CURRENT TRENDS IN SHALE OIL AND GAS EXPLORATION

INCLUDING HYDRAULIC FRACTURING

FOR

NEW OPPORTUNITIES FOR CHEMICAL BUSINESSES

AT SERMACS

(SOUTHEAST REGIONAL MEETING OF THE AMERICAN CHEMICAL SOCIETY)

NOVEMBER 14, 2013
STANDARDS DEVELOPMENT AND BEST PRACTICES

• API AMERICAN PETROLEUM INSTITUTE HTTP://WWW.API.ORG
• ASTM INTERNATIONAL HTTP://WWW.ASTM.ORG
• MARCELLUS SHALE COALITION HTTP://MARCELLUSCOALITION.ORG
OVERVIEW

• UNDERSTAND SHALE OIL & GAS WITHIN ENERGY MARKETS
• LEARN ABOUT HYDRAULIC FRACTURING AND CHEMICALS USED
• UPDATES ON NEW CHEMICAL MARKETS IN US AND OVERSEAS
• EDUCATE YOU ON MAJOR TRENDS: RISKS AND OPPORTUNITIES
The surge in unconventional oil & gas production has implications well beyond the United States.
Different trends in oil & gas import dependency

Net oil & gas import dependency in selected countries

While dependence on imported oil & gas rises in many countries, the United States swims against the tide.
The Changing U.S. Natural Gas Landscape

Prior to widespread gas shale commercialization, U.S. production was declining, and prices were volatile and rising.

U.S. shale revolution ushers in an era of greater production, and lower, more stable prices.

Source: EIA, Bloomberg, Oilpro
GLOBAL SHALE OIL AND GAS PLAYS

Source: IHS CERA, Going Global: Predicting the Next Tight Oil Revolution, July 2013
HYDRAULIC FRACTURING 101

## CHEMICALS USED

<table>
<thead>
<tr>
<th>Additive Type</th>
<th>Main Compound(s)</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diluted Acid (15%)</td>
<td>Hydrochloric acid or muriatic acid</td>
<td>Help dissolve minerals and initiate cracks in the rock</td>
</tr>
<tr>
<td>Biocide</td>
<td>Glutaraldehyde</td>
<td>Eliminates bacteria in the water that produce corrosive byproducts</td>
</tr>
<tr>
<td>Breaker</td>
<td>Ammonium persulfate</td>
<td>Allows a delayed break down of the gel polymer chains</td>
</tr>
</tbody>
</table>
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</thead>
<tbody>
<tr>
<td>Corrosion Inhibitor</td>
<td>N,n-dimethyl formamide</td>
<td>Prevents the corrosion of the pipe</td>
</tr>
<tr>
<td>Crosslinker</td>
<td>Borate salts</td>
<td>Maintains fluid viscosity as temperature increases</td>
</tr>
<tr>
<td>Friction Reducer</td>
<td>Polyacrylamide, Mineral Oils</td>
<td>Minimizes friction between the fluid and the pipe</td>
</tr>
</tbody>
</table>
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</thead>
<tbody>
<tr>
<td>Gel</td>
<td>Guar gum or hydroxyethyl cellulose</td>
<td>Thickens the water in order to suspend the sand</td>
</tr>
<tr>
<td>Iron Control</td>
<td>Citric acid</td>
<td>Prevents precipitation of metal oxides</td>
</tr>
<tr>
<td>KCl</td>
<td>Potassium chloride</td>
<td>Creates a brine carrier fluid</td>
</tr>
</tbody>
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</thead>
<tbody>
<tr>
<td>Oxygen Scavenger</td>
<td>Ammonium bisulfite</td>
<td>Removes oxygen from the water to protect the pipe from corrosion</td>
</tr>
<tr>
<td>pH Adjusting Agent</td>
<td>Sodium or potassium carbonate</td>
<td>Maintains the effectiveness of other components, such as crosslinkers</td>
</tr>
<tr>
<td>Proppant</td>
<td>Silica, quartz sand</td>
<td>Allows the fractures to remain open so the gas can escape</td>
</tr>
</tbody>
</table>
# CHEMICALS USED

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<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale Inhibitor</td>
<td>Ethylene glycol</td>
<td>Prevents scale deposits in the pipe</td>
</tr>
<tr>
<td>Surfactant</td>
<td>Isopropanol</td>
<td>Used to increase the viscosity of the fracture fluid</td>
</tr>
<tr>
<td>Water</td>
<td></td>
<td>Deliver proppant</td>
</tr>
</tbody>
</table>

Note: The specific compounds used in a given fracturing operation will vary depending on company preference, source water quality and site-specific characteristics of the target formation. The compounds shown above are representative of the major compounds used in hydraulic fracturing of gas shales.
Average Hydraulic Fracturing Fluid Composition for US Shale Plays

- Water: 99.2%
- Other: 0.79%
- Acid: 0.07%
- Corrosion Inhibitor: 0.05%
- Friction Reducer: 0.05%
- Crosslinker: 0.032%
- Scale Inhibitor: 0.023%
- Breaker: 0.02%
- Iron Control: 0.004%
- Biocide: 0.001%

Source: FracFocus data August 2012
FRACFOCUS

• GWPC- GROUND WATER PROTECTION COUNCIL
• FRACFOCUS – CHEMICAL REPOSITORY
• HOW TO SEARCH FOR WELL AND CHEMICAL INFO

UNITED STATES
HTTP://FRACFOCUS.ORG

EUROPEAN UNION
HTTP://WWW.NGSFACTS.ORG/
US DEMAND FOR OILFIELD CHEMICALS IS EXPECTED TO REMAIN STRONG THROUGH 2017 FOLLOWING DOUBLE DIGIT ANNUAL GROWTH IN RECENT YEARS.

CHEMICALS USED IN HYDRAULIC FRACTURING HAVE BECOME THE LARGEST SEGMENT OF THE US MARKET

SOURCE: FREEDONIA INDUSTRY STUDY, OILFIELD CHEMICALS
NEW ACC STUDY: US CHEMICAL INDUSTRY OUTPUT FROM SHALE-RELATED INVESTMENTS

By 2020, additional output from shale-related chemical investments generates $66.8 billion in additional chemical industry shipments.

This is an ongoing, permanent upward shift in the level of shipments.

NATURAL GAS LIQUID (NGL) SUPPLIES, ESPECIALLY ETHANE, ARE KEY TO THE CHEMICAL INDUSTRY’S NEWFOUND COMPETITIVENESS. NGLS ARE THE PRINCIPAL FEEDSTOCK FOR BASIC CHEMICAL AND PLASTICS IN THE U.S., WHILE FOREIGN COMPETITORS USE OIL--BASED NAPHTHA, WHICH IS MORE EXPENSIVE. IHS SEES NGL PRODUCTION DOUBLING TO 3.8 MILLION BARRELS A DAY BY 2020.

DOWNLOAD THE IHS REPORT NOW:

BY 2025, UNCONVENTIONAL OIL AND NATURAL GAS WILL HELP LEAD TO AS MUCH AS $100 BILLION IN NEW INVESTMENT IN U.S. CHEMICAL AND PLASTICS FACILITIES, WITH INDUSTRY CAPACITY GROWING BY NEARLY 89 MILLION TONS, ACCORDING TO THE IHS STUDY. THE INDUSTRY WILL ADD 318,000 JOBS IN 2025, UP FROM 53,000 NEW JOBS IN 2012, ACCORDING TO THE IHS STUDY.

SOURCE: HTTP://WWW.IHS.COM/INFO/ECC/A/AMERICAS-NEW-ENERGY-FUTURE-REPORT-VOL-3.ASPX
## Top 15 North American Producers (6 months ending 2013):

<table>
<thead>
<tr>
<th>2013 Rank</th>
<th>Company</th>
<th>Production (MMcf/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Exxon (XTO)</td>
<td>3585</td>
</tr>
<tr>
<td>2</td>
<td>Chesapeake Energy</td>
<td>3043</td>
</tr>
<tr>
<td>3</td>
<td>Anadarko</td>
<td>2668</td>
</tr>
<tr>
<td>4</td>
<td>Devon</td>
<td>1969</td>
</tr>
<tr>
<td>5</td>
<td>Southwestern Energy</td>
<td>1698</td>
</tr>
<tr>
<td>6</td>
<td>BP</td>
<td>1553</td>
</tr>
<tr>
<td>7</td>
<td>Conoco Phillips</td>
<td>1526</td>
</tr>
<tr>
<td>8</td>
<td>Encana</td>
<td>1428</td>
</tr>
<tr>
<td>9</td>
<td>BHP Billiton</td>
<td>1314</td>
</tr>
<tr>
<td>10</td>
<td>Chevron (Atlas)</td>
<td>1241</td>
</tr>
<tr>
<td>11</td>
<td>Royal Dutch Shell</td>
<td>1167</td>
</tr>
<tr>
<td>12</td>
<td>WPX Energy</td>
<td>997</td>
</tr>
<tr>
<td>13</td>
<td>Cabot Oil and Gas</td>
<td>971</td>
</tr>
<tr>
<td>14</td>
<td>EOG Resources</td>
<td>931</td>
</tr>
<tr>
<td>15</td>
<td>Range Resources</td>
<td>894</td>
</tr>
</tbody>
</table>

Source: Natural Gas Association
TRENDS

1. PUBLIC PROTESTS—WILL CONTINUE
   - ENVIRONMENTAL RISKS
   - PUBLIC DISCLOSURE

2. FED REGULATIONS COMING

Photo credit
TRENDS

3. USING LNG TO REPLACE DIESEL FUEL FOR LONG HAUL TRUCKS, TRAINS AND CARS.

4. USING DIESEL FUEL PRODUCED FROM THE GTL (GAS TO LIQUID) PROCESS FOR EXPORT.
TRENDS

5. NEED FOR GREEN CHEMICALS

6. INCREASING CHEMICAL R&D FOR NEW PRODUCTS IN SHALE OIL AND GAS E&P
SUMMARY

• ADVANCES IN TECHNOLOGY HAVE LED TO SURGE IN SHALE OIL & GAS SUPPLY
• OTHER COUNTRIES WANT TO LEARN AND APPLY TO THEIR SHALE PLAYS
• OPPORTUNITIES AS NATURAL GAS PRICES REMAIN STABLE AND COMPETITIVE
• CONCERNS WITH ENVIRONMENTAL, NATURAL RESOURCE, SOCIAL ISSUES
• STATE REGULATIONS MAY COME UNDER MORE FEDERAL CONTROL
THANK YOU FOR ATTENDING

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Milton, GA 30004
404.513.5429
caryl@earthresourcesystems.com

Technical Chair, ASTM D18.26.10
Hydraulic Fracturing Reporting Section
Current Work Item:
Proposed Standard Practice for Data Management and Reporting Associated with Shale Oil and Gas Hydraulic Fracturing Operations