Gas-Lift Valve Testing

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Gas-Lift Valve Test Methods

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

- Released June 2010, effective December 2010
- Validation Testing (Levels V1, V2, and V3)
  - Performed once per design
- Function Testing (Levels 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, $C_v$, calculation
- Annex I: Back-check testing
- Annex J: Open and closing pressure testing
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API 19G2 Validation Testing at SwRI

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
  - 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
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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.
• 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
Annex G: Probe 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: Probe 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.
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 pressures per valve
  – Constant injection pressure test (historically used by SwRI) or constant production pressure test
Nitrogen Gas Test Facilities

- Flow Rate Measurement
- Cryogenic Pump
- High-Pressure Nitrogen Gas Storage
- Heat Exchanger
- Discharge to Atmosphere
- LN₂ Storage
- Vertical Test Section
- Horizontal Test Section Area
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 m³/min)
- Maximum upstream flow pressure: ~2,700 psi (187 bar)
- Maximum differential pressure: ~2,700 psi
- Nitrogen storage capacity: 1,125 ft³ (32 m³) 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
Valve Modification – Cv Testing

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

![Diagram of unmodified and modified valves showing adjustable stem and unmodified flow passage.](image)
Dynamic Testing Example

Gas Lift Valve Test
Test Flowrate and Pressures

Choked Flow

Elapsed Time [sec]

Flowrate

Pressure [psig]

Upstream Pressure
Downstream Pressure
Flowrate
Flow Coefficient Data Evaluation

Gas Lift Valve Test
Y*Cv vs. Pressure Ratio

Cv

Pressure Ratio (x)
Flow Coefficient Data Evaluation
Annex I: Back-Check Testing

• Mechanical Function Test
  – Apply pressure with water to ensure that 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, 3rd cell coming early 2014)

- Capable of withstanding catastrophic failure of the test article
- Max. N\(_2\) 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 from a remote 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

- **Burst Disk**
- **Pressure Transmitters (high)**
- **Pressure Transmitters (low)**
- **Upstream/Downstream Source Valves**
- **Filters (6 shown)**
- **Vent Valves**
- **Test Fixtures**

High-Pressure Water and Nitrogen Source Connection (pumps not shown)

Photo courtesy of Schlumberger
Annex L: Erosion Testing

- 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)

![Diagram of erosion testing setup]

Upstream Pressure Transducer
Upstream Temperature Transducer
SwRI Gas-Lift Valve Flow Fixture
Flow Direction
Differential Pressure Transducer
From Tank, Pump, Flow Meter
Other Gas-Lift Valve Testing (other than 19G2)

• Sand slurry erosion testing
  – Flow provided by triplex pump
    • Pressure: 3,600 psi
    • Flow rate: 28 gpm
  – Sand types: fine to very course
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 (LN₂) to 400°F
  – Gas through leakage measured with flow meter or bubble cup
  – Water through leakage measured through pressure decay
API 19G1 – Mandrel Qualification

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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