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Reading, Correction or Error?
Issues in Volume Calibration
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Numerous round robins in every regional group have demonstrated that there is confusion among metrologists over whether a reported value is a gauge reading, a correction to be applied (in the lab or in the field), or an error on the prover.

Gauge Reading: the observed value of the meniscus on the prover - without any corrections for temperature or delivery from the standard (e.g., no Z60 formula). Apositive gauge reading does NOT mean anything without additional information included such as the calibrated volume of the standard, whether the standard was set to nominal capacity before delivery, and what the temperatures are in the standard and unknown.

Error: the value by which the prover deviates from the nominal volume. A positive error means the prover is large. A negative error means the prover is small.

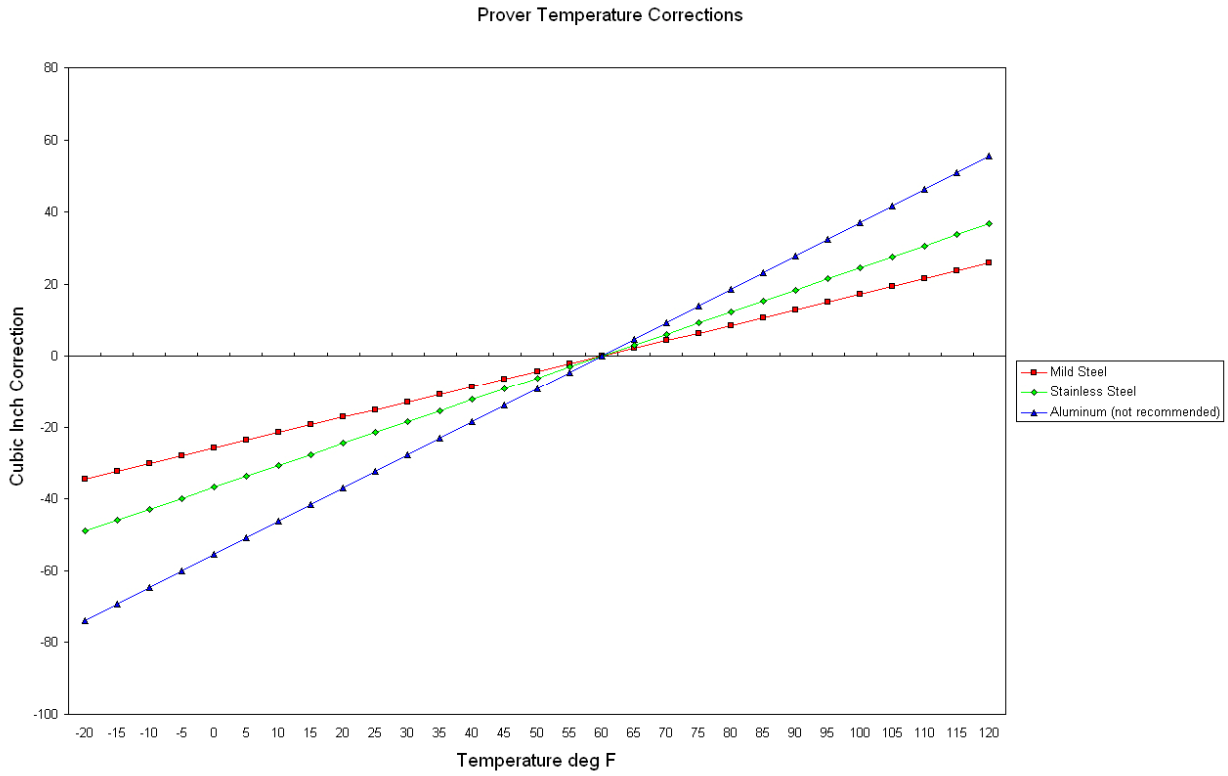
Correction: the value to be applied in use. A positive correction is the amount that is added to the gauge reading in field use.

If there is confusion among the metrologists who are doing the calibrations, what kind of confusion must exist in meter testing applications when these values are provided to the users? Setting test measures and provers to nominal values at reference temperatures (and pressures in the case of LPG) can help avoid problems with use of errors and corrections, but only when used at the reference temperatures. Providing the full calibrated volume of the prover can help avoid problems and enable subsequent temperature corrections.

Temperature corrections must be made to the prover volume in field applications when the provers are used! See the February 2004 article by Dick Suiter, on "Temperature is a Big Factor in Vehicle-Tank Meter Test" in the WMD Archives at: http://ts.nist.gov/ts/htdocs/230/235/news-letterarchive.htm. Dick provided the equations to be used to calculate the actual volume change of the prover and provided several examples of the volumetric impact in meter testing. The table and graph on the following page provides a simplified view of the impact for stainless steel and mild steel 100 gallon provers.

For example, if a 100 gallon prover is larger than nominal and a meter delivers exactly 100 gallons at 60 ºF, the gauge reading on the prover will be lower than nominal and the correction for the prover needs to be considered. Further, if a stainless steel prover is larger than nominal by 6 cubic inches at 60 ºF, and the prover is then used at 50 ºF, the prover is smaller at that temperature and is actually the nominal size of 100 gallons!

Example: 100 gallon prover CCE = cubical coefficient of expansion				
	Mild Steel		Stainless Steel	
CCE	1.86 x 10-5/F		2.65 x 10-5/F	
Temp F	cu in	gal	cu in	Gal
10	-21	-0.093	-31	-0.133
20	-17	-0.074	-24	-0.106
30	-13	-0.056	-18	-0.079
40	-9	-0.037	-12	-0.053
50	-4	-0.019	-6	-0.026
60	0	0.000	0	0.000
70	4	0.019	6	0.026
80	9	0.037	12	0.053
90	13	0.056	18	0.080
100	17	0.074	24	0.106
110	21	0.093	31	0.133
120	26	0.112	37	0.159



Recommendations:

1. Test measures and provers should be adjusted to nominal values at 60 ºF at calibration whenever possible.

2. The actual calibrated volume (e.g., 100.001 gallons or 99.999 gallons) should be reported on all calibration reports to avoid confusion among terms of error and correction, and their use in meter testing.
3. The temperature of the water at the time of calibration is also needed on the calibration report because temperature is such a critical factor for volume calibrations.