Gas Lift Valve Testing

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Gas Lift Valve Test Methods

Presentation Contents

• Overview of 19G2 Standard and Tests
• Background on SwRI
• Testing Methods and Facilities
• Other Testing
• Conclusion
API 19G2 Flow-Control Devices for Side-Pocket Mandrels

• Released June 2010, effective December 2010

• Validation Testing (Level V1, V2, V3)
  – Performed once per design

• Function Testing (Level F1, F2, and F3)
  – Performed on every valve sold

• SwRI has performed Validation Tests and custom tests to meet customer specifications
  – 19G2 does not require 3rd party test facility to perform tests
  – Test setups intended for flexibility in testing and customer requirements
API 19G2 Validation Testing

Validation testing

- Annex E: Interface testing
- Annex F: Insertion testing
- Annex G: Probe and travel testing and load rate determination
- Annex H: Dynamic flow testing and flow coefficient, Cv, calculation
- Annex I: Back-check testing
- Annex J: Open and closing pressure testing
- Annex K: Bellows actuation life cycle testing
- Annex L: Erosion testing
- Annex M: Shelf testing
- Annex N: Port/seat leakage rate testing
Validation testing performed at SwRI

- Annex E: Interface testing
- Annex F: Insertion testing
- Annex G: Probe and travel testing and load rate determination
- Annex H: Dynamic flow testing and flow coefficient, Cv, calculation
- Annex I: Back-check testing
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- Annex L: Erosion testing
  - Annex M: Shelf testing
  - Annex N: Port/seat leakage rate testing
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- Founded in 1947
- Private, independent, applied R&D company
- Over 3,000 employees
- 11 technical divisions
- Revenue in 2012 exceeded $557 million (over 4,200 contracts)
- Over 1,200 acres / 4.86 km² facility in San Antonio, Texas

Mission Statement: Benefiting government, industry and the public through innovative science and technology.
19G2 Testing Requirements

• Pressure and Flow Requirements
  – Water and gas static pressure testing (low and high pressure)
  – Low pressure water flow testing
  – High pressure gas flow testing

• Data Acquisition and Software Requirements
  – Measurement of pressure, temperature, and flow rate
  – Gas flow control through control valves
  – Perform all tests safely
Fluid Dynamics Section

Gas Test Facility

High Bay

Annex H

Annex G / Annex L

Annex I

High-Pressure Test Cell

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Annex G: Load and Travel Testing and Load Rate Determination

• **Probe Travel Test**
  - Determines the maximum effective travel distance for each device
  - Performed on a minimum of 7 flow control devices of each type
  - Stem travel measured with a micrometer or linearly variable differential transformer (LVDT)
  - Probe travel measured a minimum of 5 points along the travel (including maximum travel)

• **Load Rate Determination**
  - Calculated value from the results of the probe travel test
Annex G: Load and Travel Testing and Load Rate Determination

- Custom-built load rate testing fixture for PPO valves
- Fixture rated to 3,000 psi
- LVDT used to measure valve stem displacement
Load Rate Determination

Slope of this section is the load rate

Section of pressure rise without stem movement
Annex H – Flow Coefficient and Dynamic Flow Testing

• Flow coefficient measurement, Cv
  – Measured for each valve and port size
  – Measured at five points along stem travel (10%, 30%, 50%, 70%, and 100% open)
  – Performed with a modified valve

• Dynamic flow testing
  – Performed with a complete, unmodified valve
  – Performed for min. and max. port size, and every 1/8-inch in between (normally 4 or more valves per test)
  – Test performed at 6 constant injection or production pressures per valve
Nitrogen Gas Test Facilities

- Flow Rate Measurement
- Cryogenic Pump
- Heat Exchanger
- Discharge to Atmosphere
- High-Pressure Nitrogen Gas Storage
- Vertical Test Section
- Horizontal Test Section Area
- LN₂ Storage
Gas Flow Testing
Gas Flow Testing

- Constant injection pressure
- Controlled remotely by a custom Labview program
- Exhausts to atmosphere
- Programmable pressure ramps (based on system capabilities and valve time constant)
- Flow rate measured by a 3” orifice flow meter (AGA3 & NIST)
Nitrogen Gas Test Facility Capabilities

- Maximum flow rate: 10 mmscfd (196 m$^3$/min)
- Maximum upstream flow pressure: ~2,700 psi (187 bar)
- Maximum differential pressure: ~2,700 psi
- Nitrogen storage capacity: 1,125 ft$^3$ (32 m$^3$) at 3,000 psi (207 bar)
- Blowdown system flow time is a function of flow rate and pressure
  - 10 mmscfd at 1,500 psi upstream = ~6 min. steady flow
  - 1 mmscfd at 2,000 psi upstream = ~20 min. steady flow

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Valve Modification – Cv Testing

- Flow coefficient testing valve modifications
  - Create adjustable stem to control stem travel
  - Internal flow passage must not be modified
Dynamic Testing Example

Gas Lift Valve Test
Test Flowrate and Pressures

Choked Flow

Pressure [psig]

Flowrate

Elapsed Time [sec]

Upstream Pressure
Downstream Pressure
Flowrate
Flow Coefficient Data Evaluation

Gas Lift Valve Test
Y*Cv vs. Pressure Ratio

Data also used to calculate Critical Pressure Ratio ($R_{p,crt}$)
Flow Coefficient Data Evaluation

![Graph showing flow coefficient data for different valves. The graph illustrates the relationship between flow coefficient (Cv) and stem travel. Each valve has a distinct line: Valve 1 is shown with blue diamonds, Valve 2 with red squares, and Valve 3 with green triangles. The x-axis represents stem travel, while the y-axis represents flow coefficient (Cv).]
Annex I: Back-Check Testing

- **Mechanical function test**
  - Apply pressure with water to ensure the check dart moves freely without human intervention

- **Backflow integrity test**
  - Apply water pressure (to valve’s maximum rated pressure) on the downstream side of the check and measure through leakage through pressure decay

- **Gas Test**
  - Apply 100 psi of nitrogen gas to downstream of check and measure through leakage with a gas flow meter

- **Activation test**
  - Measure pressure required to open normally closed spring loaded valves (or flow required to close a reverse-flow valve)
Annex I: Back-Check Testing

Performed in the high-pressure test cell (2 cells available at FCTF, 3\textsuperscript{rd} cell coming late 2013)

- Capable of withstanding catastrophic failure of the test article
- Max. N\textsubscript{2} gas pressure: 40,000 psi
- Max. water pressure: 40,000 psi
- Max. hydraulic oil pressure: 35,000 psi
- Test fixtures locally heated or cooled
- Pressure applied remotely from a control room for safety
Annex I: Back-Check Testing

- Water or gas can be supplied to gas lift valves (water configuration shown)
- Vents double as flow meter ports during gas tests
- Test fixtures can be isolated
Annex I: Back-Check Testing

Photo courtesy of Schlumberger
Erosion Testing – Annex L

- Performed to simulate initial unloading of a well
  - Fresh water flow through complete valve
  - Flow rate fixed at 1 bbl/min (0.16 m³/min) for a total flow of 400 bbl (63.6 m³)
Other Gas Lift Valve Testing (other than 19G2)

- Sand slurry erosion testing
  - Sand types: fine to very coarse
- Flow provided by triplex pump
  - Pressure: 3,600 psi (257 bar)
  - Flow rate: 0.7 BBL/min (28 gpm)
Other Gas Lift Valve Testing (other than 19G2)

• Packing qualification
  – Seal integrity of gas lift valve packings
  – Pressure differential holds with water and gas
  – Temperatures: Cryogenic (LN$_2$) to 400°F
  – Gas through leakage measured with flow meter or bubble cup
  – Water through leakage measured through pressure decay

Photo courtesy of Schlumberger
Side Pocket Mandrel Qualification

• Inclinable test section
  – 100 ft long
  – Inclination up to 90°

• Horizontal and inclined running and pulling tests

• Pressure strain gauge tests

Photo courtesy of Schlumberger
Revisions to 19G2

- Task groups meeting to revise 19G2
  - Add a V0 validation level (currently V1, V2, and V3)
    - modeled after the Statoil qualification test
  - Remove gas flow testing from Functional Testing
Summary

- All valves stamped with the API 19G2 monogram undergo some or all of the testing mentioned in this presentation.
- There are several ways to do the tests outlined in 19G2, but certain high pressure water and gas facilities are required.
Questions?
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