Expect Service

Radiation Products Design Inc

BAROMETER TECH NOTE

RPD INFORMATION

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CORRECTION OF TEMPERATURE AND PRESSURE

The sensitivity of an ion chamber is directly proportional to the number of air molecules in the chamber. The number of molecules is a function of chamber volume and air density. The volume of air in the ion chamber is fixed, but since an unsealed ion chamber communicates with the atmospheric conditions, air density will vary due to external temperature and pressure fluctuations. Therefore, a correction factor should be applied to the reading given by an unsealed ion chamber, based on the ambient temperature and barometric pressure at the time the measurement is made. For diagnostic x-ray measurements under controlled environment conditions, and for health physics use, this correction tends to be disregarded in most locations in the USA since the errors are viewed as small (0.3% per °C and 0.1% per mmHg). However, it should be remembered that at elevations of only 3000 ft, the error due to barometric pressure will be 11.8%. To achieve accuracy that is expected in therapy and calibration measurements, barometric pressure and temperature corrections are essential.

Below is the formula that can be used to derive the air density correction factor in the USA. This formula is accurate to an approximate altitude of 5000 feet.

$$\mathrm{CTP} = \frac{273 + {}^\circ\mathrm{C}}{295} \times \frac{760}{\mathrm{P(mmHg)}}$$

Where Standard Pressure is 760 mmHg and temperature is converted to Kelvin and referenced to 22 °C.

NOTE:

A. Most people do not use the more accurate 273.16, since in the ratio the resultant error is insignificant.

B. For many years NBS (now NIST) referenced their calibration factors to 0 °C, but the AAPM ADCL's never did so.

C. The rest of the world references to 20 °C so that PTW, Nordic, NEL, etc. calibration factors must be corrected.

CAUTION

All barometers must be calibrated by the local physicist prior to using them clinically, even mercury ones. It is a good idea to take the barometer (at least the aneroid ones) to the NWS station for calibration and to observe the difference in pressure. Henceforth, one can merely call the station and mentally make the correction.

The main reason for the cautions is that aneroid barometers are capable of wrapping around, so that a reading of 760 mmHg might be an off-scale pressure of 665 mmHg, but also because most manufacturers adjust them to read 760 mmHg at whatever altitude they are manufactured.

CAUTION

Unless otherwise requested the local National Weather Service stations will give you something often referred to as "station" pressure, normalized or "corrected to sea level". That is, the average actual pressure is arbitrarily called 760 mmHg or 29.92 inHg, even though true pressure might be 650 mmHg. Presumably this is for the benefit of airline pilots in determining their altitude above the ground. Often the person answering the phone at the NWS station is unaware of this discrepancy, so it is a good idea to also determine the altitude of the station in feet. Then one can estimate to within 2%, generally, the actual expected pressure using the rule-of-thumb that the pressure is reduced by very close to 1 inHg for each 1000 feet of elevation.

For accurate measurements, aneroid barometers must be calibrated and read in the same orientation (vertical, horizontal. etc.) and must be gently tapped to allow equilibrium positioning of the needle; whereas, mercury barometers must be corrected for temperature and latitude (approximately 1-3 mmHg total correction in the USA.)

REFERENCE: "Manual of Barometry", (WBAN), Volume 1, First Edition, U.S. Department of Commerce, Weather Bureau, Washington DC, 1963

BAROMETRIC UNITS CONVERSION TABLE

	inHg	mmHg	Mb	kPa
Atmosphere	29.92	760	1013.3	101.33
inHg	1	25.4	33.87	3.387
mmHg	0.0394	1	1.333	0.1333
Mb	0.0295	0.75	1	0.1
kPa	0.295	7.5	10	1
Hpa	0.0295	0.75	1	0.1

Reference: Heise Pressure Measurement Reference Data

AIR DENSITY CORRECTION TABLE

Multiplication factors, normalized to 22°C and 760 mmHg

Mm Hg	Temperature in °C												
	16°	**18°**	**20°**	**22°**	**24°**	**26°**	**28°**	**30°**	**32°**	**34°**	**36°**	**38°**	**40°**
500	1.489	1.499	1.510	1.520	1.530	1.541	1.551	1.561	1.572	1.582	1.592	1.602	1.613
510	1.460	1.470	1.480	1.490	1.500	1.510	1.521	1.531	1.541	1.551	1.561	1.571	1.581
520	1.432	1.442	1.452	1.462	1.471	1.481	1.491	1.501	1.511	1.521	1.532	1.541	1.551
530	1.405	1.415	1.424	1.434	1.444	1.453	1.463	1.473	1.483	1.492	1.503	1.512	1.521
540	1.379	1.388	1.398	1.407	1.417	1.426	1.436	1.446	1.455	1.465	1.475	1.484	1.493
550	1.354	1.363	1.372	1.382	1.391	1.401	1.410	1.419	1.429	1.438	1.448	1.457	1.466
560	1.330	1.339	1.348	1.357	1.366	1.376	1.385	1.394	1.403	1.412	1.422	1.431	1.440
570	1.306	1.315	1.324	1.333	1.342	1.351	1.360	1.369	1.379	1.388	1.397	1.406	1.415
580	1.284	1.293	1.301	1.310	1.319	1.328	1.337	1.346	1.355	1.364	1.373	1.381	1.390
590	1.262	1.271	1.279	1.288	1.297	1.306	1.314	1.323	1.332	1.341	1.350	1.358	1.367
600	1.241	1.249	1.258	1.267	1.275	1.284	1.292	1.301	1.310	1.318	1.327	1.335	1.344
610	1.221	1.229	1.237	1.246	1.254	1.263	1.271	1.280	1.288	1.297	1.306	1.313	1.322
620	1.201	1.209	1.218	1.226	1.234	1.242	1.251	1.259	1.267	1.276	1.285	1.292	1.301
630	1.182	1.190	1.198	1.206	1.215	1.223	1.231	1.239	1.247	1.255	1.264	1.272	1.280
640	1.163	1.171	1.179	1.188	1.196	1.204	1.212	1.220	1.228	1.236	1.245	1.252	1.260
650	1.145	1.153	1.161	1.169	1.177	1.185	1.193	1.201	1.209	1.217	1.225	1.233	1.241
660	1.128	1.136	1.144	1.152	1.159	1.167	1.175	1.183	1.191	1.198	1.207	1.214	1.222
670	1.111	1.119	1.127	1.134	1.142	1.150	1.157	1.165	1.173	1.180	1.189	1.196	1.204
680	1.095	1.102	1.110	1.118	1.125	1.133	1.140	1.148	1.156	1.163	1.171	1.178	1.186
690	1.079	1.087	1.094	1.101	1.109	1.116	1.124	1.131	1.139	1.146	1.154	1.161	1.169
700	1.064	1.071	1.078	1.086	1.093	1.100	1.108	1.115	1.123	1.130	1.138	1.145	1.152
710	1.049	1.056	1.063	1.070	1.078	1.085	1.092	1.099	1.107	1.114	1.122	1.128	1.136
720	1.034	1.041	1.048	1.056	1.063	1.070	1.077	1.084	1.091	1.098	1.106	1.113	1.120
725	1.027	1.034	1.041	1.048	1.055	1.062	1.070	1.077	1.084	1.091	1.099	1.105	1.112
730	1.020	1.027	1.034	1.041	1.048	1.055	1.062	1.069	1.076	1.083	1.091	1.098	1.105
735	1.013	1.020	1.027	1.034	1.041	1.048	1.055	1.062	1.069	1.076	1.084	1.090	1.097
740	1.006	1.013	1.020	1.027	1.034	1.041	1.048	1.055	1.062	1.069	1.076	1.083	1.090
745	0.999	1.006	1.013	1.020	10.27	1.034	1.041	1.048	1.055	1.062	1.069	1.075	1.082
750	0.993	1.000	1.006	1.013	1.020	1.027	1.034	1.041	1.048	1.055	1.062	1.068	1.075
755	0.986	0.993	1.000	1.007	1.013	1.020	1.027	1.034	1.041	1.048	1.055	1.061	1.068
760	0.980	0.986	0.993	1.000	1.007	1.041	1.020	1.027	1.034	1.041	1.048	1.054	1.061
765	0.973	0.980	0.987	0.993	1.000	1.007	1.014	1.020	1.027	1.034	1.041	1.047	1.054
770	0.967	0.974	0.980	0.987	0.994	1.0000	1.007	1.014	10.20	1.027	1.034	1.041	1.047
775	0.961	0.967	0.974	0.981	0.987	0.994	1.001	1.007	1.041	1.021	1.028	1.034	1.040
780	0.955	0.961	0.968	0.974	0.981	0.988	0.994	1.001	1.007	1.014	1.021	1.027	1.034
785	0.948	0.955	0.962	0.968	0.975	0.981	0.988	0.994	1.001	1.008	1.015	1.021	1.027
790	0.942	0.949	0.956	0.962	0.969	0.975	0.982	0.988	0.995	1.001	1.008	1.014	1.021
795	0.937	0.943	0.949	0.956	0.962	0.969	0.975	0.982	0.988	0.995	1.002	1.008	1.014
800	0.931	0.937	0.944	0.950	0.956	0.963	0.969	0.976	0.982	0.989	0.996	1.002	1.008
805	0.925	0.931	0.938	0.944	0.951	0.957	0.963	0.970	0.976	0.983	0.989	0.995	1.002