Failure modes of the V2 valves

Outside of drastic situations, fire, water and wreckage, there are two (2) levels of non rectifiable failures and one (1) correctable with the plastic body (V2) valves we are experiencing in the current OPC-M1.
I have classified the levels of failure as:

1) Operating the valve beyond its specified pressure range
2) Debris on the inlet seat hanging the valve open or causing flow restrictions.
3) Plunger stem going out of column in relation to the plastic body (deformation).

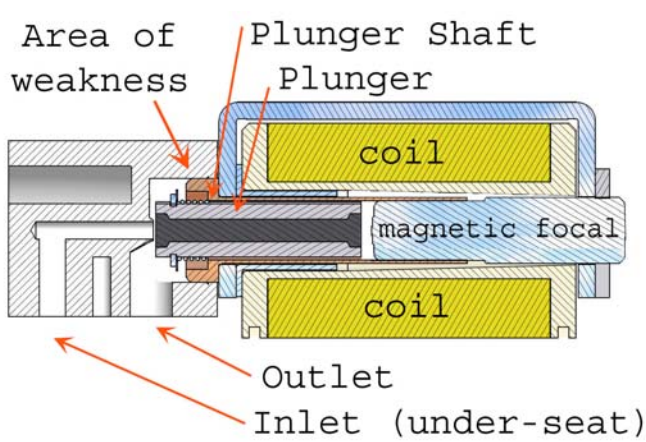
Level (1) V2 Over-pressure failures:
This mode is where there is leakage past the inlet seat caused by static over pressure or slight abnormalities with the polymer puck or the plastic seat itself. The latter is a normal production yield distribution that works out (breaks-in) over time with use. This however limits the valve to a lower margin of use over the specified operating pressure range. This is exacerbated by the fact that the selected EPDM material for lower temperature operations is pneumatically more porous against the plastic body than the (no low temperature) Viton plunger seat material is.

Because the modified* version of the SEA-MK-2 regulator used with the OPC-M1 has a lock-up to flow pressure ratio that produces pressure beyond the V2s specification margin and the OPC operating schedule, we are pre testing valves not to have any appreciable leakage at a static pressure of 40 psig. for use in each OPC-M1. See attached page 'Auqa-Lung regulator static & dynamic flow/pressure data'.

Level (2) V2 debris failures:
This is a failure mostly seen in valves coming from the field. However, we have seen this with some V2 valves directly from new stock. Other than energizing the valve and attempting to blow out any debris, there is no known method to rectify V2 valves with this failure as opposed to the brass body series 11, 25 & 26 valves. Rather they are labeled as unusable and stored for future disposition because of the inability to service them with debris on, or lodged in, the inlet seat.

Level (3) V2 deformation failures:
This mode of failure is when the valve's plunger stem has been moved 'out-of-column' with respect to the plastic V2 body causing it to leak past the seat, rendering it unusable. This mode of failure is usually from shock exposure during field use. However, we have seen this problem with some new V2 valves directly from stock right from the vendor. This mode of failure is unique to the V2 where the plunger stem is not properly aligned with the body, but otherwise deemed undamaged. Additionally, we are usually unable to detect this visually, rather it usually shows up on our leak test fixture. There is no known method to fix V2 valves with 'out-of-column' plunger-stems. Rather we label them as unusable and store them for future disposition because of the inability to service them. See figures below. With the over pressure operating mode, even the slightest misalignment from modest impacts cause a V2 leak failure. The OPC-M1 mounts the V2 valve to the manifold assy. by the plastic body. This causes a side mass moment that can dislodge the coil & plunger assy. from the body with modest impacts. A bracket (not shown) was added to mitigate V2 valve deformations from shocks and drops, but with modest success.

Current manufacturing processes of the V2 valve renders this failure issue in a much more way from our original versions of the V2 valve used for qualification. Parker Pneutronics has been made well aware of these issues and now states to us that the V2 valve is NOT suitable for use in mobile applications.



Failure modes of the V2 valves

Fig 1


Fig 2

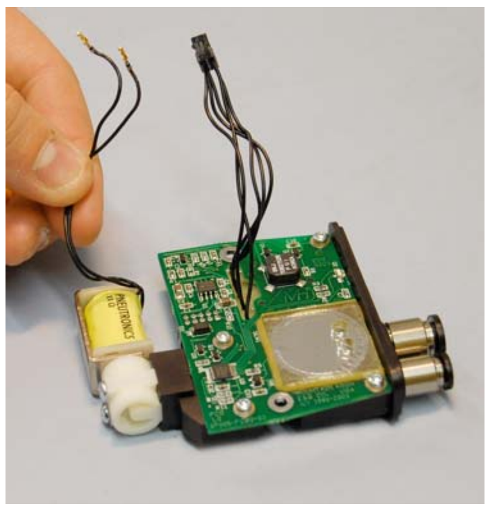
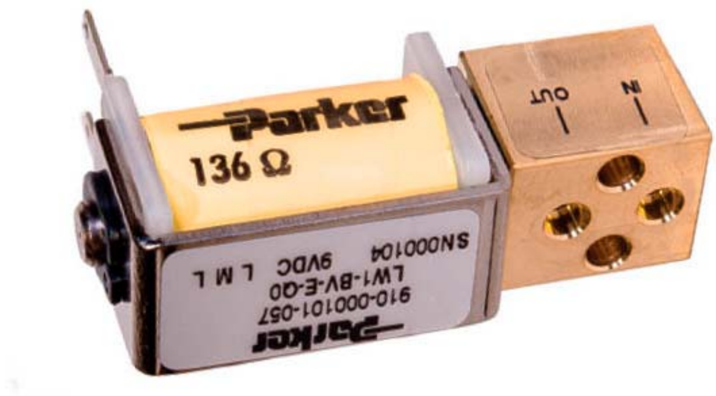
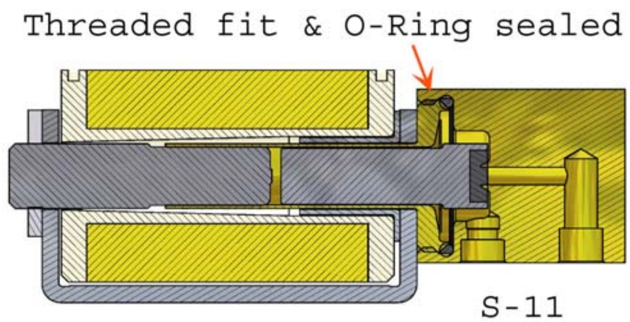



Fig 3

Failure modes of the V2 valves

Enter the (S11) manifold mounted Brass Body Valve
That is an example of the near direct replacement for the V2 Valve





Brass Body (s-11) Valve cut-a-way view

The brass bodied S11 valve is immensely more robust for the OPC-M2 application as the body is mounted to the magnet & plunger assy. via. threads and pneumatically sealed by an O-ring. This allows for the manifold mounting method to not be an issue from shocks and drops of the OPC unit.

Additionally as there is a slightly stronger spring in the V2 valve, the S11 has yet a more aggressive spring that allows for a greater sealing tolerance to the brass body inlet seat with the EPDM material to tolerate higher lock-up pressures than the V2 valve.

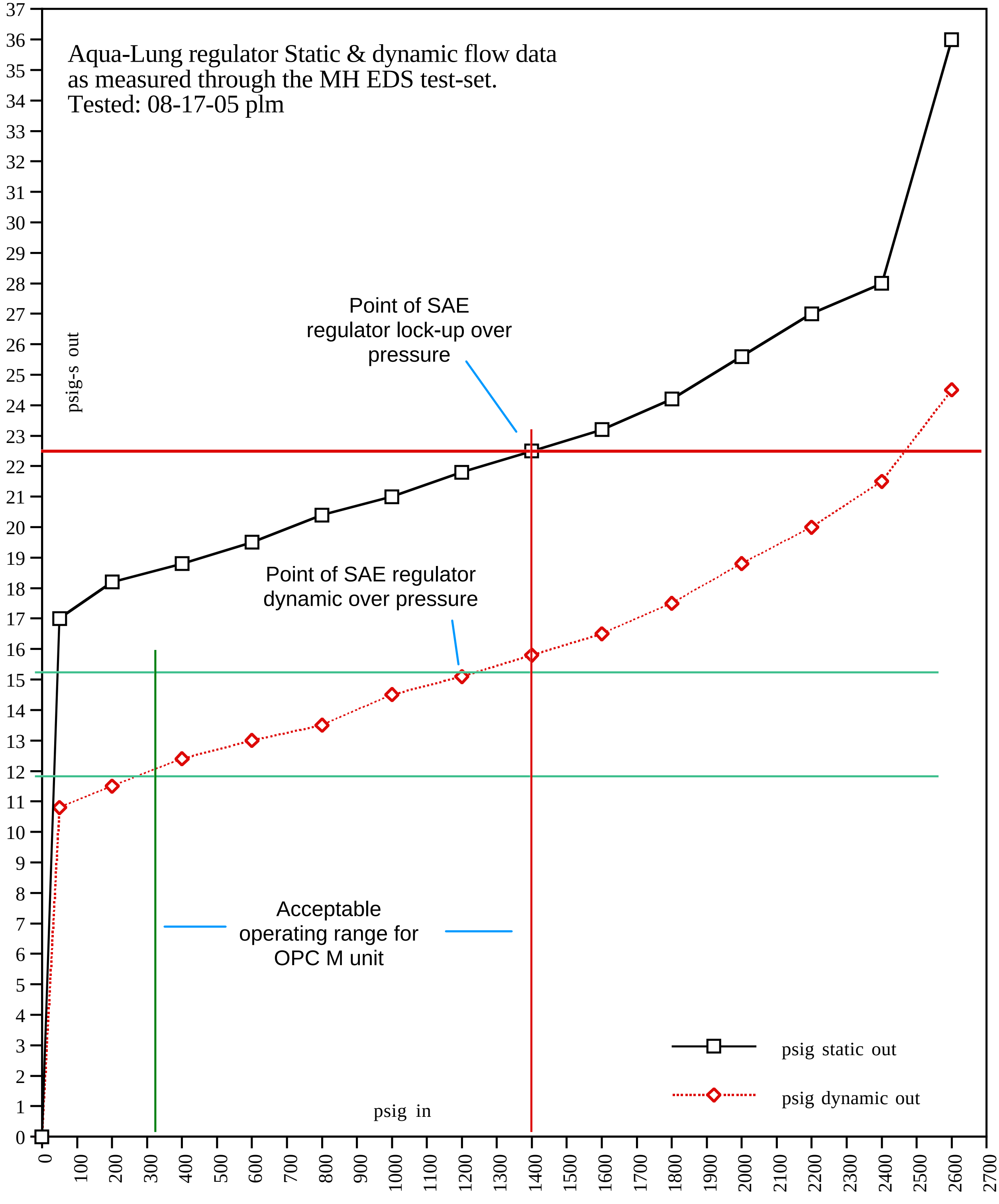
Again, outside of drastic situations; fire, water and wreckage, the brass-bodied valve (S11) has only one level of failure. This failure is where debris on the inlet seat can hang the valve open causing an obvious leak or a flow restriction that shows up in the ATP confidence test procedure. However, in this case the S11 valves are completely serviceable with basic servicing techniques. Much data collected over the years of use with these in our products since 1992 has proven that our OEM customer servicing method is a viable method of least-cost maintenance.

The manifolds for the second generation EDS system is designed to match-fit to the brass-body valve. Where the previous version manifolds for the V2 must be re-machined for an S11 valve retrofit.

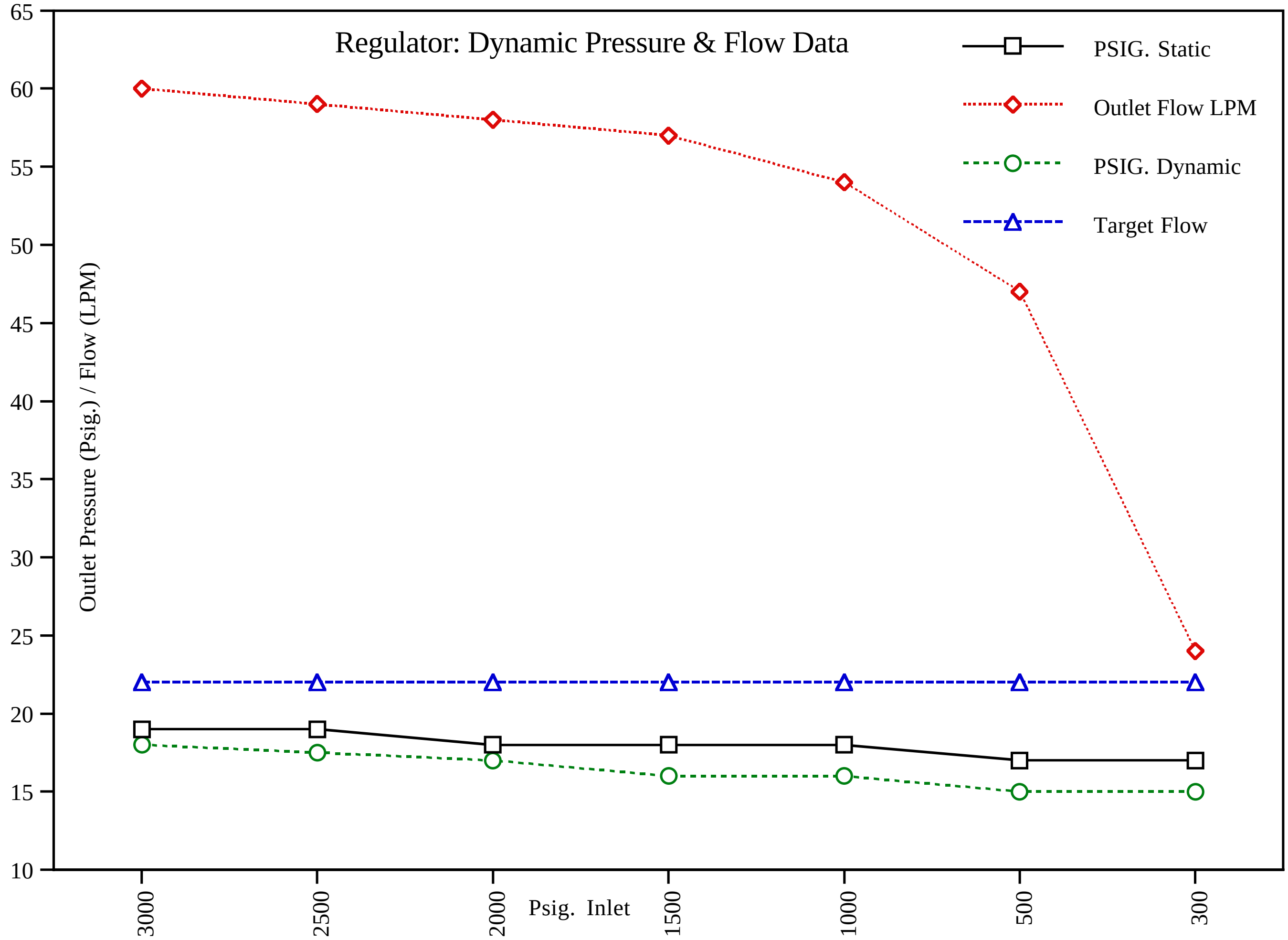
Additional information, related to this paper, is attached to the end of this document.

Note on the V2 Valves
The V2 series of valves are built with very high engineering and manufacturing standards. The V2 series are the industries best solution for an OEM valve for energy efficiency and operating speed in its class. However, the application engineer must be completely aware with the shock and vibration susceptibilities and the mechanical mounting restrictions particularly with the manifold mountable version of the V2 valve.

** Note on the Augua Lung modified SAE MK-2 for use with the OPC-M units.*
The SAE MK-2 has an inlet seat orifice diameter of ~ 0.95" where a high flow-rate at higher pressures are needed for SCBA/SCUBA application. However, in the OPC M units the SAE MK2 regulator body should be fabricated with an inlet orifice diameter of no more than 0.029" and complimented with a proper piston spring so that the lock-up and dynamic flow pressures will not violate the inlet pressure limits of the valve and the delivery schedule of the OPC unit. See next sheets.



Aqua-Lung regulator Static & dynamic flow data
as measured through the MH EDS test-set.
Tested: 08-17-05 plm
Point of SAE regulator lock-up over pressure
Point of SAE regulator dynamic over pressure
Acceptable operating range for OPC M unit
psig-s out
psig in
psig static out
psig dynamic out
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 2400 2500 2600 2700



Our regulators virtually have a flat outlet pressure regulation curve for both lock-up (static) and flowing (dynamic) with inlet pressures from 300 to 3,000 psig. Instantaneous, well dampened, oscillation free, flows through a controlled pneumatic resistance are measured at 55 to 60 liters/minute from inlet pressures of 1,000 to 3,000 psig. Target flows are ~25 liters/minute.

EDS units only need to have the regulator to Instantaneously deliver ~10 liters/minute to complement the needed amount of oxygen for pressure altitudes up to 18,000 ft.

It should be expected that the SAE-MK2 regulator could come close to this performance with the noted amendments

PNEUTRONICS DIVISION

PARKER HANNIFIN CORPORATION

Engineering Document No. ER0360

Prepared for:
Pneutronics

TITLE:

V^2 EPDM Sealing Capability

6 January 2018
Revision: 1

Prepared by:

Christopher Price

ABSTRACT

V^2 Valves with EPDM plungers are assessed for sealing capability between 0º C and -40º C at 20 PSI. Temperature was decreased with leak rate measured at fixed intervals.

1.0 PURPOSE

Determine sealing capability of V^2 EPDM plungers while operating at temperatures below 0º C.

2.0 SCOPE

Testing was performed with 10 V^2 Valves containing EPDM plungers. The plungers for all 10 valves were hand lapped to remove any imperfections. Measurements included a calibrated bubble method at fixed temperature and pressure. Pressure to the valve was applied beneath the seat.

3.0 APPARATUS AND PROCEDURE

3.1 Apparatus

Power Supply: Agilent model E3632
Pressure Regulator: Capable of maintaining 20 PSI
V^2 Manifold: 1 Manifold – 10 Valves per Manifold
Tenney Environmental Chamber
Beaker

3.2 Materials

V^2 Valves: 10 Valves w/EPDM Plungers
Vinyl Tubing: 0.078" diameter
Various wiring, tubing, fittings, and hardware to complete setup
600 Grit Emory Paper
Copper Heat Exchanger

3.3 Test Procedure

3.3.1 Disassemble 10 V^2 Valves and remove plungers, lap plungers to smooth out surface finish using 600 grit Emory paper, check surface finish before and after with micrographs.

3.3.2 Reassemble all 10 valves with new bodies, spring and bobbin retaining clips. Determine leak rate on Ateq.

3.3.3 Mount all 10 Valves to manifold and wire all valves individually so they can be operated one at a time.

3.3.4 Determine maximum leak pressure under the seat at room temperature using calibrated bubble method.

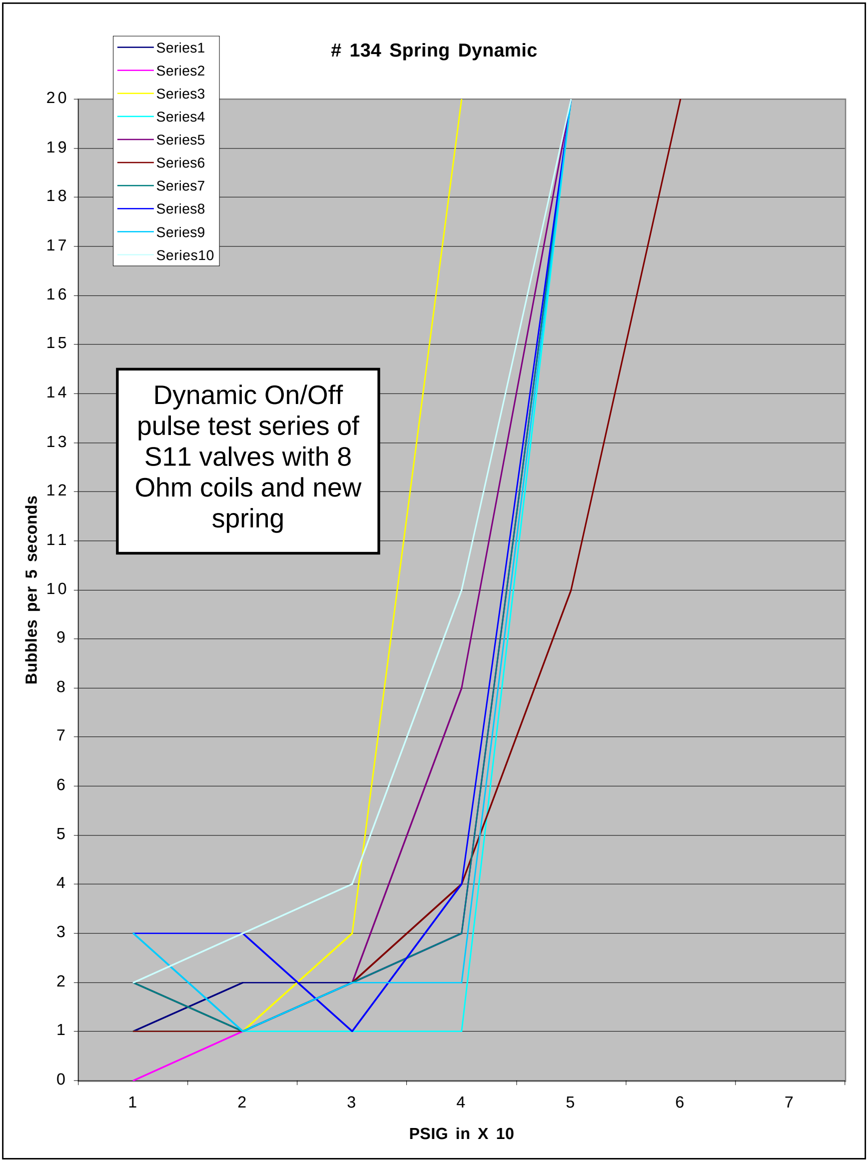
3.3.5 Setup environmental chamber, place valves inside chamber and route wires, supply line, and return lines outside chamber through access port. Insulate and tape off access port.

3.3.6 Install copper tubing coil inline with supply line inside environmental chamber to maintain constant line temperature.

3.3.7 Label all wires and return lines to its corresponding valve.

3.3.8 Set environmental chamber to 0º C, allow chamber to reach steady state. Set supply line to 20 PSI and test each valve individually for leak using calibrated bubble method. Repeat this step for -5º C to -30º C.

3.3.9 If valves are still within leak rate parameters continue reducing temperature by 10º C until valves will no longer meet leak requirements.



134 Spring Dynamic
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8
Series9
Series10
Dynamic On/Off pulse test series of S11 valves with 8 Ohm coils and new spring
Bubbles per 5 seconds
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
1
2
3
4
5
6
7
PSIG in X 10