WEIGHT EXPANSION MEASUREMENT SYSTEM

1.0 The weight expansion measurement system (WEMS) incorporates the methodology of volumetric expansion by measuring the weight (rather than the volume) of water displaced in a volumetric expansion test. The WEMS uses a siphon tube instead of an open top burette tube to measure the weight of the water displaced. The WEMS is based upon the scientific correlation between the volume of water and the weight of water: 1 cubic centimeter of water weighs 1 gram of water (at 4 degrees Celsius). Therefore the WEMS simply measures the weight of water displaced by using a weigh container on a digital weigh scale or load cell, and then determines the expansion of water displaced.

1.1 The weight expansion measurement system has certain practical advantages over the burette system. Most importantly it eliminates any possibility for operator interpretation error during burette meniscus expansion readings. Second, the expansion volumes can easily be determined with great precision and then communicated to operators or to computer-controlled automated testing systems. In addition, WEMS eliminates the need for fragile glass burette tubes and plumbing to multiple burette tubes.

1.2 However, there are several factors that must be addressed to ensure the accuracy of the WEMS: temperature, the buoyancy effect of the siphon tube, the effect of water column height, and the accuracy of the weight measurement device. All of these factors may affect the accuracy of the weight expansion readings unless adjustments are made to account for their impact on the readings.

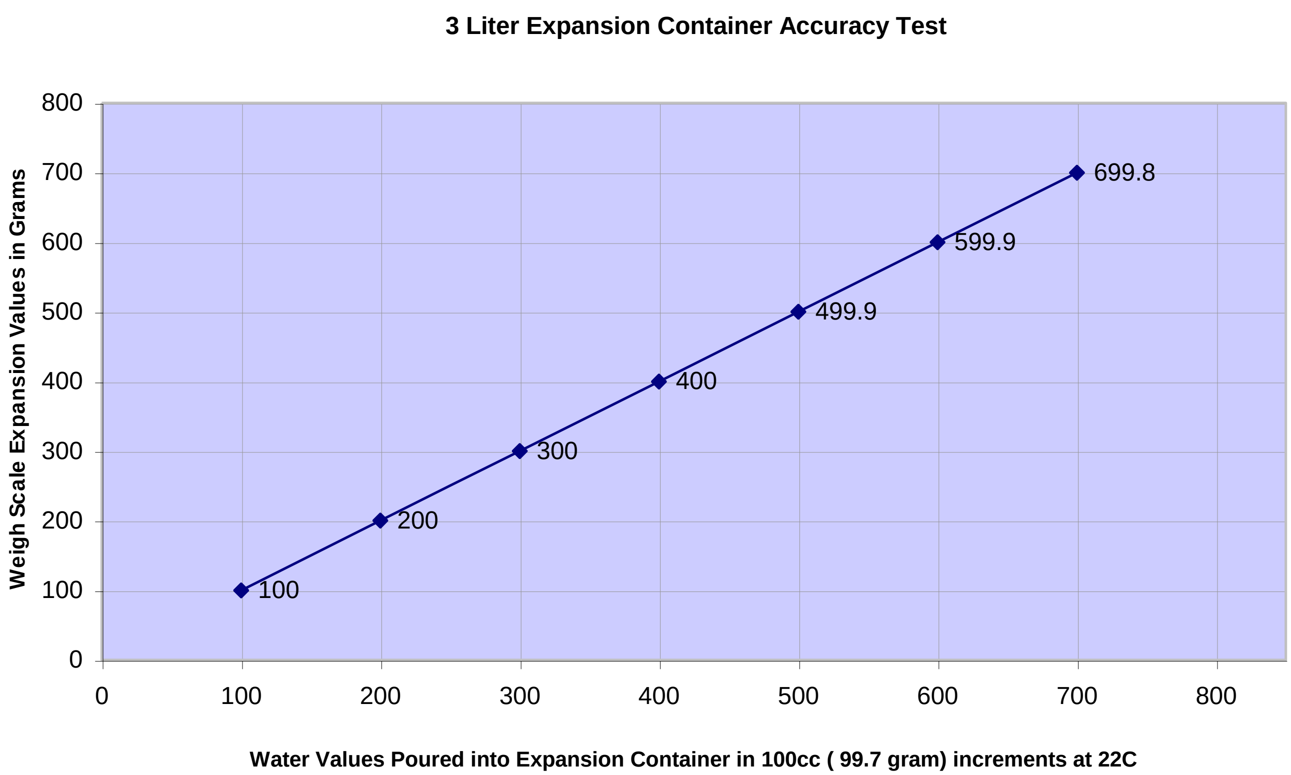
1.3 The effects of water column height change and buoyancy of the siphon tube can be easily determined by pouring a known quantity of water into the expansion measurement container when the device is open to a test jacket. The weight measurement device can be easily tested and verified by using a calibrated reference weight to determine its accuracy. Water density changes due to temperature can be corrected mathematically using known water density values at various temperatures (See Appendix B).

1.4 In a hydrostatic testing system, the above factors can operate inversely such that the aggregate impact of all effects combined has a negligible impact on the accuracy of the expansion values derived. Various tests have been conducted to verify that such combined effects do have a very minute effect on expansion values at ambient temperatures around 22 Centigrade.

1.5 The accuracy of a weight measurement device is tested by placing a calibrated reference weight upon it to verify its accuracy. Next, 100 cubic centimeters of water at ambient temperature is weighed into a container using another calibrated digital scale with a resulting weight of 99.7 grams (see Appendix B for resulting weights at different temperatures). The 100 cubic centimeters of water are then poured into a 3 liter square expansion container that rests on the expansion measuring weigh scale. Expansion weight values are then recorded. The process is repeated in 100 cc increments with expansion weight measurements being recorded respectively at each 100 cc volume level.**

The following expansion testing data and graphs clearly portray the minute and negligible impact resulting from the combined effects of temperature, buoyancy, and water column height.

APPENDIX A



APPENDIX B

Water Density versus Temperature in .1 C increments

Deg C	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0	0.999841	0.999847	0.999854	0.99986	0.999866	0.999872	0.999878	0.999884	0.999889	0.999895
1	0.9999	0.999905	0.999909	0.999914	0.999918	0.999923	0.999927	0.99993	0.999934	0.999938
2	0.999941	0.999944	0.999947	0.99995	0.999953	0.999955	0.999958	0.99996	0.999962	0.999964
3	0.999965	0.999967	0.999968	0.999969	0.99997	0.999971	0.999972	0.999972	0.999973	0.999973
4	0.999973	0.999973	0.999973	0.999972	0.999972	0.999972	0.99997	0.999969	0.999968	0.999966
5	0.999965	0.999963	0.999961	0.999959	0.999957	0.999955	0.999952	0.99995	0.999947	0.999944
6	0.999941	0.999938	0.999935	0.999931	0.999927	0.999924	0.99992	0.999916	0.999911	0.999907
7	0.999902	0.999898	0.999893	0.999888	0.999883	0.999877	0.999872	0.999866	0.999861	0.999855
8	0.999849	0.999843	0.999837	0.99983	0.999824	0.999817	0.99981	0.999803	0.999796	0.999789
9	0.999781	0.999774	0.999766	0.999758	0.999751	0.999742	0.999734	0.999726	0.999717	0.999709
10	0.9997	0.999691	0.999682	0.999673	0.999664	0.999654	0.999645	0.999635	0.999625	0.999615
11	0.999605	0.999595	0.999585	0.999574	0.999564	0.999553	0.999542	0.999531	0.99952	0.999509
12	0.999498	0.999486	0.999475	0.999463	0.999451	0.999439	0.999427	0.999415	0.999402	0.99939
13	0.999377	0.999364	0.999352	0.999339	0.999326	0.999312	0.999299	0.999285	0.999272	0.999258
14	0.999244	0.99923	0.999216	0.999202	0.999188	0.999173	0.999159	0.999144	0.999129	0.999114
15	0.999099	0.999084	0.999069	0.999054	0.999038	0.999023	0.999007	0.998991	0.998975	0.998959
16	0.998943	0.998926	0.99891	0.998893	0.998877	0.99886	0.998843	0.998826	0.998809	0.998792
17	0.998774	0.998757	0.998739	0.998722	0.998704	0.998686	0.998668	0.99865	0.998632	0.998613
18	0.998595	0.998576	0.998558	0.998539	0.99852	0.998501	0.998482	0.998463	0.998444	0.998424
19	0.998405	0.998385	0.998365	0.998345	0.998325	0.998305	0.998285	0.998265	0.998244	0.998224
20	0.998203	0.998183	0.998162	0.998141	0.99812	0.998099	0.998078	0.998056	0.998035	0.998013
21	0.997992	0.99797	0.997948	0.997926	0.997904	0.997882	0.99786	0.997837	0.997815	0.997792
22	0.99777	0.997747	0.997724	0.997701	0.997678	0.997655	0.997632	0.997608	0.997585	0.997561
23	0.997538	0.997514	0.99749	0.997466	0.997442	0.997418	0.997394	0.997369	0.997345	0.99732
24	0.997296	0.997271	0.997246	0.997221	0.997196	0.997171	0.997146	0.99712	0.997095	0.997069
25	0.997044	0.997018	0.996992	0.996967	0.996941	0.996914	0.996888	0.996862	0.996836	0.996809
26	0.996783	0.996756	0.996729	0.996703	0.996676	0.996649	0.996621	0.996594	0.996567	0.99654
27	0.996512	0.996485	0.996457	0.996429	0.996401	0.996373	0.996345	0.996317	0.996289	0.996261
28	0.996232	0.996204	0.996175	0.996147	0.996118	0.996089	0.99606	0.996031	0.996002	0.995973
29	0.995944	0.995914	0.995885	0.995855	0.995826	0.995796	0.995766	0.995736	0.995706	0.995676
30	0.995646	0.995616	0.995586	0.995555	0.995525	0.995494	0.995464	0.995433	0.995402	0.995371
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9