PROCEDURE NUMBER	APPROVED	DATE
*12.10.8	[signature]	09/27/83

VOLUME NAME	
12	CHEMISTRY PROCEDURES
SECTION	
12.10	POST ACCIDENT SAMPLING AND ANALYSIS
TITLE	
*12.10.8	DISSOLVED GAS ANALYSIS

12.10.8.1 Purpose

This procedure gives instructions for sampling and analysis of dissolved gas from the post accident sampling station.

12.10.8.2 Precautions/Prerequisites

A. Lab personnel shall be issued extremity monitoring devices per Health Physics policy.

B. Lead shielding must be set up prior to removing the sample from the cask.

C. Appropriate dose rate meter must be available and in calibration. Use continuously to assure personnel exposure is ALARA.

D. The gamma spectrometer must be operable.

E. Appropriate remote handling tools must be available and used during handling of highly radioactive samples.

12.10.8.3 Equipment

A. 14 ml gas sample bottle

B. Gas sample bottle holder

C. Stopwatch

12.10.8.4 Procedure

A. Identification of Symbols. The following section identifies the symbols which are used in the procedure:

G = total dissolved gas in gas phase, gm-mol

L = total dissolved gas in liquid phase, gm-mol

P_F = final pressure of gas, psia

P_G = partial pressure of total dissolved gas, psia

P_i = initial pressure of gas, psia

P_{RG} = partial pressure of residual expanded gases from liquid loop, psia

P_V = pressure of water vapor at temperature of liquid, psia

R = gas constant, $669 \frac{(psia)\ (cc)}{(gm - mol)\ (^oR)}$

S_H = solubility of hydrogen at temperature of liquid sample, gm-mol H_2/gm-mol H_2O

T_G = temperature of gas collection volume, ^oR ($^oR = 460 + {}^oF$)

T_L = temperature of liquid sample, ^oR ($^oR = 460 + {}^oF$)

V_G = volume of gas collection area, cc

V_L = volume of liquid in liquid collection cylinder, cc

p = density of water at temperature of liquid sample, g/cc

B. Determining Standard Parameters

Prior to using the dissolved gas sampling system for collecting samples, the volume of the gas and liquid must be determined. (See Attachment A.)

C. Obtaining Total Dissolved Gas Measurements

1. Turn "Liq/Gas" switch to liquid.

2. turn "Liq Sample Source Selector" switch to RHR - on bypass or Jet Pump - on bypass.

3. Turn PCV-627 to control flow to approximately 1 gpm or less as displayed on FI-664.

4. Turn "Liq Sample Source Selector" switch to RHR or Jet Pump.

5. Use gas sample bottle holder tool to place a gas sample bottle on the needle. Check to see that the green light below "Gas Bottle In" is on.

6. Turn "Dissolved Gas and Liquid Sample" switch to Position 1 for 10 minutes. Reduce flow rate to 0.1 gpm to minimize pressure drop.

7. Turn "Dissolved Gas and Liquid Sample" switch to Position 2 for 10 minutes.

8. Turn to Position 3. When PI662 is stable, record value as Pi on Data Sheet 1.

9. Turn quickly to Position 6 for 30 seconds.

10. Turn to Position 7 for 30 seconds.

11. Turn to Position 8 for 15 seconds; turn back to Position 7 for 30 seconds; repeat 3 times.

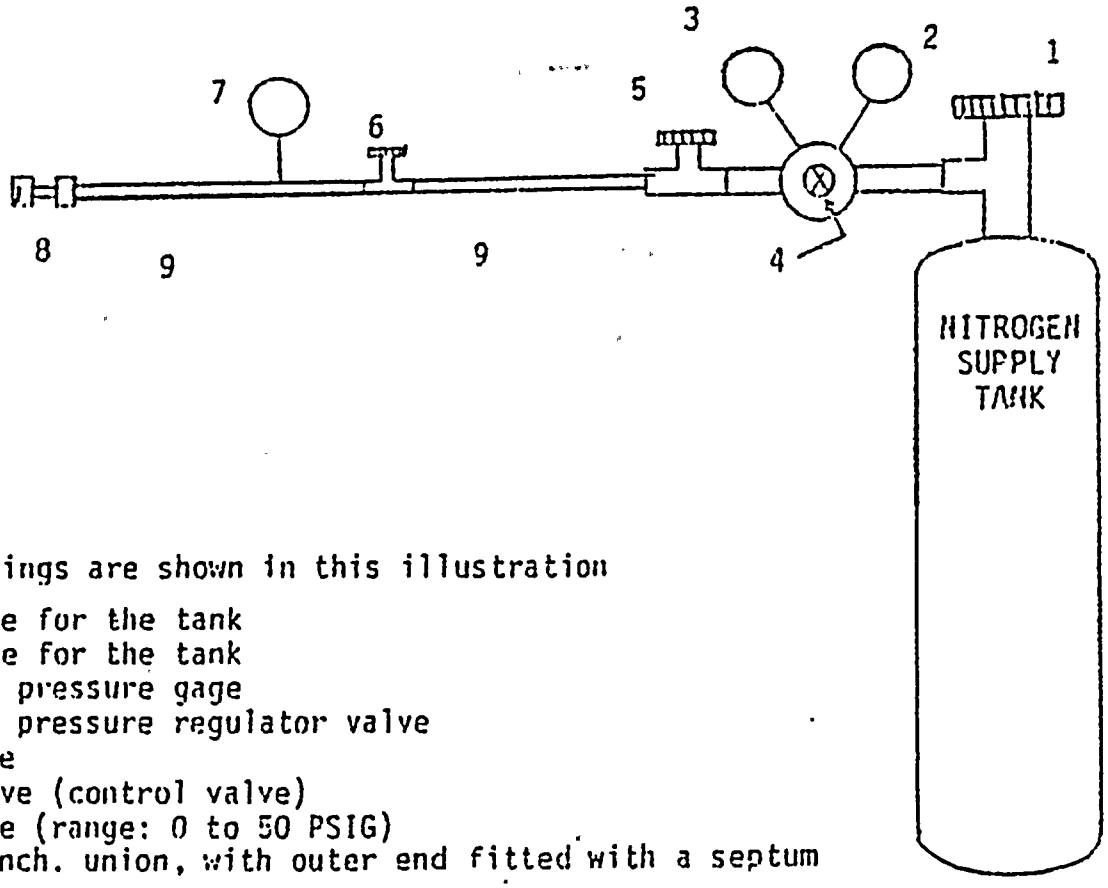
12. Turn to Position 9. Record final pressure as P_F (from PI-662) on Data Sheet 1.

13. Turn "Lower Pressure/Gas Sample" switch to "lower pressure".

14. Record water temperature from TI-660 and gas temperature from TI-724.

D. Remove trapped water in dissolved gas collection volume.

NOTE: After a dissolved gas test is performed, liquid is assumed to be trapped in the gas collection volume. When the valve CV653 opens small gas bubbles come out of solution throughout the liquid phase. As the bubbles expand and rise, entrained water is carried with them into the gas collection space. Valve CV 653 is a solenoid valve with small parts and a tortuous flow path, and therefore water cannot drain back. Assemble apparatus in Figure 1.



Note: Not all fittings are shown in this illustration

1 shutoff valve for the tank
2 pressure gage for the tank
3 second stage pressure gage
4 second stage pressure regulator valve
5 shutoff valve
6 metering valve (control valve)
7 pressure gage (range: 0 to 50 PSIG)
8 Swagelok ¼ inch. union, with outer end fitted with a septum
9 ¼ inch. tubing

FIGURE 1. APPARATUS FOR GAS COLLECTION CHAMBER WATER DRAINAGE

Figure 1

1. If the last dissolved gas test had a final pressure greater than atmospheric, depressurize the liquid lines as follows; if not go to 2.

   a. Turn "Liquid Sample Source Selector" switch to Jet Pump (2) on RHR (4).

   b. Turn "Liq/Gas" switch to liquid.

   c. Turn "Dissolved Gas and Liquid Sample" switch to Position 8.

   d. Turn power switch ON.

   e. Turn "Dissolved Gas and Liquid Sample" switch to Position 9.

   f. Turn "Lower Press/Gas Sample" switch to lower pressure.

   g. Repeat from c until PI 662 reads atmospheric at Step C.

2. Turn "Liquid Sample Source Selector" switch to Jet Pump or RHR.

3. Turn "Liquid/Gas" switch to liquid.

4. Turn "Dissolved Gas and Liquid Sample" switch to Position 9.

5. Place septum end of tube on dissolved gas sample needle. Be sure that green light below "gas bottle in" is on. Set 2nd stage of 2 stage regulator for 45 psig.

6. Turn "lower press/gas samples" switch to gas sample. Have a second person turn on the small control valve on the nitrogen supply. Release gas sample switch when pressure, as indicated on PI-662, is approximately 50 psia.

7. Turn power switch OFF.

8. Turn "dissolved gas and liquid sample" switch to Position 6.

9. Turn power switch ON.

10. When pressure is reduced, water should be forced into liquid space.

11. Complete Data Sheet 1.

E. To Calculate Dissolved Gas Concentrations

1. The following values must be obtained prior to calculating gas concentrations:

   V_L = volume of liquid sample (cc) from 12.10.8.4.B

   V_G = volume of gas collection area (cc) from 12.10.8.4.B

   T_G = temperature of gas collection volume (^oR) from 12.10.8.4.C

   T_L = temperature of liquid sample (^oR) from 12.10.8.4.C

   P_F = final pressure of gas (psia) from 12.10.8.4.C

   P_i = initial pressure of gas (psia) from 12.10.8.4.C

   S_H = solubility of H_2 at temperature of liquid sample (gm-mol/gm H_2O-atm) (see Attachment B)

   p = density of water at temperature of liquid sample (gm/ml) (see Attachment D)

   P_V = pressure of water vapor at temperature of liquid (psia) (see Attachment C)

   P_{RG} = partial pressure gases from liquid loop, (psia) from 12.10.8.4.B

2. Determination of partial pressure of total dissolved gas, P_G

   $$P_G = P_F - P_i - P_V - P_{RG}$$

3. Determination of dissolved gas concentration in the liquid.

   Total dissolved gas = Gas in liquid phase (gm-mols) + gas in gas phase (gm-mols)

   $$= L + G$$

   $L = S_H \times V_L \times P \times P_G/14.4$ for liquid phase

   $G = P_G \times V_G/(R_X T_G)$ for gas phase

   Total dissolved gas per cc water = $\frac{L + G}{V_L}$

12.10.8.5 Attachments

A. Volume Determination

B. Solubility of Gases

C. Vapor Pressure of Water

D. Density of Mercury and Water

E. Data Sheets 1, 2 and 3

TENTATIVE VOLUME DETERMINATION

PROCEDURE FOR THE PASS SYSTEM

DISSOLVED GAS SAMPLING CHAMBERS

The purpose for the procedure is to determine the volumes of the dissolved gas collection chamber (expansion volume) and the liquid circulation chamber (liquid sample volume).

The principle of the method is based on gas expansions and pressure measurements performed against a known standard reference volume. The pressure readings are taken at ambient conditions in quick succession and the simple gas law pressure-volume relationship is applied without temperature corrections.

The procedure is meant to be applied to PASS Systems that have not been put into operation, i.e. dry, without any liquid in the lines.

PASS SYSTEM VOLUME DETERMINATION

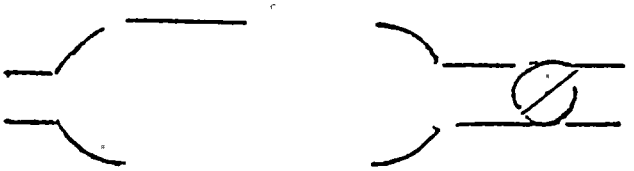
PROCEDURE (TENTATIVE)

EQUIPMENT

- Reference Volume Capsule, 15 - 20 cc nominal (sketch)÷
- Vacuum Pump
- Vacuum Gage
- Flexible Vacuum Hose (6 ft.)
- Shut-off Valve
- Rubber Septums

÷SKETCH - Pyrex Glass Capsule

Rubber Septum



Valve (Teflon Plug)

1. Standard Reference Volume (V_S)

1.1 Weigh reference capsule to the nearest 0.1 gram.

1.2 With valve closed, fill the reference capsule with distilled water thru the septum port.

1.3 Seal the port of the capsule with a rubber septum allowing some of the water to overflow. Remove the excess water with tissue or paper towels.

1.4 Weigh reference capsule and its content of water to the nearest 1 gram. Record difference on Data Sheet 2.

1.5 Note ambient temperature and from Attachment B obtain the density of water in grams per cubic centimeter at the temperature noted. Record ambient temperature and density on Data Sheet 1.

1.6 Calculate the volume of the reference capsule (V_S) as follows: (Record on Data Sheet 1)

$$V_S = \frac{\Delta W}{P}$$

Where:

ΔW = weight difference between the empty capsule and the capsule filled with water (grams)

P = density of water (gram/cc)

V_S = standard reference volume (cc)

1.7 Drain and thoroughly dry the reference capsule.

1.8 Reseal the capsule with a new rubber septum.

2. Determination of the Dissolved Gas Collection Chamber Volume, V-622 (PASS System)

2.1 On the PASS system control panel set switches as follows:

Mode Selector Switch to "LIQUID"
Sequencing Switch HC-601 to Position 10

2.2 Evacuate the standard reference capsule thru its valve to 50 microns or better. Record pressure as Po on Data Sheet 1.

2.3 Insert an open vial (without rubber septum) into the dissolved gas sampling station such that the limit switch near the needle is depressed and the "Vial Position" status light on the panel changes from red to green.

2.4 Turn switch HC-652 clockwise to "Gas Sample" and hold.

2.5 Record pressure from PI-662 as P_1 (should be atmospheric) on Data Sheet 1.

2.6 Release switch HC-652, then remove open vial from the sampling station.

2.7 Close the valve on the standard reference capsule to isolate it from the vacuum pump.

2.8 Inser the standard reference capsule into the dissolved gas sampling station such that the needle punctures the rubber septum and the limit switch is depressed. Note the status light changing from red to green.

2.9 Turn switch HC-652 clockwise to "Gas Sample" and hold.

2.10 Record pressure from PI-662 as P_2 on Data Sheet 1.

2.11 Calculate V_T as follows: (Record on Data Sheet 1)

$$V_T = \frac{P_2 - P_0}{P_1 - P_2} \cdot V_S$$

Where: V_S = standard reference capsule volume (cc)

V_T = volume of dissolved gas collection chamber + the volume of tubing, needle block and needle (cc)

2.12 Install a new rubber septum on the standard reference capsule.

2.13 Repeat Steps 2.2 through 2.12 three or more times and then calculate an average value for V_T.

2.14 Insert an open vial (no rubber septum) into the dissolved gas sampling station. Note that the limit is depressed and the "Vial Position" status light changes from red to green.

2.15 Turn switch HC-652 clockwise to "Gas Sample" and hold.

2.16 Record pressure from PI-662 as P_3 (should be atmospheric) on Data Sheet 1.

2.17 Release switch HC-652, then remove the open vial from the dissolved gas sampling station.

2.18 Insert the standard reference capsule into the dissolved gas sampling station as was done in Step 2.8.

2.19 Connect the valved end of the reference capsule to the vacuum pump, open the valve and evacuate to 50 microns or better, then close the valve. Record pressure as Po on Data Sheet 1.

2.20 Turn switch HC-652 clockwise to "Gas Sample" and hold.

2.21 Record pressure from PI-662 as P4.

2.22 Calculate V_G as follows: (and record on Data Sheet 1)

$$V_G = (V_T + V_S)\frac{P_4 - P_0}{P_3 - P_0}$$

Where: V_T = the average value obtained from Step 2.12 (cc)

V_S = standard reference capsule volume (cc)

V_G = dissolved gas collection chamber volume, V-662 (cc)

2.23 Install a new rubber septum on the standard reference capsule.

2.24 Repeat Steps 2.14 through 2.23 three or more times and then calculate an average value V_G (V-662).

3. Determination of the Liquid Circulation Chamber Volume, V-610

3.1 Disconnect sample source lines (JET PUMP, RHR, etc.) from the PASS System.

3.2 On the control panel set switches as follows:

Mode Selector Switch to "LIQUID"
Sequencing Switch HC-601 to Position 10
Liquid Sample Source Selector Switch HC-626 to Position 2

3.3 Insert an open vial (without rubber septum) into the dissolved gas sampling station. Make sure the limit switch near the needle is depressed and green indicator light is on.

3.4 Turn switch HC-652 clockwise to "Gas Sample" and hold.

3.5 Record pressure from PI-662 as P_1 (atmospheric pressure) on Data Sheet 3.

3.6 Release switch H-652, then remove the open vial from the sampling station.

3.7 Insert a vial with rubber septum into the dissolved gas sampling station. Note that the needle punctures the septum and that the vial is inserted far enough to depress the limit switch. "Vial Position" status light on the panel should change from red to green.

3.8 Turn sequencing switch HC-601 from Position 10, quickly thru Position 11 to OFF.

3.9 Turn sequencing switch HC-601 to Position 2. Observe that P-701 starts and the pressure reading on PI-662 decreases.

3.10 Allow the pressure reading from PI-662 to stabilize then record the pressure as P_2 (partial vacuum) on Data Sheet 3.

3.11 Turn sequencing switch HC-601 from Position 2 very quickly thru Positions 3, 4, 5 and 6 to Position 7.

3.12 Record pressure from PI-662 as P_3 on Data Sheet 3.

3.13 Calculate V_L as follows: (on Data Sheet 3)

$$V_L = \frac{P_3 - P_2}{P_1 - P_3} \cdot V_G$$

Where: V_G = average value for the dissolved gas collection chamber volume (V-662) obtained previously (cc)
V_L = liquid circulation loop volume, V-610 (cc)

3.14 Turn sequencing switch HC-601 to Position 10 and remove the vial with rubber septum from the dissolved gas sampling station.

3.15 Repeat Steps 3. through 3.14 three or more times and then calculate an average value V_L (V-610).

Table 10-1 (*Continued*)
SOLUBILITY OF GASES IN WATER

Temp. °C.	CARBON DIOXIDE		CARBON MONOXIDE		CHLORINE		ETHANE		ETHYLENE		HYDROGEN	
	a	q	a	q	a	q	a	q	a	q	a	q
0	1.713	0.3346	0.03537	0.004397	.....	.....	0.09674	0.01317	0.226	0.0231	0.02149	0.0001922
1	1.646	0.3213	0.03455	0.004293	.....	.....	0.09478	0.01253	0.219	0.0272	0.02105	0.0001901
2	1.584	0.3091	0.03375	0.004191	.....	.....	0.09093	0.01212	0.211	0.0262	0.02105	0.0001881
3	1.527	0.2978	0.03297	0.004092	.....	.....	0.08725	0.01152	0.204	0.0253	0.02064	0.0001862
4	1.473	0.2871	0.03222	0.003996	.....	.....	0.08372	0.01114	0.197	0.0244	0.02024	0.0001843
5	1.424	0.2774	0.03149	0.003903	.....	.....	0.08033	0.01069	0.191	0.0237	0.02044	0.0001824
6	1.377	0.2681	0.03078	0.003813	.....	.....	0.07709	0.01025	0.184	0.0228	0.02025	0.0001806
7	1.331	0.2593	0.03009	0.003725	.....	.....	0.07400	0.00983	0.178	0.0220	0.02007	0.0001789
8	1.292	0.2490	0.02942	0.003640	.....	.....	0.07108	0.00943	0.173	0.0214	0.01989	0.0001772
9	1.257	0.2403	0.02878	0.003559	.....	.....	0.06828	0.00906	0.167	0.0207	0.01972	0.0001755
10	1.194	0.2313	0.02816	0.003479	3.149	0.9972	0.06561	0.00870	0.162	0.0200	0.01955	0.0001740
11	1.154	0.2239	0.02757	0.003405	3.047	0.9654	0.06323	0.00838	0.157	0.0194	0.01940	0.0001725
12	1.117	0.2165	0.02701	0.003332	2.950	0.9346	0.06106	0.00808	0.152	0.0188	0.01925	0.0001710
13	1.083	0.2098	0.02646	0.003261	2.856	0.9050	0.05894	0.00780	0.148	0.0183	0.01911	0.0001696
14	1.050	0.2032	0.02593	0.003194	2.767	0.8758	0.05684	0.00753	0.143	0.0176	0.01897	0.0001682
15	1.019	0.1970	0.02543	0.003130	2.680	0.8495	0.05504	0.00727	0.139	0.0171	0.01883	0.0001668
16	0.985	0.1903	0.02494	0.003068	2.597	0.8232	0.05325	0.00703	0.136	0.0167	0.01869	0.0001654
17	0.956	0.1845	0.02448	0.003007	2.517	0.7979	0.05159	0.00680	0.132	0.0162	0.01856	0.0001641
18	0.923	0.1739	0.02402	0.002947	2.440	0.7733	0.05003	0.00659	0.129	0.0158	0.01844	0.0001629
19	0.902	0.1737	0.02360	0.002891	2.368	0.7510	0.04858	0.00639	0.125	0.0153	0.01831	0.0001615
20	0.878	0.1688	0.02319	0.002838	2.299	0.7293	0.04724	0.00620	0.122	0.0149	0.01819	0.0001603
21	0.854	0.1640	0.02281	0.002789	2.238	0.7100	0.04589	0.00602	0.119	0.0146	0.01805	0.0001589
22	0.829	0.1590	0.02244	0.002739	2.180	0.6918	0.04469	0.00584	0.116	0.0142	0.01792	0.0001575
23	0.804	0.1540	0.02208	0.002691	2.123	0.6738	0.04335	0.00567	0.114	0.0139	0.01779	0.0001561
24	0.781	0.1493	0.02174	0.002646	2.070	0.6572	0.04217	0.00551	0.111	0.0135	0.01766	0.0001548
25	0.759	0.1449	0.02142	0.002603	2.019	0.6413	0.04104	0.00535	0.108	0.0131	0.01754	0.0001535
26	0.738	0.1406	0.02110	0.002560	1.970	0.6259	0.03997	0.00520	0.106	0.0129	0.01742	0.0001522
27	0.718	0.1366	0.02080	0.002519	1.923	0.6112	0.03895	0.00506	0.104	0.0125	0.01731	0.0001509
28	0.699	0.1327	0.02051	0.002479	1.880	0.5975	0.03799	0.00493	0.102	0.0123	0.01720	0.0001498
29	0.682	0.1292	0.02024	0.002442	1.839	0.5847	0.03709	0.00480	0.100	0.0121	0.01709	0.0001484
30	0.665	0.1257	0.01998	0.002405	1.799	0.5723	0.03624	0.00468	0.098	0.0118	0.01699	0.0001474
35	0.592	0.1105	0.01877	0.002231	1.602	0.5104	0.03230	0.00412	.....	.....	0.01668	0.0001425
40	0.530	0.0973	0.01775	0.002075	1.438	0.4590	0.02915	0.00368	.....	.....	0.01644	0.0001384
45	0.479	0.0860	0.01690	0.001933	1.302	0.4228	0.02660	0.00327	.....	.....	0.01624	0.0001341
50	0.436	0.0761	0.01615	0.001797	1.225	0.3925	0.02459	0.00294	.....	.....	0.01608	0.0001237
60	0.359	0.0578	0.01483	0.001562	1.023	0.3295	0.02177	0.00239	.....	.....	0.01600	0.0001178
70	.....	.....	0.01440	0.001276	0.852	0.2793	0.01948	0.00185	.....	.....	0.0160	0.000102
80	.....	.....	0.01430	0.000980	0.693	0.2227	0.01826	0.00134	.....	.....	0.0160	0.000075
90	.....	.....	0.0142	0.00057	0.39	0.127	0.3178	0.0008	.....	.....	0.0160	0.000046
100	.....	.....	0.0141	0.00000	0.00	0.000	0.0172	0.0000	.....	.....	0.0160	0.000000

q = weight in grams per 100 grams H_2O when total pressure = 760 mm

Attachment 8

Table 10-1 (*Continued*)
SOLUBILITY OF GASES IN WATER

Temp. °C.	CARBON DIOXIDE		CARBON MONOXIDE		CHLORINE		ETHANE		ETHYLENE		HYDROGEN	
	a	q	a	q	l	q	a	q	a	q	a	q
0	1.713	0.3346	0.02537	0.004397	.....	.....	0.09674	0.01317	0.226	0.0311	0.02148	0.0001922
1	1.646	0.3213	0.02455	0.004293	.....	.....	0.09476	0.01283	0.219	0.0302	0.02126	0.0001901
2	1.584	0.3091	0.02375	0.004191	.....	.....	0.09093	0.01212	0.211	0.0282	0.02105	0.0001881
3	1.527	0.2978	0.02307	0.004092	.....	.....	0.08725	0.01162	0.204	0.0253	0.02084	0.0001862
4	1.473	0.2871	0.02222	0.003996	.....	.....	0.08372	0.01114	0.197	0.0244	0.02064	0.0001843
5	1.424	0.2774	0.02149	0.003903	.....	.....	0.08033	0.01069	0.191	0.0237	0.02044	0.0001824
6	1.377	0.2681	0.02078	0.003813	.....	.....	0.07709	0.01025	0.184	0.0228	0.02025	0.0001806
7	1.331	0.2589	0.02009	0.003725	.....	.....	0.07400	0.00983	0.179	0.0220	0.02007	0.0001789
8	1.288	0.2502	0.01942	0.003640	.....	.....	0.07106	0.00943	0.173	0.0214	0.01989	0.0001772
9	1.247	0.2423	0.01878	0.003559	.....	.....	0.06826	0.00906	0.167	0.0207	0.01972	0.0001756
10	1.194	0.2318	0.01816	0.003479	3.149	0.9972	0.06561	0.00870	0.162	0.0200	0.01955	0.0001740
11	1.154	0.2239	0.01757	0.003405	3.047	0.9654	0.06328	0.00838	0.157	0.0194	0.01940	0.0001725
12	1.117	0.2165	0.01701	0.003332	2.950	0.9346	0.06106	0.00808	0.152	0.0188	0.01925	0.0001710
13	1.083	0.2098	0.01646	0.003261	2.856	0.9050	0.05894	0.00780	0.148	0.0183	0.01911	0.0001696
14	1.050	0.2032	0.01593	0.003194	2.767	0.8768	0.05694	0.00753	0.143	0.0176	0.01897	0.0001682
15	1.019	0.1970	0.01543	0.003130	2.680	0.8495	0.05504	0.00727	0.139	0.0171	0.01883	0.0001668
16	0.985	0.1903	0.01494	0.003066	2.597	0.8232	0.05326	0.00703	0.136	0.0167	0.01869	0.0001654
17	0.956	0.1845	0.01448	0.003007	2.517	0.7979	0.05159	0.00680	0.132	0.0162	0.01856	0.0001641
18	0.928	0.1789	0.01402	0.002947	2.440	0.7733	0.05003	0.00659	0.129	0.0158	0.01844	0.0001628
19	0.902	0.1737	0.01360	0.002891	2.368	0.7510	0.04858	0.00639	0.125	0.0153	0.01831	0.0001615
20	0.878	0.1688	0.01319	0.002838	2.299	0.7293	0.04724	0.00620	0.122	0.0149	0.01819	0.0001603
21	0.854	0.1640	0.01281	0.002789	2.238	0.7100	0.04589	0.00602	0.119	0.0146	0.01805	0.0001588
22	0.829	0.1590	0.01244	0.002739	2.180	0.6918	0.04459	0.00584	0.116	0.0142	0.01792	0.0001575
23	0.804	0.1540	0.01208	0.002691	2.123	0.6739	0.04336	0.00567	0.114	0.0139	0.01779	0.0001567
24	0.781	0.1493	0.01174	0.002646	2.070	0.6572	0.04217	0.00551	0.111	0.0135	0.01766	0.0001548
25	0.759	0.1449	0.01142	0.002603	2.019	0.6413	0.04104	0.00535	0.108	0.0131	0.01754	0.0001535
26	0.738	0.1406	0.01110	0.002560	1.970	0.6259	0.03997	0.00520	0.106	0.0129	0.01742	0.0001522
27	0.719	0.1366	0.01080	0.002519	1.923	0.6112	0.03895	0.00506	0.104	0.0126	0.01731	0.0001509
28	0.699	0.1327	0.01051	0.002479	1.880	0.5975	0.03799	0.00493	0.102	0.0123	0.01720	0.0001496
29	0.682	0.1292	0.01024	0.002442	1.839	0.5847	0.03709	0.00480	0.100	0.0121	0.01709	0.0001484
30	0.665	0.1257	0.01998	0.002405	1.799	0.5723	0.03624	0.00468	0.098	0.0118	0.01699	0.0001474
35	0.592	0.1105	0.01877	0.002231	1.602	0.5104	0.03230	0.00412	.....	.....	0.01668	0.0001425
40	0.530	0.0973	0.01775	0.002075	1.438	0.4590	0.02915	0.00366	.....	.....	0.01644	0.0001384
45	0.479	0.0860	0.01690	0.001933	1.322	0.4228	0.02660	0.00327	.....	.....	0.01624	0.0001341
50	0.436	0.0761	0.01615	0.001797	1.225	0.3925	0.02459	0.00294	.....	.....	0.01608	0.0001287
60	0.359	0.0576	0.01488	0.001522	1.023	0.3295	0.02177	0.00239	.....	.....	0.01600	0.0001178
70	.....	.....	0.01440	0.001276	0.852	0.2793	0.01948	0.00185	.....	.....	0.0160	0.000102
80	.....	.....	0.01430	0.000980	0.693	0.2227	0.01826	0.00134	.....	.....	0.0160	0.000079
90	.....	.....	0.0142	0.00057	0.39	0.127	0.0176	0.0008	.....	.....	0.0160	0.000046
100	.....	.....	0.0141	0.00000	0.00	0.000	0.0172	0.0000	.....	.....	0.0160	0.000000

q = weight in grams per 100 grams H_2O
when total pressure = 760 mm

Attachment B

Table 10-6
VAPOR PRESSURE OF WATER IN MILLIMETERS OF MERCURY
For Temperatures from −10 to 120°C

The values in the table are for water in contact with its own vapor. Where the water is in contact with air at a temperature t°C, the following correction must be added: Correction (for temperatures up to 100°C) = $p(0.775 - 0.0013\ t)/100$; correction (for temperatures above 50°C) = $p(0.0652 - 0.0007\ 5\ t)/100$.

t, °C	p, mm Hg	t, °C	p, mm Hg	t, °C	p, mm Hg	t, °C	p, mm Hg
−10.0	2.149	14.5	12.382	24.0	23.198	34.4	40.296
−9.5	2.236	15.0	12.788	24.2	23.476	34.6	41.251
−9.0	2.326	15.2	12.953	25.0	23.756	34.8	41.710
−8.5	2.418	15.4	13.121	25.2	24.039	35.0	42.175
−8.0	2.514	15.6	13.290	25.4	24.326	35.2	42.644
−7.5	2.613	15.8	13.461	25.6	24.617	35.4	43.117
−7.0	2.715	16.0	13.634	25.8	24.912	35.6	43.595
−6.5	2.822	16.2	13.809	26.0	25.209	35.8	44.078
−6.0	2.931	16.4	13.987	26.2	25.509	36.0	44.563
−5.5	3.046	16.6	14.166	26.4	25.812	36.2	45.054
−5.0	3.163	16.8	13.347	26.6	26.117	36.4	45.549
−4.5	3.284	17.0	14.530	26.8	26.426	36.6	46.050
−4.0	3.410	17.2	14.715	27.0	26.739	36.8	46.556
−3.5	3.540	17.4	14.903	27.2	27.055	37.0	47.067
−3.0	3.673	17.6	15.092	27.4	27.374	37.2	47.582
−2.5	3.813	17.8	15.284	27.6	27.696	37.4	48.102
−2.0	3.956	18.0	15.477	27.8	28.021	37.6	48.627
−1.5	4.105	18.2	15.673	28.0	28.349	37.8	49.157
−1.0	4.258	18.4	15.871	28.2	28.680	38.0	49.692
−0.5	4.416	18.6	16.071	28.4	29.015	38.2	50.231
0.0	4.579	18.8	16.272	28.6	29.354	38.4	50.774
0.5	4.750	19.0	16.477	28.8	29.697	38.6	51.323
1.0	4.926	19.2	16.685	29.0	30.043	38.8	51.879
1.5	5.107	19.4	16.894	29.2	30.392	39.0	52.442
2.0	5.294	19.6	17.105	29.4	30.745	39.2	53.009
2.5	5.486	19.8	17.319	29.6	31.102	39.4	53.580
3.0	5.685	20.0	17.535	29.8	31.461	39.6	54.158
3.5	5.889	20.2	17.753	30.0	31.824	39.8	54.737
4.0	6.101	20.4	17.974	30.2	32.191	40.0	55.324
4.5	6.318	20.6	18.197	30.4	32.561	40.5	56.81
5.0	6.543	20.8	18.422	30.6	32.934	41.0	58.34
5.5	6.775	21.0	18.650	30.8	31.312	41.5	59.90
6.0	7.013	21.2	18.880	31.0	33.695	42.0	61.50
6.5	7.259	21.4	19.113	31.2	34.082	42.5	63.13
7.0	7.513	21.6	19.349	31.4	34.471	43.0	64.80
7.5	7.775	21.8	19.587	31.6	34.864	43.5	66.51
8.0	8.045	22.0	19.827	31.8	35.261	44.0	68.26
8.5	8.323	22.2	20.070	32.0	35.663	44.5	70.05
9.0	8.609	22.4	20.316	32.2	36.068	45.0	71.88
9.5	8.905	22.6	20.565	32.4	36.477	45.5	73.74
10.0	9.209	22.8	20.815	32.6	36.891	46.0	75.65
10.5	9.521	23.0	21.068	32.8	37.308	46.5	77.61
11.0	9.841	23.2	21.324	33.0	37.729	47.0	79.60
11.5	10.176	23.4	21.583	33.2	38.155	47.5	81.64
12.0	10.510	23.6	21.845	33.4	38.584	48.0	83.71
12.5	10.870	23.8	22.110	33.6	39.018	48.5	85.85
13.0	11.231	24.0	22.387	33.8	39.457	49.0	88.02
13.5	11.604	24.2	22.648	34.0	39.898	49.5	90.24
14.0	11.987	24.4	22.922	34.2	40.344	50.0	92.51

t, °C	p, mm Hg	t, °C	p, mm Hg	t, °C	p, mm Hg	t, °C	p, mm Hg
50.5	93.86	67.5	209.57	84.5	425.2	97.6	697.10
51.0	97.20	68.0	214.17	85.0	433.6	97.8	702.17
51.5	99.65	68.5	218.85	85.5	442.3	98.0	707.27
52.0	102.09	69.0	223.73	86.0	450.9	98.2	712.40
52.5	104.65	69.5	228.72	86.5	459.8	98.4	717.56
53.0	107.20	70.0	233.7	87.0	468.7	98.6	722.75
53.5	109.86	70.5	238.8	87.5	477.9	98.8	727.98
54.0	112.51	71.0	243.9	88.0	487.1	99.0	733.24
54.5	115.28	71.5	249.3	88.5	496.6	99.2	738.54
55.0	118.04	72.0	254.6	89.0	506.1	99.4	743.85
55.5	120.92	72.5	260.2	89.5	515.9	99.6	749.20
56.0	123.80	73.0	265.7	90.0	525.78	99.8	754.58
56.5	126.81	73.5	271.5	90.5	535.83	100.0	760.00
57.0	129.82	74.0	277.2	91.0	546.05	101.0	787.57
57.5	132.95	74.5	283.2	91.5	556.44	102.0	815.86
58.0	136.08	75.0	289.1	92.0	566.99	103.0	845.12
58.5	139.34	75.5	295.3	92.5	577.71	104.0	875.06
59.0	142.60	76.0	301.4	93.0	588.60	105.0	906.07
59.5	145.99	76.5	307.7	93.5	599.66	106.0	937.92
60.0	149.38	77.0	314.1	94.0	610.90	107.0	970.60
60.5	152.91	77.5	320.7	94.5	622.31	108.0	1004.12
61.0	156.43	78.0	327.3	95.0	633.90	109.0	1038.92
61.5	160.10	78.5	334.2	95.2	638.59	110.0	1074.56
62.0	163.77	79.0	341.0	95.4	643.30	111.0	1111.20
62.5	167.58	79.5	348.1	95.6	648.05	112.0	1148.74
63.0	171.38	80.0	355.1	95.8	652.82	113.0	1187.42
63.5	175.35	80.5	362.4	96.0	657.62	114.0	1227.25
64.0	179.31	81.0	369.7	96.2	662.45	115.0	1267.98
64.5	183.43	81.5	377.3	96.4	667.31	116.0	1309.91
65.0	187.54	82.0	384.8	96.6	672.20	117.0	1352.95
65.5	191.82	82.5	392.8	96.8	677.12	118.0	1397.10
66.0	196.09	83.0	400.6	97.0	682.07	119.0	1442.64
66.5	200.53	83.5	408.7	97.2	687.04	120.0	1489.14
67.0	204.98	84.0	416.8	97.4	692.05		

$$(p, \text{mmHg})\ \frac{14.696}{760} = \text{psia}$$

Attachment C

Table 10-6

PROCEDURE NUMBER	REVISION NUMBER	PAGE NUMBER
12.10.8	0	12.10.8-15 of 19

Table 10-28
DENSITY OF MERCURY AND WATER

The density of mercury and pure air-free water under a pressure of 101 325 Pa (1 atm) is given in units of grams per cubic centimeter ($g \cdot cm^{-3}$). For mercury, the values are based on the density at 20°C being 13.545 884 $g \cdot cm^{-3}$. Water attains its maximum density of 0.999 973 $g \cdot cm^{-3}$ at 3.98°C. For water, the temperature (t_m, °C) of maximum density at different pressures (p) in atmospheres is given by

$$t_m = 3.98 - 0.0225(p - 1)$$

Density of Water	Temp., °C	Density of Mercury	Density of Water	Temp., °C	Density of Mercury
	−20	13.644 59	0.987 12	52	13.467 68
	−18	13.639 62	0.986 18	54	13.462 32
	−16	13.634 66	0.985 21	56	13.457 96
	−14	13.629 70	0.984 22	58	13.453 09
	−12	13.624 75	0.983 20	60	13.448 23
	−10	13.619 79	0.982 16	62	13.443 37
	−8	13.614 85	0.981 09	64	13.438 52
	−6	13.609 90	0.980 01	66	13.433 67
	−4	13.604 96	0.978 90	68	13.428 82
	−2	13.600 02	0.977 77	70	13.423 97
0.999 84	0	13.595 08	0.976 61	72	13.419 13
0.999 94	2	13.590 15	0.975 44	74	13.414 28
0.999 97	4	13.585 22	0.974 24	76	13.409 43
0.999 94	6	13.580 29	0.973 03	78	13.404 60
0.999 85	8	13.575 36	0.971 79	80	13.399 77
0.999 70	10	13.570 44	0.970 53	82	13.394 92
0.999 50	12	13.565 52	0.969 26	84	13.390 09
0.999 24	14	13.560 60	0.967 96	86	13.385 26
0.998 94	16	13.555 70	0.966 65	88	13.380 42
0.998 60	18	13.550 79	0.965 31	90	13.375 60
0.998 20	20	13.545 88	0.963 96	92	13.370 77
0.997 77	22	13.540 97	0.962 59	94	13.365 94
0.997 30	24	13.536 06	0.961 20	96	13.361 12
0.996 78	26	13.531 17	0.959 79	98	13.356 30
0.996 23	28	13.526 26	0.958 36	100	13.351 48
0.995 65	30	13.521 37		120	13.303 4
0.995 03	32	13.516 47		140	13.255 4
0.994 37	34	13.511 58		160	13.207 6
0.993 69	36	13.506 70		180	13.159 8
0.992 97	38	13.501 82		200	13.112 0
0.992 22	40	13.496 93		220	13.064 3
0.991 44	42	13.492 07		240	13.016 9
0.990 63	44	13.487 18		260	12.969 2
0.989 79	46	13.482 29		280	12.921 5
0.988 93	48	13.477 42		300	12.873 7
0.988 04	50	13.472 56			

DATA SHEET 1

1. P_i = _____ (PI - 662)

2. P_F = _____ (PI - 662)

3. Water Temperature (^oF) _____ (TI - 660)

4. Gas Temperature (^oF) _____ (TI - 724)

5. V_L = _____ (cc)

6. V_G = _____ (cc)

7. S_H = _____ $\frac{(gm \div mol)}{SM\ H_2O - atm)}$

8. ρ = _____ (gm/ml)

9. P_V = _____ (psia)

10. P_{RG} = _____ (psia)

11. Total Dissolved gas = _____ $\frac{gm - mol}{cc\ H_2O}$

(from 12.10.8.4.3.2 and 12.10.8.4.E.3)

Reviewed by _____

DATA SHEET 2

1. Weight difference _____ gms
2. Ambient temperature _____ ^{o}C
3. Density _____ gm/cc
4. V_S = _____ cc
5. P_0 = _____ psia
6. P_1 = _____ psia
7. P_2 = _____ psia
8. V_T = _____ cc
   = _____ cc
   = _____ cc
   = _____ cc
9. Average V_T = _____ cc
10. P_3 = _____ psia
11. P_0 = _____ psia
12. V_G = _____ cc
    = _____ cc
    = _____ cc
    = _____ cc
13. Average V_G = _____ cc

Reviewed by _____

DATA SHEET 3

1. P_1 = _____ (psia)
2. P_2 = _____ (psia)
3. P_3 = _____ (psia)
4. V_L = _____ (cc)

   _____ (cc)

   _____ (cc)

   _____ (cc)
5. Average value of V_L = _____ (cc)

Reviewed by _____