SOP 21

Standard Operating Procedure for Calibration of LPG Provers[1]

1 Introduction

1.1 Purpose of Test

This procedure may be used to calibrate a volume standard used to test systems designed to measure and deliver liquefied petroleum gas (LPG) in the liquid state by definite volume, whether installed in a permanent location or mounted on a vehicle. A schematic diagram of such a prover is shown in Figure 1, together with numbers, e.g., 1, 2, 3, and 4 to clarify the various operations described in the procedure. The parts labeled A, B, and C are hose connections used in meter testing (versus prover calibrations).

1.2 Prerequisites

1.2.1 Verify the unknown prover has been properly cleaned and vented with all petroleum products removed prior to submission for calibration to ensure laboratory safety.

1.2.2 Verify that valid calibration certificates are available for the standard used in the test.

1.2.3 Verify that the standards to be used have sufficiently small standard uncertainties for the intended level of the calibration.

1.2.4 Verify the availability of an adequate supply of clean water (GLP 10).

1.2.5 Verify that the operator has had specific training in SOP 18, SOP 19, SOP 21, GMP 3, and SOP 20.

1.2.6 Cylinder of nitrogen or compressed air and a proper pressure regulator.

1.2.7 Verify that the laboratory facilities meet the following minimum conditions to make possible the expected uncertainty achievable with this procedure:

[1] Non-SI units are predominately in common use in State legal metrology laboratories, and/or the petroleum industry for many volumetric measurements, therefore non-SI units have been used to reflect the practical needs of the laboratories performing these measurements as appropriate. The majority of LPG provers in use are 20 gal, 25 gal, and 100 gal nominal sizes. The volume of LPG provers is established at 60 ºF and 100 psig.

Table 1. Laboratory environmental conditions

Procedure	Temperature	Relative Humidity
Volume Transfer	18 °C to 27 °C, maximum change 2.0 °C/h	40 % to 60 % ± 20 %, maximum change / 4 h

1.3 Field tests

1.3.1 A "field" calibration is considered one in which a calibration is conducted in an uncontrolled environment, such as out-of-doors. Calibrations conducted under field and laboratory conditions are not considered equivalent.

1.3.2 The care required for field calibrations includes proper safety, a clean and air-free water supply, measurement control programs, and a stable temperature-controlled environment shaded from direct sunshine to allow the prover, field standard, and test liquid (water) to reach an equilibrium temperature, with minimal evaporation. Environmental conditions should be controlled (or selected) to be as close to laboratory conditions as possible. All data and appropriate environmental conditions must be documented regardless of test location.

2 Methodology

2.1 Scope, Precision, Accuracy

This procedure is applicable for the calibration of LPG provers with capacities of 100 L to 500 L (20 gal to 100 gal) or larger when appropriate. Provers of the latter capacity (gal and in^3 units) are encountered most frequently, hence the procedure is written with that in mind. The changes necessary for testing provers of other capacities will be obvious and are not described in this document. The agreement of duplicate measurements made within a short period of time on a given 100-gal prover should be within 5 in^3 (0.02 gal). The accuracy will depend on the uncertainty in the volume of the standard, on the care exercised in making the various measurements and temperature readings, and on correct application of the corresponding corrections.

2.2 Summary

The procedure is a modification of one described by M.W. Jensen in NBS Handbook 99, "Examination of Liquefied Petroleum Gas Liquid- Measuring Devices." The LPG prover is calibrated with a known volume of water delivered into it from a standard prover of calibrated volume. Depending on the respective volumes, multiple transfers may be required. While these should be minimized, a maximum number of 15 transfers are permitted to ensure that final calibration uncertainties are sufficiently small to meet user applications. The LPG prover is pressurized and the liquid level is measured at each of several values of applied pressure. The calibration thus defines the capacity of the prover over its expected range of operational pressure.

2.3 Equipment

2.3.1 Calibrated standard prover of minimum volume of 10 gal but preferably of the same volume as the LPG prover, with recent calibration certificate traceable to NIST.

2.3.2 A funnel and a calibrated 1 gal flask (or other suitable size) with recent calibration certificate traceable to NIST, to calibrate the neck of prover.

2.3.3 Calibrated thermometers (2) accurately calibrated to 0.1 °C, with recent calibration certificate traceable to NIST.

2.3.4 Meniscus reading device (See GMP 3).

2.3.5 Timing device (calibration is not required.)

2.3.6 Supply of clean water, preferably soft water (filtered if necessary) (GLP 10).

2.3.7 Sturdy platform, with appropriate safety conditions, with sufficient height to hold standard and to permit transfer of water from it to the prover by gravity flow.

2.3.8 Clean the pipe or tubing (hoses) to facilitate transfer of water from the laboratory standard to prover. Nearly all LPG provers require reducers to be used between normal laboratory piping and the top hole on the prover. Pipe and hose lengths should be minimized to reduce water retention errors. Care must be taken during wet-downs and runs to ensure complete drainage and consistent retention in all hoses or pipes.

2.3.9 Compressed nitrogen cylinder or air, suitable regulator, and an appropriate pressure gauge. The calibration relies on the accuracy of the pressure gauge on the prover. It assumes that systematic errors in the prover pressure gauge will be present in field applications as well, thus calibration of the laboratory pressure gauge is not essential.

2.4 Procedure

2.4.1 Preliminary Operations

2.4.1.1 Install and level the standard(s) on a raised platform with appropriate security and safety ensured for the prover(s) and operator(s). Provide pipe or tubing for delivery of water by most direct route to prover.

2.4.1.2 Position and level the unknown prover where it can be reached from the elevated standard by the shortest feasible delivery system.

2.4.1.3 Remove the plug and relief valve (1) from the top, and extend the pipe into the hole. This may require the use of a reducer and a short length of hose (about 1 inch in diameter). If this is a tight fit, open the vapor return line valve (2) to provide an air bleed.

Use the prover inlet line (3) as a gravity drain. If necessary, remove the fitting on the end and connect a hose or pipe to make the necessary drain line.

Warning: ensure that a check valve is not plumbed into the prover inlet line. If it is, remove the check valve, otherwise the prover will need to be drained via the plug in the bottom of the lower neck.

2.4.2 Cleanliness Check

Both the standard and the prover must be internally clean. This should be verified by checking that water drains properly from them. If necessary, either or both should be cleaned with water and detergent (see GMP No. 6) to attain good drainage characteristics.

2.4.3 Neck scale plate verification

2.4.3.1 Fill the prover with water from the standard. Check the prover levels and adjust if necessary. Check the prover system for leaks. This is a wet-down run.

2.4.3.2 Bleed the liquid level down to a graduation near the bottom of the upper neck. "Rock" the prover to "bounce" the liquid level, momentarily, to ensure that it has reached an equilibrium level. Read and record this setting. This is in preparation for calibration of the neck scale.

2.4.3.3 Remove the fill hose or pipe from the top and insert a funnel.

2.4.3.4 Recheck the scale reading, then add 1 gal of water (or a volume equal to approximately ¼ or $^{1}/_{5}$ of the graduated neck volume) from a suitable standard; record the scale reading.

2.4.3.5 Repeat 2.4.3.4 by successive additions until water is near the top of the scale (the neck capacity is usually about 5 gal). Record scale readings after each addition. The closer the water is to the top of the neck, the harder it may be to "bounce" the liquid in the gauge.

A plot of scale readings with respect to volume added should be linear and will be a gross check of the validity of this calibration.

2.4.3.6 Calculate and check accuracy of the neck scale for each interval. The error should be less than 0.5 % of the graduated neck volume. If more than this, the scale should be replaced or issue the NSCV and instructions to user.

2.4.3.7 The neck scale calibration value is calculated as follows:

$$NSCV = \frac{V_w}{(sr_f - sr_i)} \qquad \text{Eqn. 1}$$

where:

NSCV	Neck scale calibration value
V_w	Total volume of water added to neck
sr_f	Scale reading, final
sr_i	Scale reading, initial

2.4.4 Body Calibration

2.4.4.1 Drain the prover through its inlet valve and the liquid bleeder valve. When the liquid reaches the top of the lower gauge glass, close the inlet valve and allow the water to drain from the interior of the prover into the lower neck for 30 s, while controlling the water flow and level with the bleeder valve until the liquid meniscus reaches the zero graduation. The liquid level should be exactly at the zero graduation and the bleeder valve closed simultaneously at the 30 s drain time. (Draining with the bleeder valve close to the zero mark should be started during the 30 s drain period but should not be completed before the end of the drain period.)

Alternatively, though not recommended, the prover may be completely drained with a 30 s drain time and then refilled with a funnel that has been wet down, and small volume of water to set the zero mark. Errors from this process will result due to the additional drain and retention time and other factors associated with the process.

2.4.4.2 Transfer 100 gal (or other suitable volume) from the standard in the usual manner, and record the standard and prover temperature readings. If multiple transfers are required, record temperature of the standard at the time of each transfer, but that of the prover only after the final transfer. "Rock" the prover to "bounce" the liquid in the upper gauge glass before reading. Record the scale reading after the nominal volume has been transferred into the unknown LPG prover.

Note regarding temperature measurements: A digital temperature sensing device with a long cable can allow insertion of the probe into the standard and the unknown to enable direct liquid measurements at the bottom, middle, and top of the provers. If the prover thermometer wells are used, ensure that the prover has equalized with the temperature of the water.

2.4.4.3 Drain the LPG prover as described in 2.4.4.1 and make another test run. Record the temperatures of the standard(s) and the unknown and final scale reading. Calculate the prover error at 0 psig for each run using the appropriate equations in Section 3; these values are used to evaluate repeatability of the test only. The error at 0 psig for the test runs should agree within 0.02 % of the prover volume or approximately one-half the prover tolerance (i.e., 5 in^3 on a 100 gal LPG prover). If the repeatability is larger than 0.02 % of the prover volume, continue until replicates agree within these limits, taking care to ensure that poor cleanliness, contamination, bubbles in hoses, leaking valves or seals are not contributing to poor repeatability. Repeatability problems may also be due to poor field conditions, such as when calibration is conducted in unstable environments. Repeatability problems must be corrected before calibration can be completed.

2.4.4.4 Replace the relief valve and plug in the top of the prover using suitable pipe joint compound or tape. Allow water from 2.4.4.3 (the second run) to remain in prover.

2.4.5 Prover Adjustments

2.4.5.1 The internal pressure and hence the volume of the prover may vary during use. Accordingly, a pressure correction must be made using the data of steps 2.4.6.

To minimize the amount of correction needed when the prover is in use, the prover should be adjusted to indicate its nominal capacity when 100 psig is applied. (An internal pressure of 100 psig is suggested as being convenient.) If the actual volume of the prover is not near a convenient whole gallon value and cannot easily be adjusted to a whole gallon value, a prover correction value can be computed (see 3.4) and added to the pressure correction values to obtain a set of combined prover and pressure correction values to be computed. The pressure correction is computed in 3.4.

2.4.5.2 Use a cylinder of nitrogen or compressed air and a proper pressure regulator with an integrated pressure gauge.

Connect the cylinder regulator output to the vapor return fitting (2) near the top of the neck. This may require fashioning a connection with steel pipe nipples or other appropriate materials and the existing fittings.

Caution: Ensure that all piping and fittings are rated for the pressures to which they will be exposed.

Make sure all valves are closed except the vapor return valve. Verify that the final scale reading has not changed since it was recorded (if it has changed it may signal a leak in one of the valves or fittings), and then slowly introduce pressure until the installed prover gauge reads 100 psig. Lightly tap the gauge to ensure that the gauge needle is not sticking. "Bounce" the liquid in the neck, then read and record the liquid level at this applied pressure.

Return pressure to 0 psig and reapply pressure as above. This reading at 100 psig should agree with the above recorded reading within 0.02 % of the nominal volume of the prover. Leaking seals or valves may cause problems with repeatability of the gauge readings under pressure.

2.4.5.3 With the pressure in the prover at 100 psig, adjust the upper scale to read the nominal volume. This is accomplished by adjusting the upper scale so that the water level reading is:

Desired scale reading = $V_{X60} - (V_{NOM} * 1.00032)$ Eqn. 2

Take care to use like units in the calculation. The calculation for V_{X60} is given in 3.1, Eqn 5.

Note: The correction factor 1.00032 corrects for the compressibility of the water at 100 psig. If the upper scale is not adjustable, see 2.4.5.4.

2.4.5.4 For provers with only an adjustable lower scale (or one in which the upper scale is not adjustable), a prover correction, L_C, may be calculated at 100 psig as follows:

$$L_C = V_{X60} - (V_{NOM} * 1.00032) - sr_u \qquad \text{Eqn. 3}$$

where:

L_C	Prover correction at 100 psig
V_{X60}	Volume of unknown prover at 60° F
V_{NOM}	Nominal volume of prover
sr_u	Upper scale reading at 100 psig
1.00032	Correction factor for the compressibility of water at 100 psig

Take care to use like units in the calculation.

If the prover correction is negative, move the bottom scale down to increase the prover volume. If the prover correction is positive, move the bottom scale up to decrease the prover volume. The distance *h* that the bottom scale is to be moved is:

$$h = \frac{4 \left| L_C \right|}{\pi d^2} \qquad \text{Eqn. 4}$$

where:

h	Distance in inches the bottom scale is to be moved, up or down
L_C	Prover correction at 100 psig in cubic inches
d	Inside diameter of the lower neck of the prover in inches (as noted on identification plate)

2.4.6 Pressure Correction

2.4.6.1 Return pressure to 0 psig. Record the reading. Slowly introduce pressure until the installed prover gauge reads 50 psig. Lightly tap the gauge to ensure that the gauge needle is not sticking. "Bounce" the liquid in the neck, then read and record the liquid level at this applied pressure.

2.4.6.2 Repeat step 2.4.6.1 at 100, 150, and 200 psig. Other pressure points in between those listed may be tested if so desired. (The water level should decrease 10 in^3 to 15 in^3 for each 50 psig increase in pressure, although this varies depending on the geometry and age of the LPG prover. Water level changes significantly greater than indicated may be due to leaking seals and/or valves.) Erratic pressure readings may also be due to air entrapment based on prover design; repeated pressurizing of the prover should eliminate entrapped air. Air entrapment problems due to design may need to be investigated and corrected.

2.4.6.3 Repeat step 2.4.6.1 as the pressure is bled down to 150, 100, 50, and 0 psig (atmospheric pressure). The readings should agree with those previously obtained within approximately 0.02 % of the nominal prover volume. If the data are not linear with respect to pressure, repeat the series of measurements above to verify the nonlinearity of the readings. Leaking seals or valves may cause problems with repeatability of the gauge readings under pressure. The cause of repeatability errors must be identified and corrected before continuing the calibration.

2.4.7 Final Operations

2.4.7.1 Seal the bottom and top scales as specified by laboratory policy and as appropriate.

2.4.7.2 Drain prover, then remove plug (5) at the lower neck to facilitate drainage below the lower gauge. If time permits, let the prover drain overnight.

2.4.7.3 With the nitrogen cylinder or compressed air connected, blow nitrogen or air through the prover to remove remaining moisture. Be sure to blow out the drain line and any other portions of the system that may have become contaminated with water.

2.4.7.4 If water has entered the pump-off system, pour several gallons of alcohol into the prover and pump the alcohol through the system to remove the water to prevent it from freezing in the pump when LP gas is used.

3 Calculations

3.1 Single Delivery

3.1.1 Calculate V_{X60}, the volume of the unknown prover at 60 °F, using the following equation:

$$V_{X60} = \frac{\rho_1 \left\{ \left(V_{S60} + \Delta_1 \right) \left[1 + \alpha \left(t_1 - 60\ ^\circ\text{F} \right) \right] \right\}}{\rho_x \left[1 + \beta \left(t_x - 60\ ^\circ\text{F} \right) \right]} \quad \text{Eqn. 5}$$

3.2 Multiple Deliveries

3.2.1 Calculate V_{X60}, the volume of the unknown prover at 60 °F, using the following equation:

$$V_{X60} = \frac{\rho_1 \left\{ \left(V_{S60} + \Delta_1 \right) \left[1 + \alpha \left(t_1 - 60^\circ\text{F} \right) \right] \right\} + \rho_2 \left\{ \left(V_{S60} + \Delta_2 \right) \left[1 + \alpha \left(t_2 - 60^\circ\text{F} \right) \right] \right\} + \ldots + \rho_N \left\{ \left(V_{S60} + \Delta_N \right) \left[1 + \alpha \left(t_N - 60^\circ\text{F} \right) \right] \right\}}{\rho_x \left[1 + \beta \left(t_x - 60^\circ\text{F} \right) \right]} \quad \text{Eqn. 6}$$

Table 2. Variables for V_{X60} equations

Symbols Used in Equations	
V_{X60}	volume of the unknown vessel at 60 °F
V_{S60}	volume of the standard vessel at 60 °F
$\rho_1, \rho_2, \ldots, \rho_N$	density of the water in the standard prover where ρ_1 is the density of the water for the first delivery, ρ_2 is the density of the water for the second delivery, and so on until all N deliveries are completed
$\Delta_1, \Delta_2, \ldots, \Delta_N$	volume difference between water level and the reference mark on the standard where the subscripts 1, 2,..., N, represent each delivery as above. If the water level is below the reference line, Δ is negative. If the water level is above the reference line, Δ is positive. If the water level is at the reference line, Δ is zero NOTE: units must match volume units for the standard
$t_1, t_2, \ldots, t_N$	temperature of water for each delivery with the subscripts as above
α	coefficient of cubical expansion for the standard in units / ºF
ß	coefficient of cubical expansion for the prover in units / ºF
t_x	temperature of the water in the filled unknown vessel in units ºF
ρ_x	density of the water in the unknown vessel in g/cm^3
Note: Values for the density of water at the respective temperatures may be found in Table 9.8 (in NISTIR 6969). It may also be calculated using the formula given in GLP 10.	

3.3 Pressure Corrections

Compute the pressure correction, P_{corr}, at each pressure that the prover was read, after any adjustments, by correcting for the compressibility of the water. The equation is:

$$P_{corr} = Scale\ reading\ @\ 100\ psig - scale\ reading\ @\ X\ psig + (water\ compressiblity\ factor)\left(\frac{100\ psig - X\ psig}{100}\right) \quad \text{Eqn. 7}$$

where the water compressibility factor is 7.4 in^3 or 0.032 gal for a 100 gallon prover and 1.8 in^3 or 0.008 gal for a 25 gallon prover. The compressibility value is 0.00032 gal per gallon for 100 psig. The compressibility factor is given in both cubic inches and gallons so the proper unit can be selected depending upon the unit used for the scale readings.

Plot the pressure corrections. If the corrections versus the pressure are linear, make a straight line best fit of the data and interpolate to obtain the pressure corrections for any desired pressure. If the data is nonlinear, then perform a straight line interpolation between adjacent pressure readings to obtain pressure corrections at any desired intermediate pressures. Alternatively, a best fit curve can be drawn for the nonlinear data and the pressure corrections interpolated from the graph for intermediate pressures. See Appendix A for an example of the pressure corrections.

3.4 Prover Volume

LPG provers are generally adjusted to the nominal value using 100 psig as the reference pressure. At 100 psig, the prover reading will be lower by at least 0.032 gal/gal than it was at 0 psig due to the compressibility of water under pressure. Therefore, a prover of 100 gal should be set to read the V_{X60} value at 0 psig minus 7.4 in^3. (The water level on the prover's upper scale will be below the calculated V_{X60} reading when pressurized to 100 psig). The prover must not be set to read the V_{X60} value plus the compressibility factor at 0 psig because, in addition to compressibility of water, the prover expands as pressure is applied.

4 Measurement Assurance

4.1 If a check standard is used (See SOP 20, SOP 30), repeat the process for the unknown prover on the check standard without adjustments.

4.2 Plot the check standard volume and verify that it is within established limits. Alternatively a *t*-test may be incorporated to check the observed value against an accepted value.

4.3 The mean of the check standard values is used to evaluate bias and drift over time.

4.4 Check standard values may be used to calculate the standard deviation of the measurement process.

4.5 If a check standard is not used, the laboratory will need to maintain a Range chart according to SOP 20 to determine the repeatability for this procedure.

5 Assignment of Uncertainties

5.1 The limits of expanded uncertainty, U, include estimates of the standard uncertainty of the laboratory volumetric standards used, u_s, plus the uncertainty of measurement, u_m, at the 95 % level of confidence. See SOP 29 for the complete standard operating procedure for calculating the uncertainty.

5.2 The standard uncertainty for the standard, u_s, is obtained from the calibration report. The combined standard uncertainty, u_c, is used and not the expanded uncertainty, U, therefore the reported uncertainty for the standard will usually need to be divided by the coverage factor k.

5.3 Neck calibration uncertainty should be estimated based on the uncertainty of standards used, errors observed during calibration, and the repeatability of the neck calibration.

5.4 Standard deviation of the measurement process from control chart performance (See SOP No. 20 and SOP 30)

5.4.1 The value for s_p is obtained by estimation using the range from the control chart data for large volume transfer procedures.

Note: Fifteen is the maximum recommended number of deliveries from a laboratory standard to a prover under test to minimize calibration uncertainties to the levels identified previously.

5.5 Other standard uncertainties usually included at for this type of calibration level include uncertainties associated with the ability to read the meniscus, only part of which is included in the process variability, viscosity effects, the cubical coefficient of expansion for the prover under test, use of proper temperature corrections, the accuracy of temperature measurements, water density equation, the compressibility of water, round robin data showing reproducibility, environmental variations over time, and bias or drift of the standard.

5.5.1 To properly evaluate uncertainties and user requirements (tolerances), assessment of additional user uncertainties may be required by laboratory staff. Through proper use of documented laboratory and field procedures, additional uncertainty factors may be minimized to a level that does not contribute significantly to the previously described factors. Additional standard uncertainties in the calibration of field standards and their use in meter verification may include: how the prover level is established, how delivery and drain times are determined, the use of a proper “wet-down” prior to calibration or use, whether gravity drain is used during calibration or whether the volume of water is eliminated by pumping, the cleanliness of the prover and calibration medium, prover retention characteristics related to inside surface, contamination or corrosion, and total drain times, and possible air entrapment in the water. Systematic errors may be observed between laboratory calibration practices where a gravity drain is used and field use where the pumping system is used.

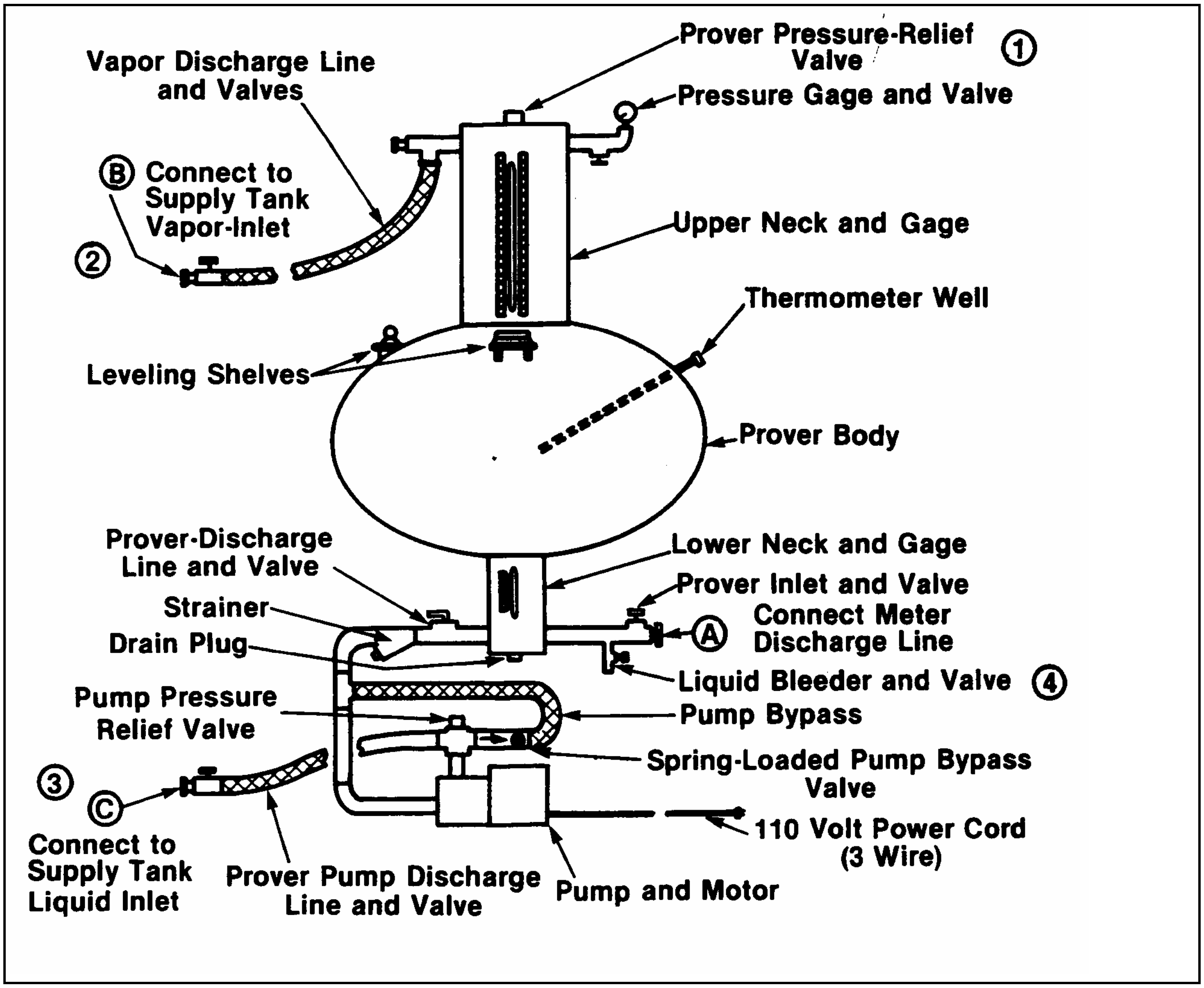
6 Report

6.1 Report results as described in SOP No. 1, Preparation of Calibration/Test Results, with the addition of the following:

6.1.1 For LPG provers, the total prover volume and uncertainty, reference temperature, material, coefficient of expansion (assumed or measured), any identifying markings, tolerances (if appropriate), laboratory temperature, water temperature, barometric pressure, relative humidity, out-of-tolerance conditions, and the total drain time from opening of the valve, including the 30 s drain after cessation of flow.

The report should also include a pressure correction table or chart, along with a note regarding possible differences in retention characteristics between water, the calibration medium, and LPG products.

Figure 1. LPG Prover Schematic



Appendix A

SOP No. 21
Recommended Standard Operations Procedure for Calibration of LPG Provers

1 Compressibility of Water

The water compressibility factor is calculated based on an equation given in a paper by Frank E. Jones and Georgia L. Harris, "ITS-90 Density of Water Formulation for Volumetric Standards Calibration", as published in the Journal of Research of the National Institute of Standards and Technology, Vol. 97, No. 3, 1992.

$$\text{Compressibility factor} = \left(V_{NOM}\right)(231)(kT)(P)$$

where

V_{NOM}	Nominal volume of Prover in gal
kT	Thermal compressibility of water in (atm)$^{-1}$
P	Pressure in atm

And

$$kT = 50.83101x10^{-8} - 3.68293x10^{-9}t + 7.263725x10^{-11}t^2 - 6.597702x10^{-13}t^3 + 2.87767x10^{-15}t^4$$

where kT is in (kPa)$^{-1}$ and 1 atm = 101 325 Pa (exactly).

The thermal compressibility of water for the reference temperature 60 °F (15.56 °C) is 4.66264002 x 10^{-9}/kPa. LPG provers are calibrated at a nominal reference point at a specified temperature and pressure, typically 60 °F and 100 psig. A pressure of 100 psig correlates to 6.8 atmospheres. The following equation was used to calculate the compressibility factor:

Compressibility factor = $(V_{Nom})(231)(kT)(P)$

Compressibility factor = 100 gal (231 in^3/gal)(4.72442x10^{-5}/atm)(6.8 atm) = 7.4 in^3 or 0.032 gal

1 Example of Pressure Corrections

The following example is printed from a Lotus 1, 2, 3 program written by L. F. Eason, Metrologist (NC) to perform calculation for volume transfer. The program was modified by Georgia Harris (NIST) to provide calculations and corrections for LPG prover testing.

VOLUME TRANSFER CALIBRATION - METAL LPG PROVER

DATE: 04/09/91

COMPANY NAME:	Handbook 145 Example
ADDRESS:	12321 Some Street
CITY, STATE:	Anywhere, USA
NOMINAL VOLUME OF PROVER:	100 GALLONS
PROVER SERIAL NO:	100-234LP
MANUFACTURER:	Provers Unlimited
NUMBER OF DELIVERIES REQUIRED:	1 (0-15)

DATA FOR INDIVIDUAL STANDARD DELIVERIES

DROP NO	VOL (GAL)	METAL (MS/SS)	EXP COEF	TEMP DEG C	TEMP DEG F	WATER DENSITY	DELTA (CU IN)
1	100	stainless	0.00003	15.55	59.99	0.999013	0

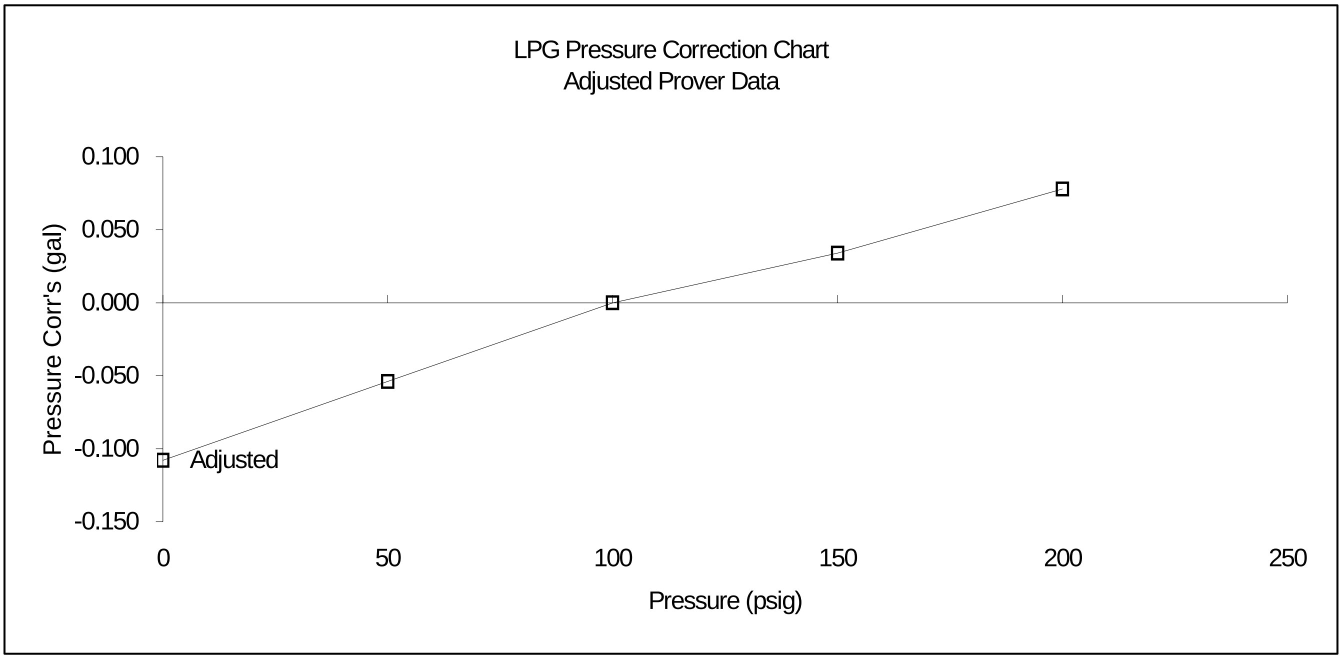
TYPE OF METAL FOR THE UNKNOWN:	mild steel
COEFFICIENT OF EXPANSION:	0.0000186 /°F
WATER TEMPERATURE:	15.55 C 59.99 F
WATER DENSITY:	0.999013 g/cm^3
GAUGE AT 0 PSIG:	0.09 gal
GAUGE AT 50 PSIG:	0.02 gal
GAUGE AT 100 PSIG:	-0.05 gal
GAUGE AT 150 PSIG:	-0.10 gal
GAUGE AT 200 PSIG:	-0.16 gal
DELIVERY VOLUME AT 60 °F:	100.0000 V_{X60}, gallons
UNKNOWN PROVER'S ERROR AT 100 PSIG:	4.2 in^3

ADJUSTMENT INSTRUCTIONS

To adjust prover to deliver exactly 100 gallons at 60 F, adjust scale to read -0.032 gallons or -7.4 in^3, at 100 psig. Move to -0.032 gals, -7.4 in^3, by 0.34 inches if 4" lower scale.

PROVER PRESSURE CORRECTIONS

	psig	P_{corr}	Prover Error	Prover Error	Volume of the Adjusted Prover (gal)
	0	-0.108	-0.108	-0.090	99.829
	50	-0.054	-0.054	-0.036	99.946
	100	0.000	0.000	0.018	100.000
	150	0.034	0.034	0.052	100.034
	200	0.078	0.078	0.096	100.078
			Adj.	Not Adj.	


LPG Pressure Correction Chart
Adjusted Prover Data
Pressure Corr's (gal)
0.100
0.050
0.000
-0.050
-0.100
-0.150
Adjusted
0
50
100
150
200
250
Pressure (psig)