CABLE PRESSURE SYSTEMS

CORRECTION OF PRESSURE MEASUREMENTS

CONTENTS PAGE

1. GENERAL

1.01 This section describes the procedures required for converting cable pressure measurements from gauge pressure, as indicated by measuring with a C pressure gauge, to an equivalent value at a nominal temperature (60°F) and an absolute pressure. Absolute pressure (psia) is the sum of the gauge pressure and the atmospheric pressure in pounds per square inch (psi). This conversion is necessary when plotting pressure measurements for the purpose of locating leaks in pressurized cables.

1.02 This section is issued to consolidate and update information previously covered in Sections 637-400-011, -501, -502, and -503.

1.03 Generally, pressure measurements are made and compared with previous measurements which may have been taken under different conditions. When an accurate comparison is necessary, the readings must be corrected for the effect of changes in temperature, atmospheric pressure, and altitude.

1.04 In order to understand under what conditions pressure measurement corrections are required and how they are made, the following fundamentals should be understood thoroughly:

- Effect of temperature
- Effect of atmospheric pressure
- Effect of altitude.

2. TEMPERATURE

EFFECT OF TEMPERATURE

2.01 When the temperature of air or other gases increase, they tend to expand and take up more space. Since the space inside a cable is fixed, the air cannot take up more space; therefore, the pressure increases with rising temperature and decreases with falling temperature.

2.02 If the temperature does not change uniformly throughout the entire length of a cable, the pressure change will not be uniform and there will be a movement of air from the section of cable at the higher temperature toward the section at the lower temperature. This movement will stop only when temperature changes cease and pressure

in the entire length of cable is equalized. In any section of pressurized cable, the average temperature change determines the average pressure change.

2.03 The pressures in cables maintained at 6 to 9 psi vary from 0.15 to 0.30 psi for each 5-degree change in temperature. Consequently, pressures measured at different temperatures first must be converted to their equivalent values at a reference temperature before they can be compared directly. This usually is done by converting all pressure readings to their equivalent values at 60°F. The value of 60°F is selected as a reference value because it is approximately the middle of the temperature range normally encountered. It is specified as the reference temperature for normal cable maintenance and contactor operating pressures.

MEASUREMENT OF TEMPERATURE

2.04 For pressure testing purposes, temperature is determined by measuring the ambient or ground temperature, using a thermometer having a range of 0° to 150°F. When measuring temperature, the thermometer should not be held in the hand. Approximately 5 minutes should be allowed for the thermometer to record the correct temperature.

2.05 When measuring the temperature of cable on reels, loading coil cases, etc, located in the sun, the thermometer should be on the sunny side, with its tube facing the sun. If they are in the rain, the thermometer is placed so that the rain strikes it directly. If they have recently been moved, allow sufficient time to permit the material to reach ambient temperature before making temperature measurements.

2.06 For aerial cable, temperature measurements are made at each point where a pressure reading is made. If the sun is shining, suspend the thermometer from the cable or a pole so that the tube is in and facing the sun (whether the pressure measuring point is in the sun or shade). If the sun is not shining, face the tube in the general direction of where the sun should be at that time of day; if raining, place the thermometer where the rain strikes it directly.

2.07 When temperature measurements are required for underground cable in conduit or buried cable, generally, they need to be made at only a few valve points. On individual reel lengths after placing and loading sections during construction of a cable, a temperature measurement at one point is sufficient. For tests on completed cable sections, temperature measurements can be made at valve locations at intervals of 12,000 to 18,000 feet.

2.08 To measure the temperature of underground cable, fasten the thermometer to a duct rod and insert it 6 to 9 feet inside the duct containing the cable to be measured. If the conduit is filled with water or there is no room to insert the duct rod, suspend the thermometer in the manhole at approximately the same level as the cable.

2.09 Temperature measurements on buried cable can be made by inserting the thermometer in a hole (1 to 2 feet in depth) formed by driving a rod or bar into the ground approximately 10 feet to the side of the cable run. Suspend the thermometer in the hole for approximately 5 minutes, then withdraw and observe its reading.

2.10 ***Nitrogen Cylinders:*** When measuring the temperature of a nitrogen cylinder, the thermometer should be placed in a vertical position alongside the cylinder. If the cylinder is in the sun, place the thermometer on the sunny side with its tube facing the sun. If the cylinder is in the rain, the thermometer should be placed so the rain strikes it directly. Recently moved cylinders should be allowed time to adjust to temperature at the new location before measurement is made.

TEMPERATURE CORRECTIONS

2.11 Temperature correction ***is required*** when pressure measurements are made for the following purposes:

(a) Determining rate of air loss in a cable section, in a reel of cable, or in some piece of equipment not connected to a cable, such as a load coil case. This is necessary because two sets of measurements are to be compared, and the effect of temperature should be taken into account to permit direct comparison of the readings.

(b) Adjusting cable pressure monitoring devices.

(c) Charging or recharging cables on reels, or during construction.

(d) Determining the exact amount of gas in a cylinder. Day-to-day operations do not

require that the exact amount of gas in a cylinder be known; but certain special tests, such as determining pneumatic resistances, may require this information.

2.12 Temperature corrections ***are not necessary*** when pressure measurements are taken simultaneously or within a relatively short period of time. In fact, any attempt to compensate for temperature is likely to reduce the accuracy of the pressure measurements.

A. Correction for Cable Temperature

2.13 Measured cable pressures can be converted to their equivalent values at 60°F, or to any other temperature by use of Table A.

TABLE A

CABLE TEMP. DEGREES F.	EQUIVALENT GAUGE PRESSURES AT VARIOUS TEMPERATURES (ASSUMING NORMAL SEA-LEVEL ATMOSPHERIC PRESSURE OF 30 INCHES MERCURY OR 15 POUNDS PRESSURE) PRESSURE IN CABLE – POUNDS PER SQUARE INCH											
110	4.7	5.8	6.9	8.0	9.1	10.2	11.3	12.4	13.5	14.6	15.7	16.8
105	4.5	5.6	6.7	7.8	8.9	10.0	11.1	12.1	13.2	14.3	15.4	16.5
100	4.4	5.4	6.5	7.6	8.7	9.7	10.8	11.9	13.0	14.1	15.1	16.2
95	4.2	5.3	6.3	7.4	8.5	9.5	10.6	11.7	12.7	13.8	14.9	15.9
90	4.0	5.1	6.1	7.2	8.3	9.3	10.4	11.4	12.5	13.5	14.6	15.7
85	3.9	4.9	5.9	7.0	8.0	9.1	10.1	11.2	12.2	13.3	14.3	15.4
80	3.7	4.7	5.8	6.8	7.8	8.9	9.9	11.0	12.0	13.0	14.1	15.1
75	3.5	4.5	5.6	6.6	7.6	8.7	9.7	10.7	11.7	12.8	13.8	14.8
70	3.3	4.4	5.4	6.4	7.4	8.4	9.5	10.5	11.5	12.5	13.5	14.6
65	3.2	4.2	5.2	6.2	7.2	8.2	9.2	10.2	11.2	12.3	13.3	14.3
60	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0
55	2.8	3.8	4.8	5.8	6.8	7.8	8.8	9.8	10.8	11.7	12.7	13.7
50	2.7	3.6	4.6	5.6	6.6	7.6	8.5	9.5	10.5	11.5	12.5	13.4
45	2.5	3.5	4.4	5.4	6.4	7.3	8.3	9.3	10.3	11.2	12.2	13.2
40	2.3	3.3	4.2	5.2	6.2	7.1	8.1	9.0	10.0	11.0	11.9	12.9
35	2.1	3.1	4.1	5.0	6.0	6.9	7.9	8.8	9.8	10.7	11.7	12.6
30	2.0	2.9	3.9	4.8	5.7	6.7	7.6	8.6	9.5	10.5	11.4	12.3
25	1.8	2.7	3.7	4.6	5.5	6.5	7.4	8.3	9.3	10.2	11.1	12.1
20	1.6	2.6	3.5	4.4	5.3	6.3	7.2	8.1	9.0	9.9	10.9	11.8
15	1.5	2.4	3.3	4.2	5.1	6.0	7.0	7.9	8.8	9.7	10.6	11.5
10	1.3	2.2	3.1	4.0	4.9	5.8	6.7	7.6	8.5	9.4	10.3	11.2
5	1.1	2.0	2.9	3.8	4.7	5.6	6.5	7.4	8.3	9.2	10.1	11.0
0	1.0	1.8	2.7	3.6	4.5	5.4	6.3	7.1	8.0	8.9	9.8	10.7
–5	0.8	1.7	2.5	3.4	4.3	5.2	6.0	6.9	7.8	8.7	9.5	10.4
–10	0.6	1.5	2.3	3.2	4.1	4.9	5.8	6.7	7.5	8.4	9.3	10.1

2.14 Table A graduations are based on the variation of absolute pressure with temperature, but are expressed in terms of average gauge pressure at sea level. An error results when this table is used to convert pressure readings taken at higher elevations. However, the error introduced is small (less than 0.1 psi) and may be neglected in ordinary pressure maintenance operations requiring temperature correction.

B. Correction for Cylinder Temperature

2.15 The pressure of gas in a cylinder varies with changing temperature. Cylinder pressure is indicated by the high-pressure gauge of the regulator. This gauge is calibrated to indicate the volume of gas contained in the cylinder, equivalent cubic feet of gas at sea-level pressure and 60°F. Readings taken at other cylinder temperatures are in error (readings increase with rising temperature).

2.16 At temperatures other than 60°F, indicated volumes on the high-pressure gauge of the regulator can be converted to equivalent volumes at 60°F by the use of Table B.

3. ATMOSPHERIC PRESSURE

EFFECT OF ATMOSPHERIC PRESSURE

3.01 Atmospheric pressure is measured with a barometer and is expressed in inches of mercury. Atmospheric pressure at sea level is approximately 30 inches of mercury, which is equivalent to approximately 15 psi. A variation of 1 inch of mercury is equivalent to a change of 0.50 psi in atmospheric pressure.

3.02 Changes in weather conditions may result in atmospheric pressure variations of 0.1 inch of mercury or 0.05 psi change in a period of 1 hour. Barometric pressure at a given location may vary by 1 inch of mercury from day to day and by more than 2 inches of mercury over a period of several days. Under storm conditions, the pressure may vary by the latter amount in a few hours.

3.03 As changes in atmospheric pressure occur, the gauge pressure of a cable will vary accordingly. For example, a measurement of 6.5 psi taken when the barometer reads 30 inches is equivalent to a measurement of 7.0 psi when the barometer reads 29 inches. This is the reason that pressure measurements taken on consecutive days, although corrected for temperature variation, may appear to show that a cable has gained pressure. Operating in the reverse direction, this effect exaggerates pressure losses. Before pressure readings (taken under different atmospheric conditions) can be compared, they must be converted to their equivalent values at a common atmospheric pressure.

3.04 The normal atmospheric pressure of 30 inches of mercury at sea level is due to the weight of the layer of air which envelopes the earth. At elevations above sea level there is less air overhead, and therefore less atmospheric pressure. Atmospheric pressure decreases approximately 1 inch of mercury for each 1000 feet increase in altitude. Normal weather changes produce about the same atmospheric pressure variations at higher altitudes as at sea level.

3.05 Barometers are equipped with movable scales graduated to read from approximately 27 to 31 inches of mercury. Regardless of the altitude, the 30-inch graduation generally is adjusted to correspond to the normal atmospheric pressure at the location of the barometer. U. S. Weather Bureau Stations are prepared to furnish barometric readings adjusted to the 30-inch (sea-level) base.

3.06 Atmospheric pressure variations caused by weather conditions can be compensated for by converting all pressure readings to their equivalent values under normal atmospheric pressure of 30 inches of mercury (sea-level base). It is specified as the reference atmospheric pressure for normal cable maintenance and contactor operating pressures.

TABLE B

TEMP. DEG. F.	EQUIVALENT VOLUME OF GAS IN 220 CUBIC FOOT CYLINDER CUBIC FEET AT NORMAL SEA-LEVEL ATMOSPHERIC PRESSURE AND 60°F.																						TEMP. DEG. F.
125	34	46	57	68	80	91	103	115	126	138	149	161	173	185	196	208	220	2230	2340	2460	2530	2590	125
120	34	45	56	67	79	90	102	113	125	137	148	159	171	183	194	206	217	2200	2310	2440	2500	2560	120
115	34	45	56	67	78	90	101	112	124	136	147	158	170	181	192	204	215	2180	2290	2410	2470	2530	115
110	33	44	55	66	78	89	100	111	122	134	145	156	168	179	190	201	213	224	2270	2380	2440	2510	110
105	33	44	55	66	77	88	99	110	121	133	144	155	166	177	188	199	211	222	2240	2360	2420	2480	105
100	33	44	54	65	76	87	98	109	120	131	142	153	164	176	186	197	208	220	2220	2330	2390	2450	100
95	32	43	53	64	76	86	97	108	119	130	141	151	163	174	184	195	206	217	2190	2300	2360	2420	95
90	32	43	53	64	75	85	96	107	118	129	139	149	161	172	182	193	204	215	225	2270	2330	2390	90
85	32	42	52	63	74	85	95	106	116	127	138	148	159	170	180	191	201	212	222	2250	2300	2360	85
80	31	42	52	63	73	84	94	105	115	126	136	146	157	168	178	189	199	210	220	2220	2270	2330	80
75	31	41	51	62	72	83	93	103	114	124	135	145	155	166	176	187	197	207	217	2200	2250	2300	75
70	31	41	51	61	71	82	92	102	112	123	133	143	154	164	174	185	195	205	215	225	2220	2280	70
65	30	40	50	61	71	81	91	101	111	121	131	141	152	162	172	182	192	203	213	223	2200	2250	65
60	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	225	2220	60
55	30	40	49	59	69	79	89	99	109	119	129	138	148	158	168	178	188	198	207	217	222	2190	55
50	29	39	49	59	69	78	88	98	107	117	127	137	146	156	166	176	185	195	205	215	220	225	50
45	29	39	48	58	68	77	87	97	106	116	126	135	145	154	164	174	183	193	202	212	217	222	45
40	29	38	48	57	67	77	86	95	105	115	124	133	143	152	162	171	181	190	199	209	214	219	40
35	28	38	47	57	66	76	85	94	104	113	122	132	141	150	159	169	179	188	197	207	211	216	35
30	28	37	47	56	65	75	84	93	102	112	121	130	139	148	157	167	176	185	194	204	209	213	30
25	28	37	46	55	65	74	83	92	101	110	119	129	138	147	155	165	174	183	192	201	206	210	25
20	27	36	46	55	64	73	82	91	100	109	118	127	136	145	153	162	171	180	189	198	203	207	20
15	27	36	45	54	63	72	81	89	99	108	116	125	134	143	151	160	169	178	187	195	200	204	15
10	27	36	45	53	62	71	80	88	97	106	115	123	132	141	149	158	167	175	184	193	197	201	10
5	26	35	44	53	62	70	79	87	96	105	113	121	130	139	147	156	164	173	181	190	194	198	5
0	26	35	43	52	61	69	78	86	95	103	111	120	129	137	145	153	162	170	179	187	191	195	0
−5	26	34	43	51	60	68	77	85	93	102	110	118	127	135	143	151	159	168	176	184	189	192	−5
−10	25	34	42	51	59	67	76	84	92	100	109	117	125	133	141	149	157	165	173	181	186	189	−10

*2220 pounds, 60°F. = 230 cu ft

Instructions:

(1) Read across line representing measured cylinder temperature and determine column in which observed volume reading appears on that line. Then read vertically in column to line representing 60°F. cylinder temperature. True volume of atmospheric gas in cylinder appears in column opposite 60°F. temperature.

(2) The volume scale of the high pressure gauge does not extend above 225 cubic feet. To obtain volume readings above end of scale, observe cylinder pressure and read across line representing measured cylinder temperature to column in which observed pressure reading appears on that line. Then proceed

MEASUREMENT OF ATMOSPHERIC PRESSURE

3.07 Barometer readings generally can be obtained from the nearest weather bureau or airport. Where this is found impracticable, barometers may be installed at the test desk or at other offices. These local barometers should be adjusted to read in accordance with weather bureau and airport barometers.

3.08 A barometer reading should be obtained each day that pressure measurements are made, and as close to the time of the measurements as practicable. Where a series of pressure measurements is to be compared, all barometer readings used to correct such measurements should be obtained from the same source. Except during periods of rapidly changing weather, barometer readings from a particular source may be applied to correct pressure readings taken within 50 to 75 miles of that source.

ATMOSPHERIC PRESSURE CORRECTIONS

3.09 Corrections for the effect of atmospheric pressure changes should be considered when making pressure measurements for the purpose of:

(a) Determining rate of air loss

(b) Adjusting cable pressure monitoring devices

(c) Charging or recharging cables on reels, or during construction.

3.10 Pressure measurements made for the purpose of locating a leak generally are made within a short interval of time, during which little or no atmospheric pressure changes occur; and hence, no correction is necessary.

3.11 Measured pressures can be converted to their equivalent values in psi at normal barometric pressure of 30 inches of mercury as follows:

(1) Calculate the difference between 30 inches and the barometer reading in inches of mercury.

(2) Divide this difference by two (1 inch of mercury is equivalent to approximately 1/2 pound pressure).

(3) Add the value found in (2) to the ***pressure reading*** if the barometer reads more than 30 inches; subtract the value found in (2) if the barometer reading is less than 30 inches.

3.12 ***Example:*** Assume that pressure readings have been made to determine the rate of air loss in a cable section. The ***first set of readings*** was found to average 6.8 psi at 60°F, with a barometer reading of 29.6 inches. A ***second set of readings,*** taken 10 days later, indicates an average pressure of 6.4 psi at 60°F, with a barometer reading of 30.2 inches.

(1) First, convert the average pressure found for the ***first set of readings*** to normal barometric pressure. Subtract 29.6 inches from the normal 30.0 inches and divide this value by two to find:

$$\frac{30.0 - 29.6}{2} = 0.2 \text{ psi.}$$

(2) Since the barometer reading was ***less*** than 30 inches, subtract the value found in (1) from the average pressure reading:

6.8 - 0.2 = 6.6 psi.

(3) Next, convert the average pressure found for the ***second set of readings*** to normal barometric pressure. Subtract the normal 30.0 from 30.2 and divide this value by two to find:

$$\frac{30.2 - 30.0}{2} = 0.1 \text{ psi.}$$

(4) Since the barometer reading was ***greater*** than 30 inches, add the value found in (3) to the average pressure reading:

6.4 + 0.1 = 6.5 psi.

(5) The pressure loss in 10 days is:

6.6 - 6.5 = 0.1 psi.

(6) The pressure loss in 30 days would be:

$$0.1 \left(\frac{30}{10}\right) = 0.3 \text{ psi.}$$

3.13 If correction for variation in atmospheric pressure had been omitted in the example given in 3.12, the computed loss would have been:

$$6.8 - 6.4 = 0.4 \text{ psi (10-day period)}$$

$$0.4 \left(\frac{30}{10}\right) = 1.2 \text{ psi (30-day period).}$$

4. ALTITUDE

EFFECT OF ALTITUDE

4.01 As stated previously, normal atmospheric pressure at sea level is equal to 30 inches of mercury or approximately 15 psi and decreases approximately 1 inch of mercury or 0.50 psi for each 1000-foot increase in altitude. Thus, at 4000 feet above sea level, the normal atmospheric pressure is 26 inches of mercury, which is equivalent to approximately 13 psi.

4.02 Gauge or manometer readings of a given absolute pressure will be influenced accordingly. For example, the gauge pressure of a reel of cable is measured as 6 psi at seal level. The cable is shipped to a point 3000 feet above sea level. On arrival, the gauge pressure (assuming no leakage and comparable temperature conditions) should measure 7.5 psi. In both cases, the absolute cable pressure is the same (21.0 psia). At sea level the normal atmospheric pressure is 15.0 psi.

15.0 psi + 6.0 psi = 21.0 psia.
Whereas, at 3000 feet, it is
13.5 psi + 7.5 psi = 21.0 psia.

4.03 Consequently, pressure readings on a reel of cable, load coil case, etc, made at different altitudes must be converted to their equivalent values at a common altitude before they can be compared. This may be done by converting the pressure readings to their equivalent value at sea level.

4.04 Another factor must be taken into account when a ***completed cable section*** is placed, at considerably different altitudes, in mountainous country. In such cases, pressure measurements will read ***higher*** at the lower elevation than at the higher elevations due to the gravitational pull on the air inside the cable. For example, a buried cable charged to 9 psi will vary approximately 0.1 psi per 300-foot difference in elevation.

MEASUREMENT OF ALTITUDE

4.05 ***Ordinary Measurements:*** These measurements apply only in correcting pressure measurements taken with a C pressure gauge or a mercury manometer.

4.06 In order that pressure measurements made at different elevations can be converted to their equivalent values at a common elevation, the elevation of all valve points in a cable section must be determined. In general, this should be done whenever there is a difference in elevation of approximately 150 feet or more between the highest and lowest valve points in the cable section.

4.07 The elevation of each valve point should be determined to an accuracy of ±10 feet by use of a surveyor level or hand level, or by other approved instruments such as precise altimeters.

4.08 When determining elevation of a buried cable section in mountainous country, it is desirable to obtain the elevation of each cable marker along the route in addition to the elevation at valve points. These marker elevations are shown on the plant records for pressure maintenance purposes.

4.09 When temporary valves are installed for leak location measurements, the elevations should be determined at that time. The known elevation of a regular valve point or marker can be used as the base and starting point of the survey.

4.10 If the elevation of a regular valve point or marker is not known, an assumed elevation can be used as the base and starting point for the survey of elevations for leak location measurements.

4.11 ***Precise Measurements:*** These measurements apply only in correcting

pressure measurements taken with precision instruments that measure absolute pressures to the nearest 0.001 psi, such as the Type FA-176021 W. and T. manometer.

4.12 When making precise measurements at different elevations, determine the elevation differences between the temporary valve points where measurements are made for leak location purposes. This is done whenever there is a difference in elevation of 1 foot or more between the lowest and highest valves at which pressure measurements are taken.

4.13 The difference in elevations between each of the temporary valve points and the base valve (lowest valve point) must be determined to an accuracy of approximately 1 foot. These elevations are determined for each valve at the point where the precision instrument will be placed when the pressure measurement of that valve is taken. Elevations may be determined to the accuracy required by the use of a surveyor level, builder level, or suitable equivalent.

ALTITUDE CORRECTIONS

4.14 Good judgment is necessary in order to determine when and to what extent altitude correction should be applied. Measurements generally are recorded to the nearest 0.1 psi when making routine readings and charging and recharging cables. In these cases, altitude correction should be made whenever there is a difference in elevation of about 150 feet or more between the highest and lowest pressure measuring points.

4.15 Smaller differences in elevation will be significant in the location of a small leak in an underground or buried cable. When a mercury manometer or C pressure gauge is employed and accuracy to the nearest 0.01 psi is required, altitude correction should be applied for differences in elevation of 20 feet or more. Pressure measurements made with a W. and T. manometer, which provides accurate measurements to ±0.001 psi, should be corrected for differences of 1 foot or more in elevation.

4.16 No altitude correction is necessary when checking or adjusting the operating pressures of contactors. All contactors are set to operate at a fixed pressure above atmospheric pressure, regardless of altitude. However, it should be recognized that the cable pressure will be less at the higher elevations of a cable section.

4.17 Altitude correction is necessary when the pressure measurement(s) at one elevation are to be compared with a measurement(s) at a different elevation.

4.18 ***Ordinary Corrections:*** Pressure measurements made at different elevations may be converted to their equivalent values at a common elevation by the use of Table C.

4.19 The altitude correction always should be based on the difference in elevation between the valve point where the pressure is measured and the elevation of the lowest valve point in the section of cable under test. The altitude correction is added to the pressure readings taken at valves above the base elevation to obtain the equivalent pressure at the base elevation. The reverse is true when determining the correct charging pressure to use at a charging valve above the base elevation of a section. In the latter case, the altitude correction is subtracted from the nominal charging pressure in order to obtain the proper regulator setting at that valve.

4.20 The values of altitude correction given in Table C are based on cable pressure at 60°F and normal sea-level atmospheric pressure of 15.0 psi. The corrections will differ slightly at other cable temperatures and atmospheric pressures. For all practical purposes, the cable pressures given in Table C may be considered to be the measured cable pressures, regardless of cable temperature or atmospheric pressure.

4.21 ***Example:*** Assume that a small leak exists in a section of cable and that appreciable differences in altitude exist between the valve points which must be read to secure a gradient.

(1) Prepare a table similar to Table D, and enter in columns 1, 2, and 3 the valve number, pressure at valve, and elevation of each valve, respectively.

(2) Enter in column 4 the difference in elevation between the valves and the base elevation. (For convenience, valve number 6 was selected, since it has the lowest elevation—1590 feet.)

TABLE C

ALTITUDE CORRECTION (ADD TO PRESSURE MEASURED AT HIGHER VALVE POINT)										
DIFFERENCE IN ALTITUDE (FEET)	CABLE PRESSURE (PSI)									
	1	2	3	4	5	6	7	8	9	10
20	0	0	0	0	0	0	0	0.01	0.01	0.01
30	0	0	0	0	0	0.01	0.01	0.01	0.01	0.01
40	0	0	0	0.01	0.01	0.01	0.01	0.01	0.01	0.01
50	0	0	0	0.01	0.01	0.01	0.01	0.01	0.02	0.02
60	0	0	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
70	0	0	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
80	0	0	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03
90	0	0	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03
100	0	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03
200	0	0.01	0.02	0.02	0.03	0.04	0.05	0.05	0.06	0.07
300	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.10
400	0.01	0.02	0.04	0.05	0.06	0.08	0.09	0.10	0.12	0.13
500	0.01	0.03	0.04	0.06	0.08	0.10	0.11	0.13	0.15	0.17
600	0.01	0.03	0.05	0.07	0.10	0.12	0.14	0.16	0.18	0.20
700	0.01	0.04	0.06	0.09	0.11	0.14	0.16	0.18	0.21	0.23
800	0.01	0.04	0.07	0.10	0.13	0.15	0.18	0.21	0.24	0.27
900	0.02	0.05	0.08	0.11	0.14	0.17	0.21	0.24	0.27	0.30
1000	0.02	0.05	0.09	0.12	0.16	0.19	0.23	0.26	0.30	0.34

Note: Correction for differences in elevation greater than shown above may be obtained by adding the corrections for two or more of the differences in elevation to obtain the desired total.

(3) Enter in column 5 the altitude correction obtained from Table C by use of columns 2 and 4 of Table D. For example, the observed pressure at valve 1 is 8.00 psi and the altitude difference from the base is 190 feet. In Table C, the altitude correction for 8.00 psi at 100 feet is 0.03 psi, and at 90 feet, it is 0.02 psi, which gives a total of 0.05 psi. This total (0.05 psi) is entered in column 5 and then added to the observed pressure (column 2) to give a corrected pressure of 8.05 psi, which is entered in column 6. Corrections for the other values are obtained in a similar manner.

4.22 When the observed pressure falls between two columns (Table C) and the difference in altitude correction in the two columns is 0.01 psi, use the correction value in the column which is nearest the pressure reading. For example, if the pressure reading is 7.40 psi and the difference in altitude from base is 300 feet, use 0.07 psi as the correction.

4.23 When the observed pressure falls between two columns (Table C) and the difference in altitude correction in the two columns is 0.02 psi or greater, it is necessary to interpolate between

TABLE D

VALVE NO.	OBSERVED PRESSURE READING (PSI)	ELEVATION OF INSTRUMENT (FT)	DIFF. IN ALTITUDE FROM BASE* (FT)	ALTITUDE CORRECTION (PSI)	CORRECTED PRESSURE READING (PSI)
COL 1	COL 2	COL 3	COL 4	COL 5	COL 6
1	8.00	1780	190	0.05	8.05
2	7.74	1845	255	0.07	7.81
3	7.48	1775	185	0.04	7.52
4	7.48	1715	125	0.03	7.51
5	7.73	1660	70	0.02	7.75
6	8.05	1590	0	--	8.05

*Base Elevation 1590 Feet

the two values to determine the altitude correction. For example, if the observed pressure is 8.50 psi and the difference in altitude from the base elevation is 500 feet, use an altitude correction of 0.14 psi because it is halfway between the values of 0.13 for 8 psi and 0.15 for 9 psi.

4.24 ***Precise Corrections:*** The elevation corrections for precise measurements given in Table E are for absolute pressure readings of 19.0 to 24.0 psia at cable temperatures of 30° to 101°F. By interpolation, correction values are determined for pressure readings to the closest 0.01 psia. This degree of accuracy will be sufficient for determining the altitude correction to be applied.

4.25 Since the correction values in Table E are given in psia-per-foot elevation difference, these values must be multiplied by the difference in elevation before being added to the pressure readings to obtain the equivalent pressure at the base elevation.

4.26 ***Example:*** Assume that a pressure measurement of 23.128 psia taken at a cable temperature of 65°F is to be corrected for an elevation difference of 4.7 feet above the base location (lowest valve point):

(1) The 23.128 psia pressure reading is rounded off to the closest 0.01 psi, which is 23.13 psia.

(2) For a cable temperature of 65°F, Table E shows a correction value of 0.000799 psi for a pressure of 23.1 psia, and 0.000802 psi for a pressure of 23.2 psia.

(3) The correction value for the 23.13 psia is approximately one-third the difference of 0.000003, or 0.000001. Adding to 0.000799, we get 0.0008.

(4) The 0.0008 then is multiplied by the elevation difference of 4.7 feet to obtain the total correction.

$0.0008 \times 4.7 = 0.00376$ or 0.004 psi.

(5) Add the 0.004 psi correction to the 23.128 psia measurement to obtain the equivalent pressure at the base elevation.

23.128 + 0.004 = 23.132 psia (corrected absolute pressure measurement).

TABLE E

ELEVATION CORRECTIONS FOR PRECISE MEASUREMENTS

PRESSURE CORRECTION PER FT CHANGE IN ELEVATION — Cable Temperature of °F

Absolute Pressure P.S.I.A.	30°	31°	32°	33°	34°	35°	36°	37°	38°
19.0	.000704	.000702	.000701	.000700	.000698	.000697	.000695	.000694	.000693
19.1	707	706	705	703	702	700	699	698	696
19.2	711	710	708	707	705	704	703	701	700
19.3	715	714	712	711	709	708	706	705	703
19.4	719	717	716	714	713	711	710	708	707
19.5	722	721	719	718	716	715	714	712	711
19.6	726	725	723	722	720	719	717	716	714
19.7	730	728	727	725	724	722	721	719	718
19.8	733	732	730	729	727	726	724	723	722
19.9	737	736	734	733	731	730	728	727	725
20.0	741	739	738	736	735	733	732	730	729
20.1	745	743	741	740	738	737	735	734	733
20.2	748	747	745	744	742	741	739	738	736
20.3	752	750	749	747	746	744	743	741	740
20.4	756	754	753	751	749	748	746	745	744
20.5	759	758	756	755	753	752	750	749	747
20.6	763	762	760	758	757	755	754	752	751
20.7	767	765	764	762	761	759	757	756	755
20.8	770	769	767	766	764	763	761	760	758
20.9	774	773	771	770	768	766	765	763	762
21.0	778	776	775	773	772	770	768	767	765
21.1	782	780	778	777	775	774	772	771	769
21.2	785	784	782	781	779	777	776	774	773
21.3	789	787	786	784	783	781	779	778	776
21.4	793	791	789	788	786	785	783	782	780
21.5	796	795	793	792	790	788	787	785	784
21.6	800	799	797	795	794	792	790	789	787
21.7	804	802	801	799	797	796	794	792	791
21.8	807	806	804	803	801	799	798	796	795
21.9	811	810	808	806	805	803	801	800	798
22.0	815	813	812	810	808	807	805	803	802
22.1	819	817	815	814	812	810	809	807	806
22.2	822	821	819	817	816	814	812	811	809
22.3	826	824	823	821	819	818	816	814	813
22.4	830	828	826	825	823	821	820	818	816
22.5	833	832	830	828	827	825	823	822	820
22.6	837	836	834	832	830	829	827	825	824
22.7	841	839	837	836	834	832	831	829	827
22.8	845	843	841	839	838	836	834	833	831
22.9	848	847	845	843	841	840	838	836	835
23.0	852	850	848	847	845	843	842	840	838
23.1	856	854	852	851	849	847	845	844	842
23.2	859	858	856	854	852	851	849	847	846
23.3	863	861	860	858	856	854	853	851	849
23.4	867	865	863	862	860	858	856	855	853
23.5	870	869	867	865	863	862	860	858	857
23.6	874	872	871	869	867	865	864	862	860
23.7	878	876	874	873	871	869	867	866	864
23.8	882	880	878	876	874	873	871	869	868
23.9	885	884	882	880	878	876	875	873	871
24.0	.000889	.000887	.000885	.000884	.000882	.000880	.000878	.000876	.000875

Absolute Pressure P.S.I.A.	39°	40°	41°	42°	43°	44°	45°	46°	47°
19.0	.000691	.000690	.000688	.000687	.000686	.000684	.000683	.000682	.000680
19.1	695	693	692	691	689	688	686	685	684
19.2	698	697	696	694	693	691	690	689	687
19.3	702	701	699	698	696	695	694	692	691
19.4	706	704	703	702	700	699	697	696	695
19.5	709	708	706	705	704	702	701	699	698
19.6	713	711	710	709	707	706	704	703	702
19.7	716	715	714	712	711	709	708	707	705
19.8	720	719	717	716	714	713	712	710	709
19.9	724	722	721	720	718	717	715	714	712
20.0	727	726	725	723	722	720	719	717	716
20.1	731	730	728	727	725	724	722	721	720
20.2	735	733	732	730	729	727	726	725	723
20.3	738	737	735	734	732	731	730	728	727
20.4	742	741	739	738	736	735	733	732	730
20.5	746	744	743	741	740	738	737	735	734
20.6	749	748	746	745	743	742	740	739	737
20.7	753	751	750	749	747	745	744	743	741
20.8	756	755	754	752	750	749	748	746	745
20.9	760	759	757	756	754	753	751	750	748
21.0	764	762	761	759	758	756	755	753	752
21.1	767	766	764	763	761	760	758	757	755
21.2	771	770	768	767	765	763	762	760	759
21.3	775	773	772	770	769	767	766	764	763
21.4	778	777	775	774	772	771	769	768	766
21.5	782	780	779	777	776	774	773	771	770
21.6	786	784	783	781	779	778	776	775	773
21.7	789	788	786	785	783	781	780	778	777
21.8	793	791	790	788	787	785	783	782	780
21.9	797	795	793	792	790	789	787	786	784
22.0	800	799	797	796	794	792	791	789	788
22.1	804	802	801	799	797	796	794	793	791
22.2	807	806	804	803	801	799	798	796	795
22.3	811	809	808	806	805	803	801	800	798
22.4	815	813	812	810	808	807	805	803	802
22.5	818	817	815	814	812	810	809	807	806
22.6	822	820	819	817	815	814	812	811	809
22.7	826	824	822	821	819	817	816	814	813
22.8	829	828	826	824	823	821	819	818	816
22.9	833	831	830	828	826	825	823	821	820
23.0	837	835	833	832	830	828	827	825	823
23.1	840	839	837	835	833	832	830	829	827
23.2	844	842	841	839	837	835	834	832	831
23.3	847	846	844	843	841	839	837	836	834
23.4	851	849	848	846	844	843	841	839	838
23.5	855	853	851	850	848	846	845	843	841
23.6	858	857	855	853	851	850	848	847	845
23.7	862	860	859	857	855	853	852	850	848
23.8	866	864	862	861	859	857	855	854	852
23.9	869	868	866	864	862	861	859	857	856
24.0	.000873	.000871	.000870	.000868	.000866	.000864	.000863	.000861	.000859

Absolute Pressure P.S.I.A.	48°	49°	50°	51°	52°	53°	54°	55°	56°
19.0	.000679	.000678	.000676	.000675	.000674	.000672	.000671	.000670	.000668
19.1	682	681	680	678	677	676	674	673	672
19.2	686	685	683	682	681	679	678	677	675
19.3	690	688	687	686	684	683	681	680	679
19.4	693	692	690	689	688	686	685	684	682
19.5	697	695	694	693	691	690	689	687	686
19.6	700	699	698	696	695	693	692	691	689
19.7	704	703	701	700	698	697	696	694	693
19.8	707	706	705	703	702	701	699	698	696
19.9	711	710	708	707	705	704	703	701	700
20.0	715	713	712	710	709	708	706	705	703
20.1	718	717	715	714	713	711	710	708	707
20.2	722	720	719	718	716	715	713	712	710
20.3	725	724	722	721	720	718	717	715	714
20.4	729	727	726	725	723	722	720	719	717
20.5	732	731	730	728	727	725	724	722	721
20.6	736	735	733	732	730	729	727	726	725
20.7	740	738	737	735	734	732	731	729	728
20.8	743	742	740	739	737	736	734	733	732
20.9	747	745	744	742	741	739	738	737	735
21.0	750	749	747	746	744	743	742	740	739
21.1	754	752	751	749	748	747	745	744	742
21.2	757	756	755	753	752	750	749	747	746
21.3	761	760	758	757	755	754	752	751	749
21.4	765	763	762	760	759	757	756	754	753
21.5	768	767	765	764	762	761	759	758	756
21.6	772	770	769	767	766	764	763	761	760
21.7	775	774	772	771	769	768	766	765	763
21.8	779	777	776	774	773	771	770	768	767
21.9	782	781	779	778	776	775	773	772	770
22.0	786	785	783	781	780	778	777	775	774
22.1	790	788	787	785	783	782	780	779	777
22.2	793	792	790	789	787	785	784	782	781
22.3	797	795	794	792	791	789	787	786	784
22.4	800	799	797	796	794	793	791	789	788
22.5	804	802	801	799	798	796	794	793	791
22.6	807	806	804	803	801	800	798	796	795
22.7	811	809	808	806	805	803	802	800	798
22.8	815	813	811	810	808	807	805	803	802
22.9	818	817	815	813	812	810	809	807	805
23.0	822	820	819	817	815	814	812	811	809
23.1	825	824	822	821	819	817	816	814	812
23.2	829	827	826	824	822	821	819	818	816
23.3	833	831	829	828	826	824	823	821	819
23.4	836	834	833	831	830	828	826	825	823
23.5	840	838	836	835	833	831	830	828	826
23.6	843	842	840	838	837	835	833	832	830
23.7	847	845	843	842	840	839	837	835	834
23.8	850	849	847	845	844	842	840	839	837
23.9	854	852	851	849	847	846	844	842	841
24.0	.000858	.000856	.000854	.000852	.000851	.000849	.000847	.000846	.000844

Absolute Pressure P.S.I.A.	57°	58°	59°	60°	61°	62°	63°	64°	65°
19.0	.000667	.000666	.000664	.000663	.000662	.000661	.000659	.000658	.000657
19.1	671	669	668	667	665	664	663	662	660
19.2	674	673	671	670	669	668	666	665	664
19.3	678	676	675	674	672	671	670	669	667
19.4	681	680	678	677	676	675	673	672	671
19.5	685	683	682	681	679	678	677	675	674
19.6	688	687	685	684	683	681	680	679	678
19.7	692	690	689	688	686	685	684	682	681
19.8	695	694	692	691	690	688	687	686	684
19.9	699	697	696	695	693	692	691	689	688
20.0	702	701	699	698	697	695	694	693	691
20.1	706	704	703	701	700	699	697	696	695
20.2	709	708	706	705	704	702	701	700	698
20.3	713	711	710	708	707	706	704	703	702
20.4	716	715	713	712	711	709	708	707	705
20.5	720	718	717	715	714	713	711	710	709
20.6	723	722	720	719	718	716	715	714	712
20.7	727	725	724	722	721	720	718	717	716
20.8	730	729	727	726	725	723	722	721	719
20.9	734	732	731	729	728	727	725	724	723
21.0	737	736	734	733	732	730	729	727	726
21.1	741	739	738	736	735	734	732	731	729
21.2	744	743	741	740	739	737	736	734	733
21.3	748	746	745	743	742	741	739	738	736
21.4	751	750	748	747	746	744	743	741	740
21.5	755	753	752	750	749	748	746	745	743
21.6	758	757	755	754	753	751	750	748	747
21.7	762	760	759	757	756	755	753	752	750
21.8	765	764	762	761	760	758	756	755	754
21.9	769	767	766	764	763	761	760	759	757
22.0	772	771	769	768	766	765	763	762	761
22.1	776	774	773	771	770	768	767	766	764
22.2	779	778	776	775	773	772	770	769	767
22.3	783	781	780	778	777	775	774	772	771
22.4	786	785	783	782	780	779	777	776	774
22.5	790	788	787	785	784	782	781	779	778
22.6	793	792	790	789	787	786	784	783	781
22.7	797	795	794	792	791	789	788	788	785
22.8	801	799	797	796	794	793	791	790	788
22.9	804	802	801	799	798	796	795	793	792
23.0	808	806	804	803	801	800	798	797	795
23.1	811	809	808	806	805	803	802	800	799
23.2	815	813	811	810	808	807	805	804	802
23.3	818	816	815	813	812	810	809	807	805
23.4	822	820	818	817	815	814	812	811	809
23.5	825	823	822	820	819	817	815	814	812
23.6	829	827	825	824	822	821	819	818	816
23.7	832	830	829	827	826	824	822	821	819
23.8	836	834	832	831	829	828	826	824	823
23.9	839	837	836	834	833	831	829	828	826
24.0	.000843	.000841	.000839	.000838	.000836	.000834	.000833	.000831	.000830

TABLE E (Cont)

ELEVATION CORRECTIONS FOR PRECISE MEASUREMENTS

Absolute Pressure PSIA	PRESSURE CORRECTION PER FT CHANGE IN ELEVATION Cable Temperature of °F																																						
	66°	67°	68°	69°	70°	71°	72°	73°	74°	75°	76°	77°	78°	79°	80°	81°	82°	83°	84°	85°	86°	87°	88°	89°	90°	91°	92°	93°	94°	95°	96°	97°	98°	99°	100°	101°
19.0	.000656	.000654	.000653	.000652	.000651	.000649	.000648	.000647	.000646	.000645	.000643	.000642	.000641	.000640	.000639	.000637	.000636	.000635	.000634	.000633	.000632	.000630	.000629	.000627	.000626	.000625	.000624	.000622	.000621	.000620	.000619	.000618	.000617	.000616	.000615	
19.1	659	658	657	655	654	653	652	650	648	648	647	646	644	643	642	641	640	639	637	636	635	634	633	631	630	629	628	627	626	625	623	622	621	620	619	618
19.2	663	661	660	659	658	656	655	654	653	651	650	649	648	646	645	644	643	642	641	639	638	637	636	635	634	632	631	630	629	628	627	626	625	623	622	621
19.3	666	665	664	662	661	660	659	657	656	655	653	652	651	650	649	648	646	645	644	643	642	640	639	638	637	636	635	633	632	631	630	629	628	627	626	624
19.4	669	668	667	666	664	663	662	661	659	658	657	656	655	653	652	651	650	649	647	646	645	644	643	641	640	639	638	637	636	634	633	632	631	630	629	628
19.5	673	672	670	669	668	667	665	664	663	662	660	659	658	657	655	654	653	652	651	649	648	647	646	645	644	642	641	640	639	638	636	636	634	633	632	631
19.6	676	675	674	672	671	670	668	667	666	665	664	662	661	660	659	658	656	655	654	653	652	650	649	648	647	646	644	643	642	641	640	639	638	636	635	634
19.7	680	678	677	676	675	673	672	671	670	668	667	666	665	664	662	661	660	659	657	656	655	654	652	651	650	649	648	647	645	644	643	642	641	640	639	637
19.8	683	682	681	679	678	677	676	674	673	672	670	669	668	667	665	664	663	662	661	659	658	657	656	655	653	652	651	650	649	647	646	645	644	643	642	641
19.9	687	685	684	683	682	680	679	678	676	675	674	673	671	670	669	668	666	665	664	663	661	660	659	658	657	656	654	653	652	651	650	649	647	646	645	644
20.0	690	689	688	686	685	684	682	681	680	679	677	676	675	673	672	671	670	669	667	666	665	664	662	661	660	659	658	656	655	654	653	652	651	649	648	647
20.1	694	692	691	690	688	687	686	684	683	682	681	679	678	677	676	674	673	672	671	669	668	667	666	665	663	662	661	660	658	657	656	655	654	653	651	650
20.2	697	696	694	693	692	690	689	688	687	685	684	683	682	680	679	678	676	675	674	673	671	670	669	668	667	665	664	663	662	661	659	658	657	656	655	653
20.3	701	699	698	696	695	694	693	691	690	689	687	686	685	684	682	681	680	679	677	676	675	674	672	671	670	669	667	666	665	664	663	662	660	659	658	657
20.4	704	703	701	700	699	697	696	695	693	692	691	690	688	687	686	684	683	682	681	679	678	677	676	674	673	672	671	670	668	667	666	665	664	662	661	660
20.5	707	706	705	703	702	701	699	698	697	696	694	693	692	690	689	688	687	685	684	683	681	680	679	678	677	675	674	673	672	670	669	668	667	665	664	663
20.6	711	709	708	707	706	704	703	701	700	699	698	696	695	694	692	691	690	689	687	686	685	684	682	681	680	679	677	676	675	674	672	671	670	668	668	666
20.7	714	713	712	710	709	708	706	705	704	702	701	700	698	697	696	694	693	692	691	689	688	687	686	684	683	682	681	679	678	677	676	675	673	672	671	670
20.8	718	716	715	714	712	711	710	708	707	706	704	703	702	700	699	698	697	695	694	693	692	691	690	689	688	686	685	684	683	681	680	679	678	677	675	674
20.9	721	720	719	717	716	714	713	712	710	709	708	706	705	704	702	701	700	699	697	696	695	693	692	691	690	688	687	686	685	683	682	681	680	679	677	676
21.0	725	723	722	721	719	718	717	715	714	713	711	710	709	707	706	705	703	702	701	699	698	697	696	694	693	692	690	689	688	687	685	684	683	682	681	679
21.1	728	727	725	724	723	721	720	718	717	716	714	713	712	710	709	708	707	705	704	703	701	700	699	698	696	695	694	693	691	690	689	688	686	685	684	683
21.2	732	730	729	727	726	725	723	722	721	719	718	717	715	714	713	711	710	709	707	706	705	703	702	701	699	698	697	696	695	693	692	691	690	688	687	686
21.3	735	734	732	731	730	728	727	725	724	723	721	720	719	717	716	715	713	712	711	709	708	707	705	704	703	702	700	699	698	697	695	694	693	692	690	689
21.4	739	737	736	734	733	731	730	729	727	726	725	723	722	721	719	718	717	715	714	713	711	710	709	707	706	705	704	702	701	700	698	697	696	695	694	692
21.5	742	740	739	738	736	735	734	732	731	729	728	727	725	724	723	721	720	719	717	716	715	713	712	711	710	708	707	706	704	703	702	701	699	698	697	696
21.6	745	744	743	741	740	738	737	735	734	733	731	730	729	727	726	725	723	722	721	719	718	717	715	714	713	712	710	709	708	706	705	704	703	701	700	699
21.7	749	747	746	745	743	742	740	739	738	736	735	733	732	731	729	728	727	725	724	723	721	720	719	717	716	715	713	712	711	710	708	707	706	705	703	702
21.8	752	751	749	748	747	745	744	742	741	740	738	737	736	734	733	731	730	729	727	726	725	723	722	721	719	718	717	715	714	713	712	710	709	708	707	705
21.9	756	754	753	751	750	749	747	746	744	743	742	740	739	737	736	735	733	732	731	729	728	727	725	724	723	721	720	719	717	716	715	714	712	711	710	708
22.0	759	758	756	755	754	752	751	749	748	746	745	744	742	741	739	738	737	735	734	733	731	730	729	727	726	725	723	722	721	719	718	717	716	714	713	712
22.1	763	761	760	758	757	755	754	753	751	750	748	747	746	744	743	741	740	739	737	736	735	733	732	731	729	728	727	725	724	723	721	720	719	718	716	715
22.2	766	765	763	762	760	759	757	756	755	753	752	750	749	747	746	745	743	742	741	739	738	737	735	734	733	731	730	729	727	726	725	723	722	721	720	718
22.3	770	768	767	765	764	762	761	759	758	757	755	754	752	751	750	748	747	745	744	743	741	740	739	737	736	735	733	732	731	729	728	727	725	724	723	721
22.4	773	771	770	769	767	766	764	763	761	760	758	757	756	754	753	752	750	749	747	746	745	743	742	741	739	738	737	735	734	732	731	730	729	727	726	725
22.5	776	775	774	772	771	769	768	766	765	763	762	761	759	758	756	755	754	752	751	749	748	747	745	744	743	741	740	738	737	736	734	733	732	731	729	728
22.6	780	778	777	775	774	772	771	770	768	767	765	764	763	761	760	758	757	756	754	753	752	751	750	749	747	746	744	743	742	740	739	738	737	735	734	732
22.7	783	782	780	779	777	776	775	773	772	770	769	767	766	764	763	762	760	759	757	756	755	753	752	750	749	748	746	745	744	742	741	740	738	737	736	734
22.8	787	785	784	782	781	779	778	776	775	774	772	771	769	768	766	765	764	762	761	759	758	757	755	754	752	751	750	748	747	746	744	743	742	740	739	738
22.9	790	789	787	786	784	783	781	780	778	777	775	774	773	771	770	768	767	766	764	763	761	760	758	757	756	754	753	752	750	749	747	746	745	744	742	741
23.0	794	792	791	789	788	786	785	783	782	780	779	777	776	774	773	772	770	769	767	766	765	763	762	761	759	758	756	755	753	752	751	750	748	747	745	744
23.1	797	796	794	793	791	790	788	787	785	784	782	781	779	778	776	775	774	772	771	769	768	766	765	764	762	761	760	758	757	755	754	753	751	750	749	747
23.2	801	799	798	796	795	793	792	790	788	787	786	784	783	781	780	778	777	776	774	773	771	770	768	767	766	764	763	761	760	759	757	756	755	753	752	751
23.3	804	802	801	799	798	796	795	793	792	791	789	788	786	785	783	782	780	779	777	776	774	773	772	770	769	768	766	765	763	762	761	759	758	757	755	754
23.4	808	806	804	803	801	800	798	797	795	794	792	791	790	788	787	785	784	782	781	779	778	776	775	774	772	771	769	768	767	765	764	763	761	760	758	757
23.5	811	809	808	806	805	803	802	800	799	797	796	794	793	791	790	788	787	785	784	783	781	780	778	777	776	774	773	771	770	769	767	766	764	763	762	760
23.6	814	813	811	810	808	807	805	804	802	801	799	798	796	795	793	792	790	789	787	786	784	783	782	780	779	777	776	775	773	772	770	769	768	766	765	763
23.7	818	816	815	813	812	810	809	807	806	804	802	801	800	798	797	795	794	792	791	789	788	786	785	784	782	781	779	778	776	775	774	772	771	770	768	767
23.8	821	820	818	817	815	814	812	811	809	808	806	805	804	802	801	800	798	797	795	794	793	791	790	788	787	785	784	783	781	780	778	777	776	774	773	771
23.9	825	823	822	820	819	817	816	814	812	811	809	808	806	805	803	802	800	799	797	796	794	793	792	790	789	787	786	784	783	782	780	779	777	776	775	773
24.0	.000828	.000827	.000825	.000823	.000822	.000820	.000819	.000817	.000816	.000814	.000813	.000811	.000810	.000808	.000807	.000805	.000804	.000802	.000801	.000799	.000798	.000796	.000795	.000793	.000792	.000791	.000789	.000788	.000786	.000785	.000783	.000782	.000781	.000779	.000778	.000776