Why Compressibility Counts

Traditional hydrostatic testing methodologies utilize pressure decay as a means of determining the integrity of BOP Stacks, wellheads, casing, pipe, tanks, reactors, and many other pressure containment vessels throughout various industries. In these tests intensification fluid is added to the test vessel in an amount sufficient to case a pressure increase equal to the initial test pressure. Subsequent to reaching the initial test pressure, the pressure vessel is isolated and "blocked in," and over the course of a specified time period, the pressure is monitored for pressure decay. It is normally accepted that a decay in the test pressure indicates the presence of a leak. This is generally true, however, the measured pressure decay rate would not indicate the actual volumetric leak rate. The actual volumetric leak rate would be a function of pressure decay and the apparent compressibility of the test vessel. The apparent compressibility of the test vessel is a result of the compressibility of the intensification fluid, any trapped air within the test vessel, and the mechanical flexibility of the test vessel. The following examples depict the importance of understanding the effects of apparent compressibility in hydrostatic testing.

In this first example related to residual trapped air, a hydrostatic test of a BOP stack, with a theoretical liquid full volume of 2 bbls, is to be tested to an initial pressure of 250 psi. The hydrostatic test specification specifies a test period of 5 minutes with a maximum pressure decay rate of 5 psi/min or 25 psi over the entire test time. Consider, for example, during the hydrostatic test the residual trapped air within the BOP stack is 1% and the results of the hydrostatic test indicates a pressure decay rate of approximately 4 psi/min. The test would have been deemed to have passed as the pressure decay rate was less than the 5 psi/min specification. The approximate volumetric leak rate is 6.95 cc/min considering that the BOP stack with a trapped air volume of 1% has apparent compressibility at 250 psi of approximately 1.65 cc/psi. Now consider, for example, during the hydrostatic test the residual trapped air within the BOP stack is 3% and the results of the hydrostatic test indicates the very same pressure decay rate of approximately 4 psi/min. The test would have been deemed to have passed as the pressure decay rate was less than the 5 psi/min specification. However the approximate volumetric leak rate is now 12.97 cc/min considering that the BOP stack with a trapped air volume of 3% has apparent compressibility at 250 psi of approximately 3.07 cc/psi.

In a second example related to volume a BOP stack with 1% residual trapped air is to be tested to 5,000 psi. The test specification is the same as above, 5 minutes with a maximum pressure decay rate of 5 psi/min or 25 psi over the entire test time. Now consider, for example, during the hydrostatic test the test volume of the BOP stack and associated valves lined up for this test is approximately 1bbl and the results of the hydrostatic test indicates a pressure decay rate of approximately 4 psi/min. The test would have been deemed to have passed as the pressure decay rate was less than the 5 psi/min specification. The approximate volumetric leak rate is 1.64 cc/min considering that the BOP stack with a test volume of 1bbl has apparent compressibility at 5,000 psi of approximately 0.389 cc/psi. Now consider, for example, during the hydrostatic test the test volume of the BOP stack and associated valves lined up for this test is approximately 2bbl and the results of the hydrostatic test indicates the same pressure decay rate of approximately 4 psi/min. The test would have been deemed to have passed as the pressure decay rate was less than the 5 psi/min specification. However the approximate volumetric leak rate is 3.28 cc/min considering that the BOP stack with a test volume of 2bbl has apparent compressibility at 5,000 psi of approximately 0.778 cc/psi. FIG 1 and FIG. 2 graphically depicts the significantly different results of the respective tests.

The actual volumetric leak rate is a much more precise indictor of the overall reliability of the system than the traditional pressure decay test in which merely a pass or fail measurement is derived indirectly

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from the volumetric leak rate without regard for apparent compressibility. To further illustrate, consider for example that a standard gate valve associated with a BOP stack and manifold system has a leak rate of 3.28 cc/min as previously described. If this valve were tested at 5,000 psi in conjunction with a BOP stack having a test volume of 1 bbl, it would fail the previously describe pressure decay test with a psi decay rate of approximately 8 psi/min. If the very same valve with the very same leak were tested in conjunction with a BOP stack having a test volume of 2 bbls, it would pass the previously describe pressure decay test with a psi decay rate of 4 psi/min. FIG. 3 graphically depicts the results of this test scenario where the 5 psi/min line is plotted against test volume. Any volumetric leak rate which falls above and to the left of the line is deemed to have failed and any volumetric leak rate that falls below and to the right of the line is deemed to have passed. The volumetric leak rate (3.28cc/min) is plotted as blue dots. Notice that the volumetric leak rate for both test (1 bbl and 2 bbl) is 3.28 cc/min but the 1bbl test fails and the 2bbl test passes.

It is evident that a psi decay testing methodology is not an accurate means of establishing the leak rate or the sealing integrity of BOP stack and associated ancillary sealing devices. Ei recognizes the deficiencies of utilizing psi decay without regard for the apparent compressibility associated with hydrostatic tests. Therefore all of the technologically advanced hydrostatic test systems manufactured by Ei are capable of performing standard pressure decay hydrostatic tests as well as enhanced hydrostatic tests where the apparent compressibility associated with the hydrostatic test is measured in real time and applied to report an actual volumetric leak rate.

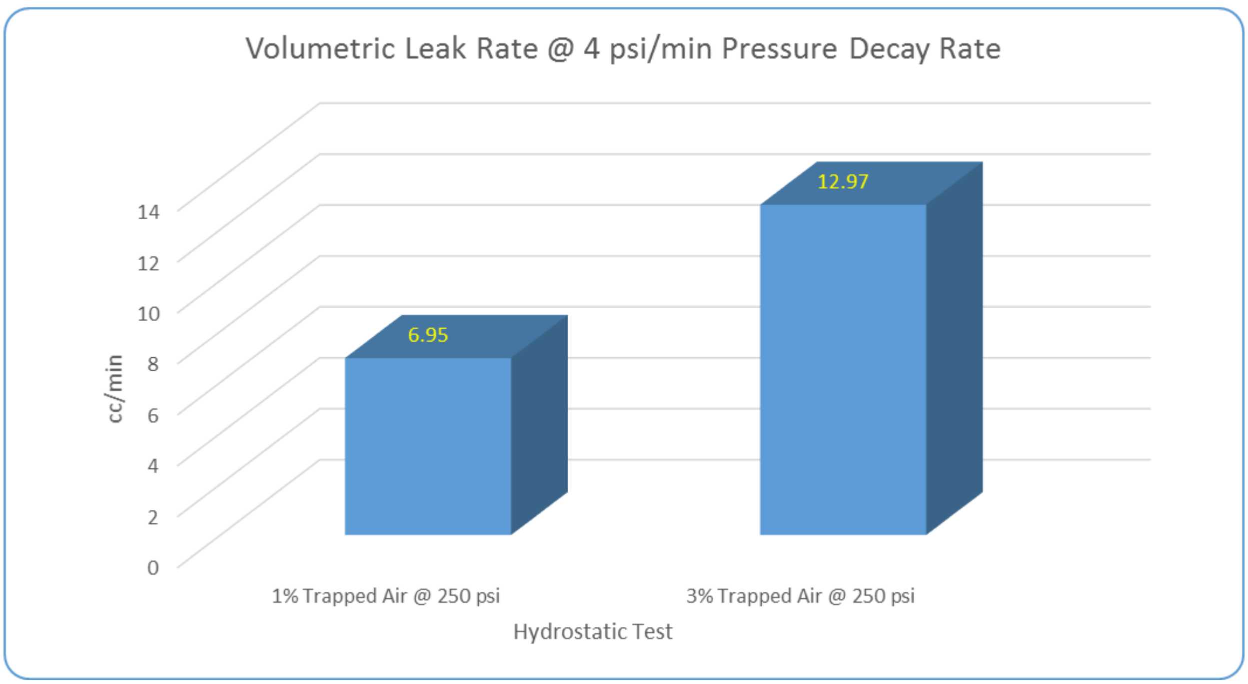

FIG.1

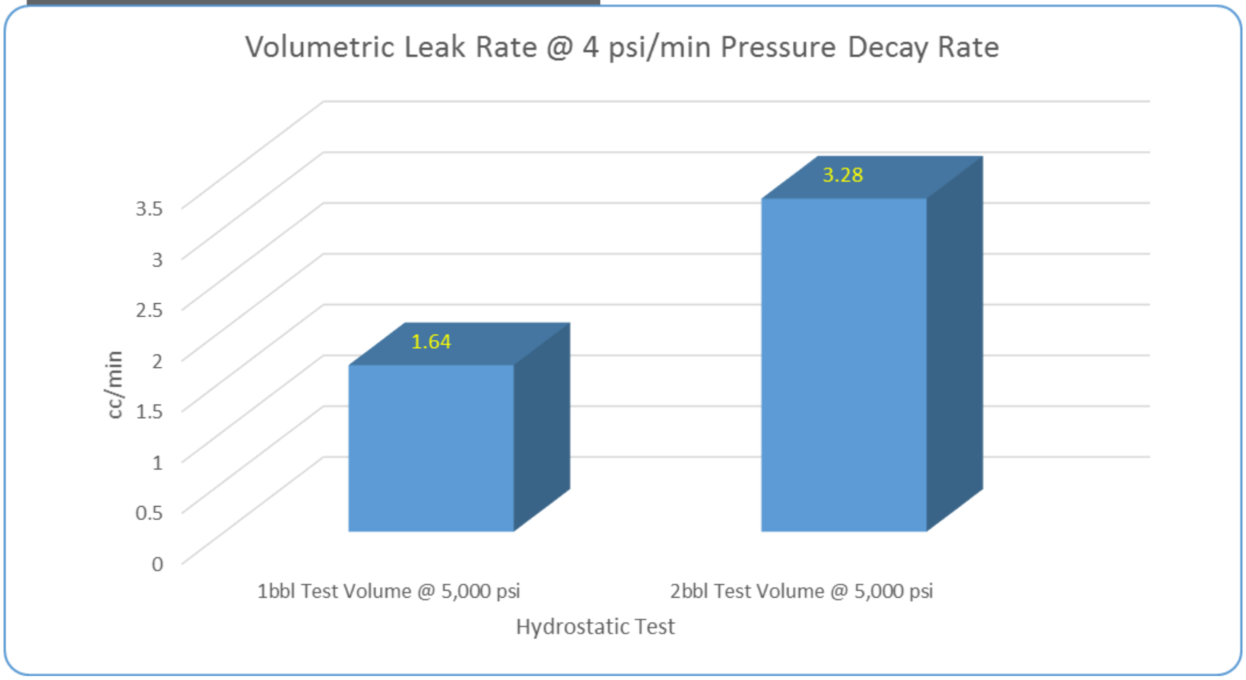
Volumetric Leak Rate @ 4 psi/min Pressure Decay Rate
cc/min
0
0.5
1
1.5
2
2.5
3
3.5
1.64
3.28
1bbl Test Volume @ 5,000 psi
2bbl Test Volume @ 5,000 psi
Hydrostatic Test

FIG. 2

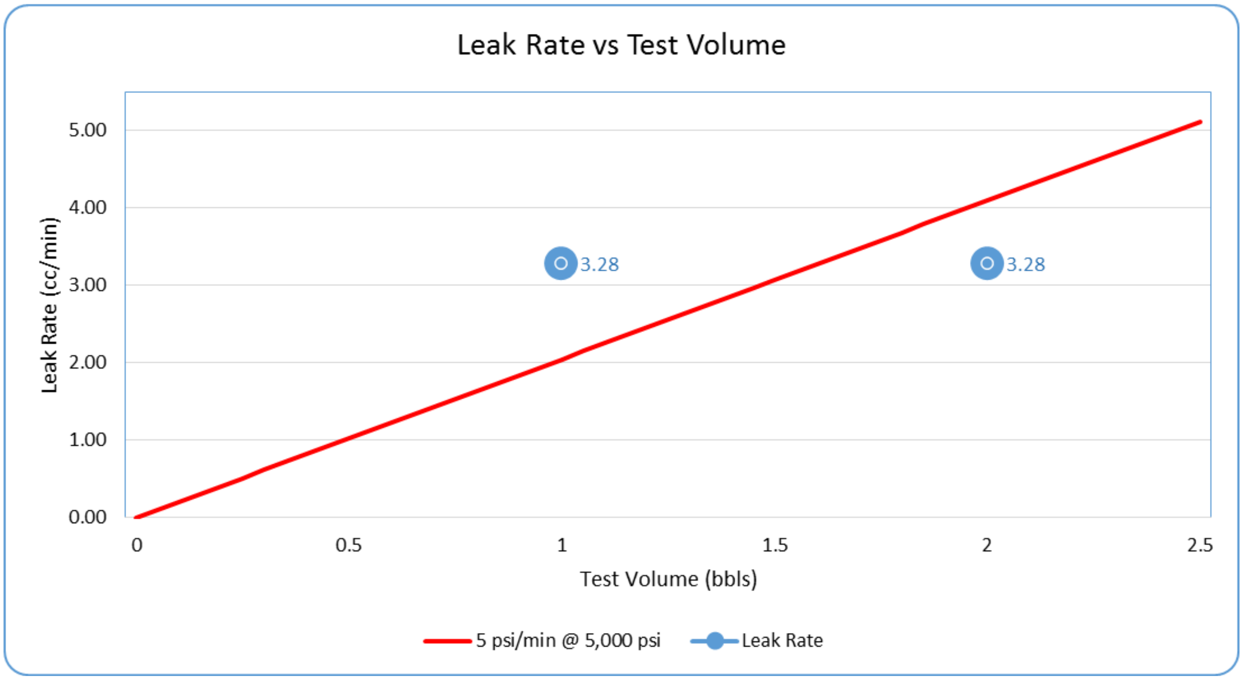
Leak Rate vs Test Volume
Leak Rate (cc/min)
0.00
1.00
2.00
3.00
4.00
5.00
3.28
3.28
0
0.5
1
1.5
2
2.5
Test Volume (bbls)
5 psi/min @ 5,000 psi
Leak Rate

FIG. 3