ATK Company Overview

Experience with Propellant Well Stimulation

Steve Moore

February 2014
• Introduction and Responsibilities

• Overview of ATK

• ATK’s Propellant-Based Well Stimulation Technology

• Overview of the Stimulation Tool

• Case Histories

• Summary
**ATK at a Glance**

**ATK** is an aerospace, defense and commercial products company with almost $5B in annual sales

### Aerospace Group
President: Blake Larson

- Propulsion for space exploration, commercial launch vehicles, strategic and missile defense
- Composite structures for military and commercial aircraft
- Satellite components and subsystems
- Military flares and decoys
- Space engineering services

### Defense Group
President: Mike Kahn

- Strike weapons
- Medium-caliber gun systems
- Precision-guided munitions
- Missile warning
- Small / medium / large-caliber ammo
- Tactical propulsion & controls
- Advanced fuzing & warheads
- Defense facility management
- Weaponized special mission aircraft

### Sporting Group
President: Jay Tibbets

- Sporting and hunting ammunition
- Law enforcement and security forces ammunition
- Gun powder for ammo and re-loaders
- Shooting sport accessories
- Tactical systems and accessories for:  
  — Military customers  
  — Law enforcement and security markets
ATK’s History of Diversification

- **E.I. DuPont Incorporated**
  - 1802

- **Alfred Nobel Invents Dynamite**
  - 1866

- **ATK’s History of Diversification**
  - 1940

- **Honeywell Enters Defense Business**
  - 1983

- **Honeywell Systems Group**
  - 1990

- **Hercules Powder Co. Incorporated**
  - 1912

- **Hercules Aerospace Division**
  - 1977

- **Acquisition of Hercules Aerospace Co.**
  - 1995

- **Acquisition of Ordnance Operations of Boeing**
  - 2001

- **Acquisition of Blount International Inc. ammunition business**
  - 2001

- **Acquisition of GASL & Micro Craft**
  - 2003

- **Acquisition of Mission Research Corporation (MRC)**
  - 2004

- **Acquisition of Swales Aerospace**
  - 2007

- **Acquisition of BLACKHAWK!**
  - 2010

- **Acquisition of Savage Arms & Bushnell Holdings**
  - 2013

- **Acquisition of Eagle Industries**
  - 2009

**Historical Timeline**

- **1902**
  - Split back to Thiokol Corporation

- **1926**
  - Cordant Technologies

- **1982**
  - Morton Thiokol Merger

- **1989**
  - Thiokol Chemical Corp

- **1989**
  - Purchase by Alcoa

- **1998**
  - Acquisition of Thiokol Propulsion

- **2000**
  - Acquisition of COI

- **2001**
  - Acquisition of SAT, Inc.

- **2002**
  - Acquisition of The PSI Group (Satellite Components)

- **2003**
  - Acquisition of Mission Research Corporation (MRC)

- **2004**
  - Acquisition of Pressure Systems Inc. (PSI, ABLE, PCI)

- **2005**
  - Acquisition of Eagle Industries

- **2007**
  - Acquisition of Swales Aerospace

- **2008**
  - Acquisition of BLACKHAWK!

- **2010**
  - Acquisition of Savage Arms & Bushnell Holdings

- **2013**
  - Purchase by Alcoa
• Founded in 1948 – rocket motor research, design, development, and production
• 550 acres, 150 buildings, and 380,000 ft² of enclosed floor space – wholly owned facility
• ISO 9001:2000 certified and AS9100 Rev C certified
Experience with Propellant Well Stimulation

John Arrell

February 2014
Current Hydraulic Fracturing Process

Water usage nominally 3 to 5 million gallons per well
ATK’s Fracking Procedure

ATK’s propellant-based procedure requires:

– No change in current well drilling, casing, and perforation
– No specialized or modified tools
– Minimal equipment
– Short set-up and operations time
ATK, partnered with PPS, has developed a propellant-based alternative/augmentation to the current hydraulic fracturing process

- Solid propellant is ignited generating specified volume of gas creating pressure that fractures the rock

- Propellant type, amount, and burning rate can be adjusted depending on geological conditions
  - Propellants can be designed to operate in the pressure and rise rate regime between single-blast explosives and HF
  - Extension of fractures can be controlled
    - Distance from wellbore: 10 to 100 feet
    - Directional: 360 deg to 45 deg

- Propellant solution is adaptive and can be readily modified, fabricated, and demonstrated with new formulations based on fracturing requirements

- Applicable for use in oil, gas, and geothermal wells
  - Re-stimulation of existing wells
  - In concert with hydro-fracking (e.g., reduce breakdown pressures)
  - Substitution for hydro-fracking operations
Solid Propellant Stimulation Tool Description

- Environmentally sealed ignition designed tool with premachined fracturing segments that ideally provide equal flame spreading and, therefore, *completely burn the propellant grain*

- Configuration design is critical to the success of the tool

- Assembled at well site to assure maximum tool benefit and ease of transportation

- Results can be measured in the same day

- Successfully demonstrated in many applications and down-hole conditions
Benefits of Energetics Fracturing Process

**PRIMARY BENEFITS**

- Release of the gas disbursement
  - Explosives 1,000,000 psi in 1 microsecond
  - Hydraulic 5,000 psi in 1 hour
  - Propellants 20,000 psi in 10-1000 milliseconds (Tailored)
- Reduces or eliminates the amount of water required
- Drastically reduces or eliminates the disposal of used fracturing water
- Much lower cost
  - 50% cost reduction versus current procedure
  - Minimal on-site equipment
  - Shorter service time needed to get well on line

**ADDITIONAL BENEFITS**

- Eliminates the need for chemicals to alter the success of the fracturing technique
- Creates multiple fractures with controls instantly around boreholes to eliminate aquifer contamination
- Increases injection and withdraw rates in gas storage wells
  - Removes “skin” and cleans the wellbore damage the perforating process creates, which reduces breakdown pressure in some formations
  - Improves effectiveness of acidizing by using propellant before acidizing
  - Stimulates selected zones without the need to set packers
  - Minimal formation damage from incompatible fluids and minimal vertical growth out of the pay zone

**Bottom line:** Demonstrated performance, lower cost
Energetics-based Stimulation Technology

Features
• Propellant is highly energetic and long burning for an extended propellant treatment
• Unique initiation process and patented coating process ensures predictability
• Variable surface area ignition increases or decreases the release of gas as needed
• Wireline, tubing (TCP) and coiled tubing conveyed

Specifications
• Maximum temperature: 450° F 1 hour
• Hydrostatic pressure up to 14,500 psi
• Standard propellant cartridges come in four sizes
  – Multiple diameters (1.2 to 3.6 inches in diameter)
  – Propellant is cast in sticks up to 27 inches long
• We can manufacture custom sizes based upon your application
Beyond time and production advantages, ATK’s propellant-based stimulation technology has the following attributes:

– Eases competing community demands for (often scarce) water resources

– Reduces traffic congestion/usage and the need for associated road repairs

– Smaller operating footprint is more acceptable to environmentally conscious communities

– ATK’s record of handling, transporting, and operating safety provides additional assurance to hosting communities

– Reduction/elimination of chemicals viewed more favorably by communities with concerns regarding impact to their land

– Reduced infrastructure required in remote or foreign locations
Case Studies

- ATK has conducted demonstrations on more than 600 wells using solid propellant technology with various data from ~60 demonstrations

- Demonstrations performed in 11 states, off-shore, and internationally in multiple oil, gas, & geothermal wells demonstrated positive results
  - 225% increase in production propellant versus hydraulic stimulated wells
  - 100% increase in old, re-stimulated well production
  - 30% to 50% reduction in pressure required to breakdown wells
  - 200% increase in volume with 75% decrease in the pressure for disposal wells
  - Created opportunity for production in a well that was dormant for 30 years
  - Demonstrated utility for repair operations (e.g., stuck components, damaged wells)
  - Demonstrations proved successful in test wells in Alabama, Alaska, Arkansas, California, Colorado, Louisiana, Kentucky, Mississippi, Oklahoma, Texas, Utah, North Sea, Gulf of Mexico, Nicaragua, Iceland, and Ukraine

- Data is vital to long-term improvement of the energetic stimulation technology
  - Each well provides an opportunity to collect important data to identify key parameters to improve performance
ATK has submitted a DoE proposal to gather hi-fidelity data from a well stimulation scenario

- Subject well is a horizontal gas well in Louisiana
- Instrumentation includes the advanced 3-dimensional micro-seismic capability available in the US
- Instrumentation also includes remote pressure transducer for precision measurement of the pressure vs. time curve

Data from this test, other US and international wells will support a data based statistical solution to optimize the propellant technology

- The more data gathered will benefit other wells with other customers by improving the efficiency and effectiveness of the propellant stimulation
- Additionally, ATK is partnering to build an analytical model to support stimulation optimization
• Subject well in Western Ukraine was abandoned for more than 10 years
  • Vertical well depth was >10,000 feet
  • No infrastructure available
  • Demonstration of concept
  • Long-term production data unavailable

• Partnered with local company and received a purchase order for stimulation of 100 wells in Ukraine
  • >3000 existing wells available
  • In negotiation with one independent
  • Other Ukrainian independents lining up

• Formation Type: Paleaogen shale

• Stimulated 3 Intervals
  • 2083-2086m
  • 2380-2386m
  • 2394-2397m

• Video was shot during retrieval of tool after second zone was stimulated
• ATK is actively pursuing the following worldwide:
  – Additional test wells to validate and quantify initial positive results
  – Additional contract opportunities to improve production or supplement/replace hydraulic fracking
  – Collaborative teaming with industry leaders to develop additional propellant treatments that are customized to optimize specific geological plays
  – Extension of geological penetration beyond current reach using energetics and modeling & simulation technology.