Fracturing

First performed in 1903

First commercially used in 1949

Used in many old wells to give them new life

By 1988 more than 1,000,000 wells have been stimulated

Today with new technology approximately 35,000 wells are Hydraulically Fractured per year

As noted in prior slide there is no record of damage to drinking water due to Hydraulic Fracturing
Exploration
Leasing
Construction
Drilling
Completion
Flow-back
Production
Maximum Approved Daily Consumptive Use

- Water Supply: 350 mgd
- Power Generation: 150 mgd
- Recreation: 50 mgd
- Gas Drilling: 50 mgd
- Manufacturing: 50 mgd
- Other: 50 mgd
- Mining: 5 mgd
- Education: 5 mgd

Current Estimate: 350 mgd
The average depth of a deep shale gas well is about 7,500 feet, which is:
- 1 ½ miles below the Earth’s surface
- More than six Empire State Buildings stacked end to end
- 1 ½ times deeper than the deepest part of the Grand Canyon
- More than 25 football fields laid out goal post to goal post.
Horizontal VS Vertical – Ten times more land is disturbed with individual verticals than one multi-well pad.
Six wells per Pads
What is changing in the Process

- Horizontal rather than Vertical
- Wellsite Containment
- Reducing Truck traffic
- Pad Size and well Configurations
- Reducing Fractionization
- First Responder Training
- 60% + Water Reuse
Recycle and Reuse Technology

TDS dependent segregation
Filtration and distillation
Use of brine tolerant fracturing chemistries
Alternative sources
Acid mine drainage
Effluent from manufacturing, etc.
**A Fluid Situation:**
Typical Solution* Used in Hydraulic Fracturing

### 0.49% Additives*

- **Potassium chloride**: 0.06%
- **Ethylene glycol**: 0.04%
- **Sodium carbonate**: 0.01%
- **Sodium chloride**: 0.01%
- **N,N-Dimethylformamide**: 0.01%
- **Gua gum**: 0.006%
- **Polynene surfactin**: 0.006%
- **Isopropanol**: 0.123%

### Compound*  | Purpose  | Common Application
--- | --- | ---
**Acids**: | Help dissolve minerals and initiate flow in rock (pre-fracture) | Swimming pool cleaner
**Gluconate**: | Eliminates bacteria in the water | Disinfectant, biofilm for medical and dental equipment
**Sodium Chloride**: | Allows a delayed break down of the gel polymer chains | Table Salt
**N,N-Dimethylformamide**: | Prevents the corrosion of the pipe | Used in pharmaceuticals, acrylic fibers and plastics
**sodium sulfide**: | Maintains fluid density and 
& 

esignificantly increases | Blood in blood transfusions, hosed escape and crematoriums
**Polyethylene glycol**: | Maintains friction between fluid and pipe | Water treatment, soil conditioner
**Polyacrylamide**: | "Take" the water to minimize friction | Makeup remover, lubricants, and candy
**Gua gum**: | Thicken the water to suspend the sand | Thicker used in cosmetics, baked goods, ice cream, toothpaste, rinse, and salad dressing
**CHLORAL**: | Prevents precipitation of metal oxides | Food additives, food, beverage; lemon juice
**Potassium chloride**: | Creates a brine carrier fluid | Low sodium table salt substitute
**Ammonium bisulfate**: | Rinses oxygen from the water to protect the pipe from corrosion | Cosmetic, food and beverage processing, water treatment
**Sodium or potassium carbonate**: | Maintains the effectiveness of other components, such as crosslinks | Washing soda, detergents, soap, water softener, glass and ceramic
**Propano**: | Allows the bacteria to remain open in the pipe at an escape | Drinking water filtration, grape sand
**Ethylene glycol**: | Prevents scale deposits in the pipe | Prevents antifreeze, engine coolant, deicing, and cattle
**Isopropanol**: | Used to increase the viscosity of the fracture fluid | Glass cleaner, and paint, plant, and bulk color

On average, 99.5% of fracturing fluids are comprised of freshwater and compounds are injected into deep shale gas formations and are typically confined by many thousands of feet or rock layers.

*Source DOE/GWPC: Modern Gas Shale Development in the United States (2009)
*The specific compounds used in a given fracturing operation will vary depending on reservoir quality and site, and specific characteristics of the target formation. The compounds listed above are representative of the major material components used in hydraulic fracturing of natural gas shales. Equipment and operating conditions may vary.*
Frac Fluid “Life Cycle”

- Storage at service company facility
- Transport to field
- Addition and dilution with water
- Pumping dilute form on surface
- Transport to perforations through “protective” casings
- Transport through fractures at depth
- Return to surface through protective casings
- Storage at surface
- Disposal or Reuse
Common Additives

- Surfactants
- Biocides
- Scale Inhibitors
- Friction Reducers
- Proppants
Proppants

Typically inert material such as sand or ceramic beads used to hold fractures open against formation pressure, allowing gas to flow to the wellbore.
Surfactants

Keeps solid particles suspended in liquids. Surfactants can be thought of as soap. They reduce surface tension in liquids. Surfactants are used to increase recovery of flow back fluids in the oilfield.
Friction Reducers

Allows the hydraulic fracturing fluid to flow into and out of the production casing and tubing easily, minimizing pumping costs.
Biocides

Inhibits or prevents the growth of bacterial, algae, fungi and other microscopic organisms. Bacteria can consume hydrocarbons or can form a slime or black residue in a gas well that can plug or damage the formation.
Scale Inhibitors

Formation brines can create deposits called “scales” on the inside of well piping. Scale inhibitors prevent these scales from forming. These scales are similar to the deposits that form in household plumbing restricting flow.
Storage at service company facility
Transport to well location to DOT Regulations
Pumped to Blender
Blending into dilute form
When there is a concern in this area (RED), refer to the MSDS section of this document. Once additives (chemicals) have been blended and pumped they are in a very diluted state and do not conform to MSDS properties.

All other areas observe proper well site safety and wear PPE.
1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION
Product identifier: Floxan 50
Chemical Name: Not Applicable, A Blend
Chemical Family: Not Applicable, A Blend
Manufacturer: CES Chemical (a Poblete Industries, Inc. company)
1004 S. Plantsman Road, Marion, OK 73055
Emergency Phone: 1-405-282-8510
Prepared by: Denise Patterson
Phone: (580) 468-8608
Issue Date: 10/21/2002
Revised Date: 05/21/2007

2. COMPOSITION/INFORMATION ON INGREDIENTS
Ingredient: Secondary Alcohol
CAS No.: Proprietary
W. Percent Range: Proprietary
OSHA PEL: 400 ppm TWA
ACGIH TLV: 400 ppm TWA
LD50: Oral: 6.65 mg/kg (rat) Percutaneous: 6.0 mg/kg (rabbit)
LC50: Fathead Minnow: 8,390 mg/l (96 h) Daphnia: 7,550 mg/l (48 h)

3. HAZARDS IDENTIFICATION
Human health hazards: Eye, skin and inhalation irritation. Harmful if swallowed.
Acute health hazards: None.
Chronic health hazards: None.
Route(s) of entry: Eyes, skin, inhalation, ingestion.
Safety hazards: Flammable liquid.
Environmental hazards: None.

4. FIRST AID MEASURES
Eye: Remove contact lenses at once. Immediately flush with copious amounts of water for at least 15 minutes while holding eyelids open. If irritation persists, seek medical attention.
Skin: Wash affected area thoroughly with soap and water for at least 15 minutes. Remove contaminated clothing and launder before reuse. If irritation develops, seek medical attention.
Inhalation: Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Seek prompt medical attention.
Ingestion: Call a physician or poison control center immediately. Only induce vomiting at the instruction of medical personnel. Never give anything by mouth to an unconscious person.

5. FIRE FIGHTING MEASURES
Flash Point: 8°F (32°C) (Closed Cup)
Lower Explosion Limit: 0.7% (Essential Oils)
Upper Explosion Limit: 6.1% (Essential Oils)
Protective equipment: NIOSH/MSHA approved self-contained breathing apparatus (SCBA) and turnout gear.
Hazardous combustion products: Carbon monoxide may be evolved if incomplete combustion occurs.

6. ACCIDENTAL RELEASE MEASURES
Personal precautions: Wear hand, eye, protective clothing and respiratory protective equipment to eliminate contact.
General precautions: Eliminate ignition sources. Evacuate all non-essential personnel.
Small spills: Soak up residue with an inert absorbent and place into appropriate containers for disposal or reclamation. Flush contaminated area thoroughly with water. Retain washings as contaminated waste.
Large spills: If possible stop the flow of chemical. Use to contain and prevent spreading. Remove with vacuum truck or pump to salvage vessels. Treat residue as for small spills.

7. HANDLING AND STORAGE
Handling: Avoid contact with eyes, skin and clothing. Avoid breathing vapors. Use with adequate ventilation. Do not take internally. Wear appropriate protective clothing and equipment during handling. Wash thoroughly after handling. Remove contaminated clothing and launder before reuse.
Storage: Store away from heat, sparks and open flames. Keep container closed when not in use. Store drums with the bung up. Carefully vent container before removing bung.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION
Occupational exposure standards: Not established for the product.
Hand protection: Nitrile rubber gloves.
Eye protection: Chemical splash goggles and face shield if conditions warrant.
Respiratory protection: Not normally required.
Engineering control measures: General (mechanical) room ventilation is expected to be satisfactory.
Other: Emergency eye wash fountains and safety showers should be in the immediate vicinity of any potential exposure.

9. PHYSICAL AND CHEMICAL PROPERTIES
Form: Liquid
Appearance: Dark to opaque
Color: Colorless to milky white
Odor: Citrus
Specific Gravity: 1.0557
Bulk Density: 8.81 lb/bag
Boiling Point: Not determined
Freezing Point: -40°F (-40°C)
Solubility in water: 69.79%
Vapor Pressure: Not determined
Percent Volatiles: 55-75% weight

10. STABILITY AND REACTIVITY
Stability: Stable
Conditions to avoid: Heat, sparks, open flames
Hazardous polymerization: Will not occur
Hazardous decomposition products: Carbon monoxide may be evolved if incomplete combustion occurs.
Incompatibility: Strong oxidizing agents

11. TOXICOLOGICAL INFORMATION
Acute Effects
Eye: Causes moderate to severe irritation. If not removed promptly, permanent injury may result.
Skin: May cause mild to moderate irritation with brief contact. Prolonged contact may cause severe irritation, drying, and dermatitis.
Inhalation: May cause nose, throat and general upper respiratory tract irritation, coughing and headache.
Ingestion: Product is harmful if swallowed. May cause vomiting, headache, nausea, diarrhea, abdominal cramps, drowsiness and dizziness.
Chronic Effects: No other known chronic effects.
Carcinogenicity: None of the ingredients are listed in NTP, IARC monographs or OSHA.
Hydraulic Fracturing
Water usage 4-5 million gallons per well
Perforation Shot Testing

Perforation testing ensures optimal performance.  

API RP 19B
Horizontal Perforation
Horizontal Perforating
Post Frac Flowback

• Once the frac commences, it is the responsibility of flow-back company to obtain the following data: total load pumped, shut in pressure and if there are any problems that should be known before opening up.

• The well will be opened up once the frac crew has rigged off of wellhead or unless instructed by the customer representative.

• The well be opened on a pre-determined choke size chosen by the customer within safety flowing standards.
Oilfield Additives
Perception or Reality
Caution--Keep Away

Causes mutagenic, teratogenic and reproductive effects...

Causes painful burns and ulcerations...

Lacrimation, cough, labored breathing

Skin burns and mucosal irritation...

Pneumonitis and pulmonary edema...

Extremely Dangerous
CHLORINE

MATERIAL SAFETY DATA SHEET

PRODUCT NAME: CHLORINE

1. Chemical Product and Company Identification

24-HOUR EMERGENCY TELEPHONE NUMBER: CHEMTREC (800) 424-9300
EMERGENCY RESPONSE PLAN NO: 20101

PRODUCT NAME: CHLORINE
CHEMICAL NAME: Chlorine
COMMON NAMES/SYNONYMS: Bertholite, Molecular Chlorine
TDG (Canada) CLASSIFICATION: 2.3 (5.1)
WHMIS CLASSIFICATION: A, D1A, D2A, D2B, E, C

PREPARED BY: Loss Control
PREPARATION DATE: 6/1/95
REVIEW DATES: 6/7/96

2. Composition, Information on Ingredients

<table>
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<tr>
<th>INGREDIENT</th>
<th>% VOLUME</th>
<th>PEL-OSHA³</th>
<th>TLV-ACGIH²</th>
<th>LD₅₀ or LC₅₀ Route/Species</th>
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<tr>
<td>Chlorine</td>
<td>100.0</td>
<td>1 ppm Ceiling</td>
<td>0.5 ppm TWA 1 ppm STEL</td>
<td>LC₅₀ 293 ppm/1H (rat)</td>
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<td>FORMULA: Cl₂</td>
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<td>CAS: 7782-50-5</td>
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<td>RTECS #: FO210000</td>
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</table>

³ As stated in 29 CFR 1910, Subpart Z (revised July 1, 1993)
² As stated in the ACGIH 1994-95 Threshold Limit Values for Chemical Substances and Physical Agents

3. Hazards Identification

EMERGENCY OVERVIEW
Corrosive and irritating to the eyes, skin and mucous membranes. Inhalation may result in chemical pneumonitis and pulmonary edema. Nonflammable. Oxidizer, may explode or accelerate combustion if contacting reducing agents.
But, It’s ok to drink!!

(in a diluted form, of course)
BEFORE AND AFTER IN DAMASCUS, PA
The real-life experience of GAS DRILLING...

BEFORE:

AFTER:

Copyright, 2008 The New York Times
Site Restoration
Natural gas is an affordable and readily available energy source we can turn to now!

- For power generation
- Industrial use
- Transportation
- Home heating
Conclusion
WE must continually strive to improve the process
WE must continually educate and train
WE must continually remind our people
what and how they do our jobs does matter
WE must protect the environment
WE must develop this resource responsibly to help our
state, country, create jobs, and reduce our dependency
on countries that do not like us.

Question: Where would we be today without
Marcellus Shale?
What Americans Want For Energy

ABUNDANT  DOMESTIC  CLEAN  AFFORDABLE  JOBS
Thank You for your Attention