FIELD TESTING GAS-LIFT VALVES BEFORE WELL INSTALLATION

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INTRODUCTION

The cost to roundtrip tubing to replace the gas-lift valves on tubing mandrels increases with the well depth and in certain locations as offshore platform wells. Wireline retrievable gas-lift valves and mandrels were developed to decrease the replacement costs of the valves in deeper inland and offshore platform wells. It is extremely costly at present to perform wireline operations in wells with subsea wellheads. Every individual gas-lift valve to be run by wireline in these subsea wellhead wells should be designed for maximum run life and tested for injection-gas throughput performance before installation in the well. The test rack opening pressure of a gas-lift valve is no indication of the injection-gas throughput performance. It is a measure of the bellows assembly closing force. There is now a method for performance testing of gas-lift valves that requires very little gas volume and seconds to complete. Details of this practical fast test procedure and why every gas-lift valve should be thoroughly tested before installation in high cost workover wells are discussed in this paper.

PROBE TEST FOR LINEAR STEM TRAVEL AND BELLOW ASSEMBLY LOAD RATE

A GLV probe tester [1] is shown in Figure 1. The purpose of a gas-lift valve probe test is to measure the maximum linear travel of the valve stem and the bellows assembly load rate. Valve stem travel is particularly important for larger port gas-lift valves in wells requiring high injection-gas rates for unloading and operating. The larger ports require greater stem travel to achieve a large or fully open port area. The area open to injection-gas flow can be calculated on the basis of the area of a frustum of a right circular cone when the gas-lift valve stem is in the throttling position (valve is not fully open). If the gas-lift valve has a sharp edged seat with a carbide ball 1/16-inch OD larger than the seat ID, the theoretical valve fully open stem travel is 0.1002 for a 1/4-inch ID port and 0.2246 for a 1/2-inch ID port. The probe tests in Figures 2 and 3 illustrate the change in the maximum linear valve stem travel and bellows assembly load rate with an increase in the test rack opening pressures of the same Camco Type J-20 injection pressure operated gas-lift valve with a 1/2-inch port. A test rack opening pressure increase from 200 to 700 psig decreases the linear stem travel from approximately 0.18 to 0.13 inch and increases the bellows assembly approximate load rate from 172 to 369 psi/inch.

API GAS-LIFT VALVE PERFORMANCE TESTING

Present methods for dynamically testing gas-lift valves as outlined by API are not ideally suited for individually testing every gas-lift valve before installation in a well. The API required test facility is extensive, the time required to perform a complete valve test is lengthy and the total high pressure gas requirement to test a valve is much greater than the method discussed in this paper. The API recommended valve testing facility requires a controllable high pressure gas source with a total gas volume available for a series of measured pseudo-steady state gas flow rates at different upstream pressures. A detailed description of the gas-lift valve test facility and testing procedure are published in the API Recommended Practice 11V2: ***Gas-lift Valve Performance Testing*** [2]. A schematic of a skid mounted test unit [1] that was designed to perform the API testing procedure is shown in Figure 4. This testing procedure was developed for API acceptance of a particular make and type of gas-lift valve. If there are any changes in the construction of an API designated gas-lift valve, this valve must be retested as outlined in API RP 11V2.

PROPOSED INDIVIDUAL GAS-LIFT VALVE TESTING METHOD

The proposed gas-lift valve testing of every valve before installation in the well does not replace the API testing method. Additional detailed and more accurate test data can be recorded using the API test procedure. The purpose of the individual gas-lift valve tests is to assure the operator that each valve's injection-gas throughput performance is equal to, or exceeds, the design assumptions for unloading and gas lifting the well. The proposed valve testing system designed to test all gas-lift valves for a high injection-gas rate installation is practical and economically feasible. The following features for this testing equipment and method of field testing every gas-lift valve before installation are possible due to modern electronics and computer controls.

1. No extensive surface test facilities should be required. The test equipment should require little space and hopefully be portable where the gas-lift valves could be tested utilizing the available injection-gas source at the wellsite.

2. Very small total gas volume should be needed for each complete valve evaluation; i.e., the test gas requirement for each valve should be minimal.

3. The time required to conduct each individual complete gas-lift valve test should be very short.

4. The test procedure should not be labor intensive. All data collection and analysis calculations should be electronically recorded and saved on a computer.

The recent availability of computer electronic systems with software that can record up to 50,000 pressure readings per second allows test procedures that provide the means to dynamically test the gas throughput performance of a gas-lift valve in seconds. The equipment for these tests includes LabVIEW software and National Instruments data acquisition and instrument control hardware. The method is based on a rapid pressure decline (blow-down) test. Actual total test time of a few seconds can provide sufficient test data to properly record and analyze each individual gas-lift valve's injection-gas throughput performance. These test procedures also provide the approximate linear valve stem travel before bellows stack and bellow assembly load rate.

DESCRIPTION OF BENCHMARK VALVE

The benchmark valve is a mechanical device that may, or may not, include a bellows. The valve stem-seat geometry and the injection-gas throughput inlet flow area of a benchmark valve should be identical to the actual gas-lift valve being evaluated. The upstream injection-gas and downstream pressures do not affect the valve-stem position. The valve stem in a benchmark valve is selectively positioned in relation to the valve port seat-line and the stem secured before each injection-gas passage test. Figure 5 is a schematic drawing of a benchmark valve [1]. The equivalent port-area open to flow can be calculated for each valve-stem position based on the calculated surface area of the frustum of a right circular cone.

BENCHMARK VALVE VOLUMETRIC INJECTION-GAS THROUGHPUT RATE TESTS:

The exact areas over which the downstream tubing and injection-gas pressures are applied are unknown in a partially open gas-lift valve port (valve stem in the throttling position). The exact actual downstream pressure is also unknown. The flow rates can be recorded for a selected upstream pressure and different set positions of a valve stem tip (usually a ball) relative to its position from the port seat-line. Reasonably accurate correlating coefficients for actual gas-lift valve flow rates can be derived utilizing the benchmark valve flow measurements.

Volumetric injection-gas throughput rates should be recorded for several throttling valve-stem positions between barely to fully open port area positions. A correlation relating valve-stem position to the gas throughput flow rate for varying valve-stem positions can be developed from the benchmark valve tests for different port sizes. These benchmark valve dynamic tests provide the method for predicting the flow rates of a gas-lift valve in the throttling mode (not fully open) for a known matched ball-seat port size. The gas-lift valve linear stem travel and bellows assembly load rate can be approximated from the actual gas-lift valve injection-gas throughput tests.

IMPORTANCE OF INDIVIDUAL GAS-LIFT VALVE PERFORMANCE TESTING

The data obtained by the test procedure for a particular type of gas-lift valve as outlined in API RP 11V2 should not be used to accurately predict the injection-gas throughput performance of this same type of gas-lift valve at significantly different set tester opening injection-gas pressures. The problem relates to the valve stem travel at different set tester opening pressures. The linear gas-lift valve stem travel and bellows assembly load rate are a function of the bellows charge pressure. As the bellows charge pressure increases, the linear valve stem travel decrease and the bellows assembly load rate increases. Actual electronic probe tests on the same gas-lift valve are shown in Figures 2 and 3. These changes in gas-lift valve performance characteristics can result in major errors in the difference between the calculated and actual gas-lift valve's injection gas throughput performance. For this reason, each gas-lift valve to be run in wells, where the cost of replacement is high should be tested. Gas-lift valves for lifting high liquid production rate wells with high daily injection-gas requirements for unloading and operating should be tested also for injection-gas passage before installation.

The widely used equation for calculating the gas flow rate through a choke is the Thornhill-Craver equation [3]. This equation applies to a square sharp-edged choke beam. This gas rate throughput equation must be modified for calculating the injection gas rate through a partially open gas-lift valve port where the area open to flow is the area of the frustum of a right circular cone. The benchmark valve can be used to determine the equation modifications for a partially open port. The stem in the benchmark valve can be set for desired equivalent partially open port sizes and the gas rate measured. An accurate injection-gas throughput equation for varying partially open port sizes can be formulated from these measured flow rates based on different set valve stem positions.

CONCLUSIONS

1. All gas-lift valves should have solid carbide seats to decrease individual gas-lift valve failures. This is particularly important for wells with costly entry and workover costs. Solid carbide seats should also assure less seat damage from wireline pounding to install the gas-lift valves in their mandrel pockets.

2. Since a gas-lift valve linear stem travel decreases and the bellows assembly load rate increases with increasing bellows charge pressure, the importance of individual gas-lift valve injection-gas throughput performance testing increases with higher injection-gas requirements.

3. Modern electronics and computer software provide a low cost, simple and fast gas-lift valve performance test procedure utilizing a "blow-down" method that can be performed at the wellsite using the injection-gas source for gas lifting the well.

REFERENCES

1. Winkler, H.W. and Camp, G.F.: "Dynamic Performance Testing of Single-Element Unbalanced Gas-Lift Valves", 60th Annual Technical Conference and Exhibition of the Society of Petroleum Engineers, Las Vegas, NV (September 22-25, 1985).

2. API Recommended Practice 11V2: ***Gas-lift Valve Performance Testing***, Second Edition, March 2001.

3. Cook, H.L. and Dotterweich, F.H.: ***Report on Calibration of Positive Flow Beans Manufactured by Thornhill-Craver Company, Inc.***, Houston, Texas, (1946).

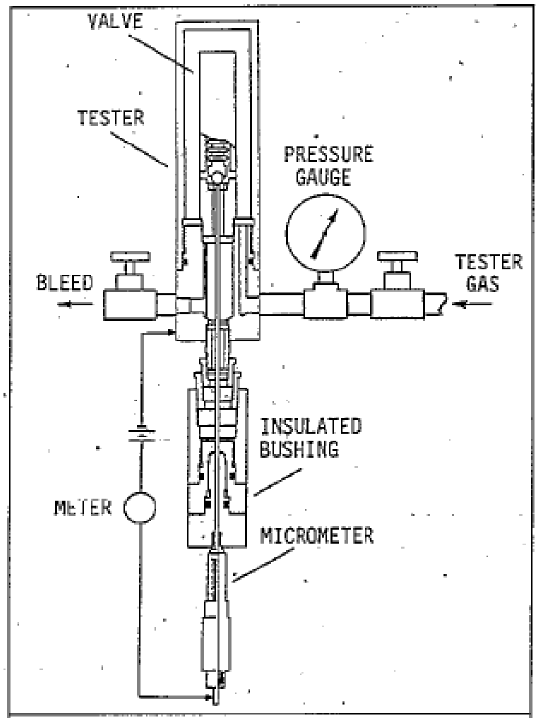

Figure 1- GLV Probe Tester

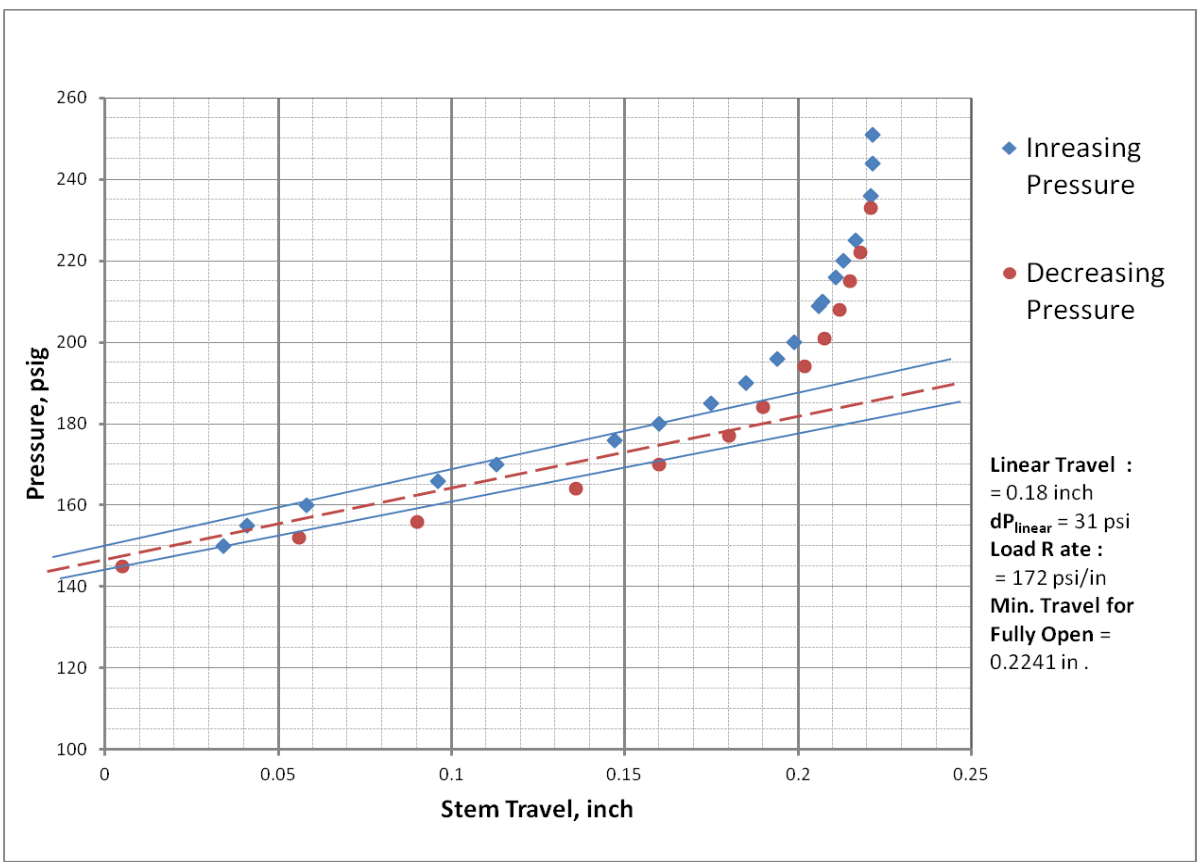

Figure 2 - Pressure vs. Stem Travel for Camco J-20 GLV with Ptro = 200 psig

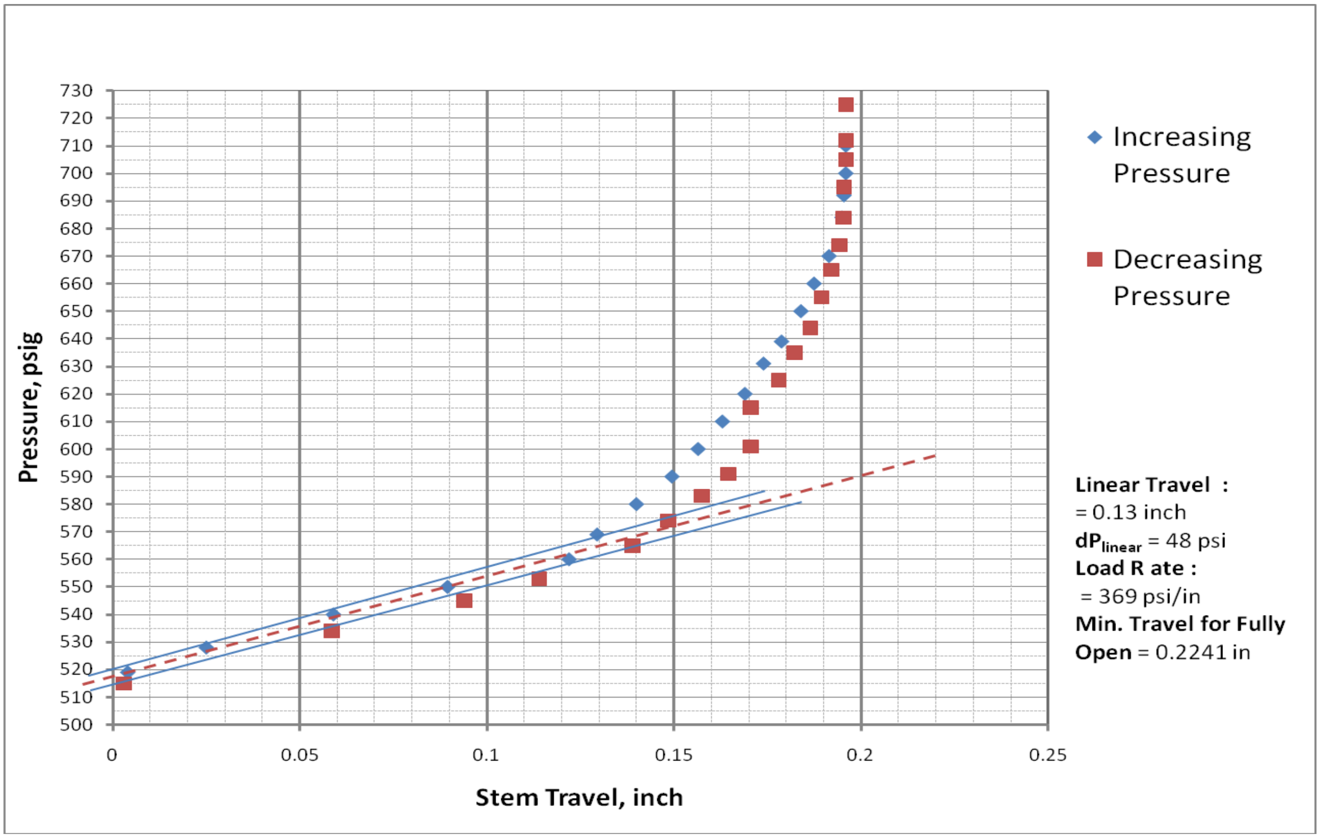

Figure 3 – Pressure vs. Stem Travel for Camco J-20 GLV with Ptro=700 psig

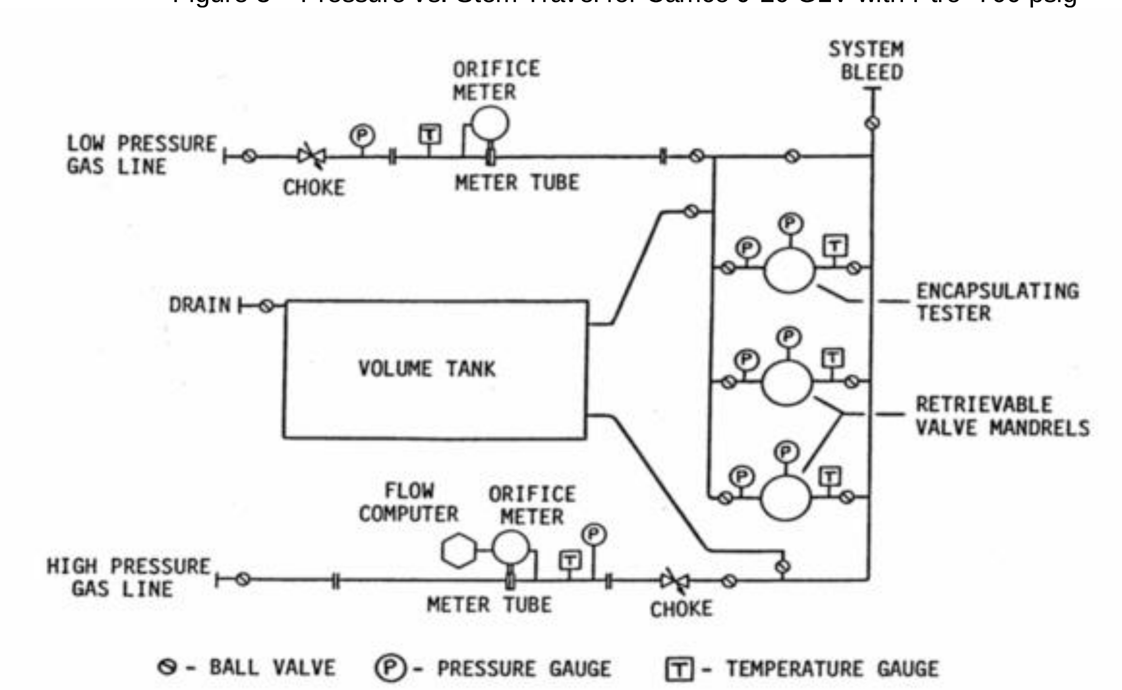

Figure 4 - Schematic of Skid Mounted Facility for API GLV Testing

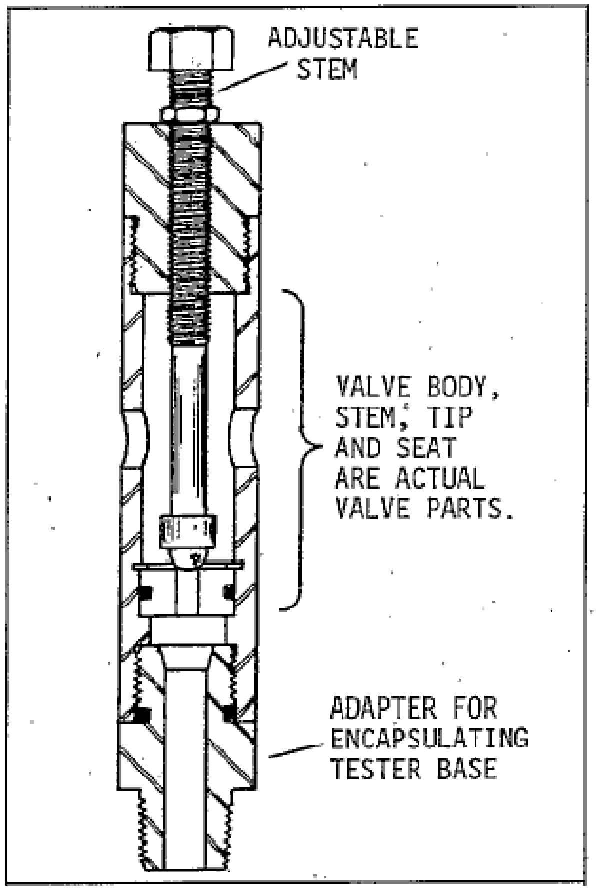

Figure 5 - Benchmark Valve