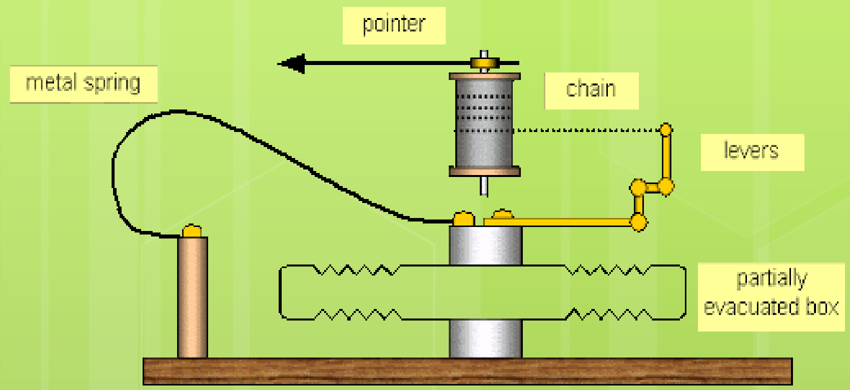
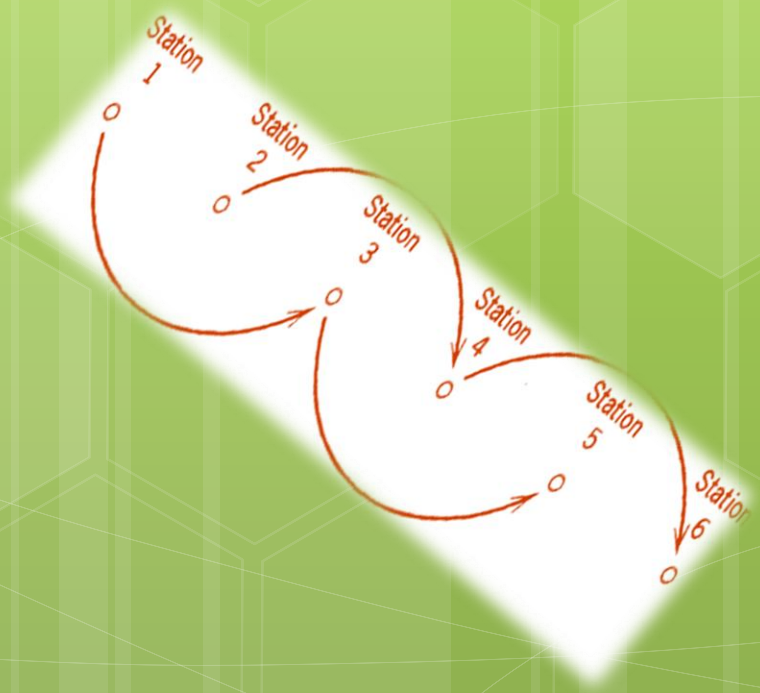


The Aneroid barometer



ENVIRONMENTAL & SAFETY OF MINES SUBJECT

Ventilation Measurements and Surveys

College of Petroleum & Mining Eng.

Mining Engineering Dept.

4th Class

Lecture No.2 – Chapter 6-Part-II

Mr. Omer Haitham Kanam

Overview-PART-II

- Pressure Survey
- Leapfrogging Method
- Examples (6.3)
- Comparison of Pressure Measurement Instruments and Methods

Pressure Survey

- *Atmospheric pressure* refers to the force per unit area exerted by the weight of a column of air in the atmosphere.
- Atmospheric pressure varies with both time and place. *Pressure difference* is the difference in air pressure between two points.
- *Gage pressure* refers to the difference between the pressure at a point within a system such as a duct and atmospheric pressure at that point.
- Gage pressure plus the atmospheric pressure at a point is known as the *absolute pressure* at that point.
- *Head* is a unit measure of pressure in terms of a column of fluid, which in mine ventilation is customarily expressed in in. water (Pa).

Pressure Survey

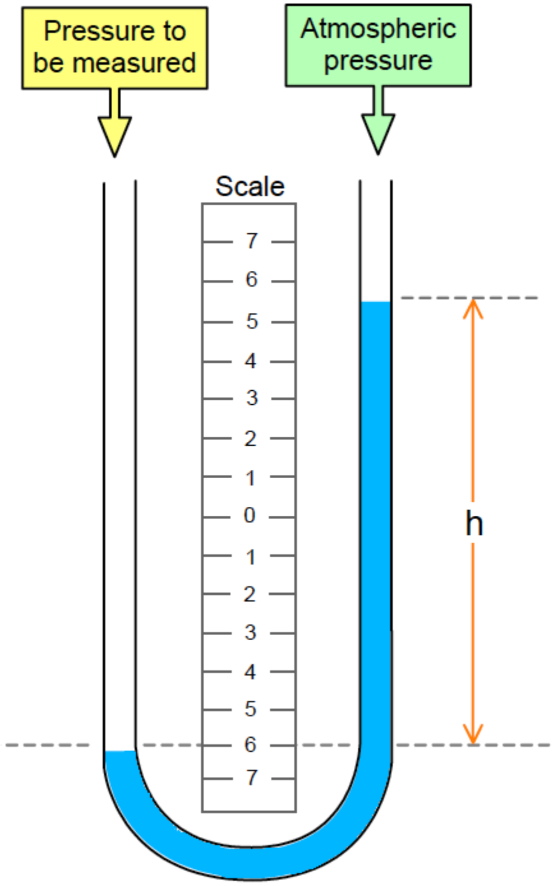
- Pressure is measured by :

1. Manometer by taking a difference in head (direct method).

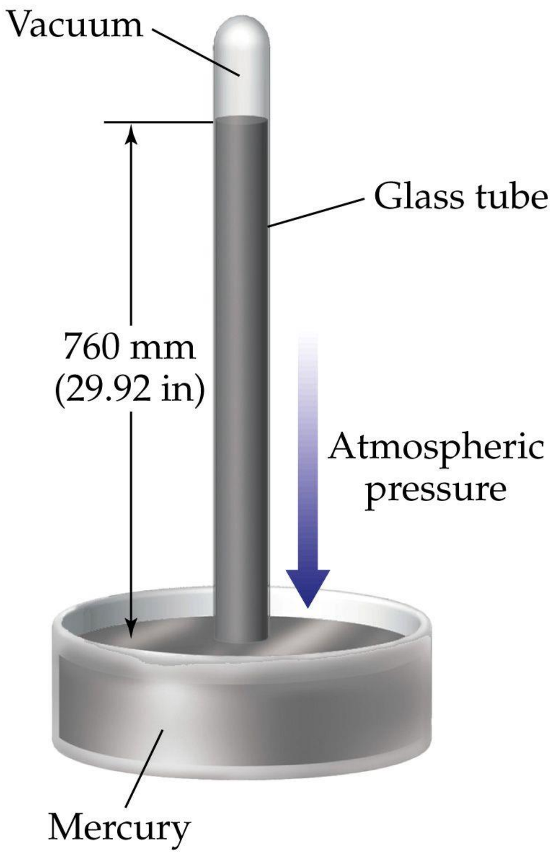
2. Absolute pressure at each station (Indirect method).

Pressure Survey

- Manometer

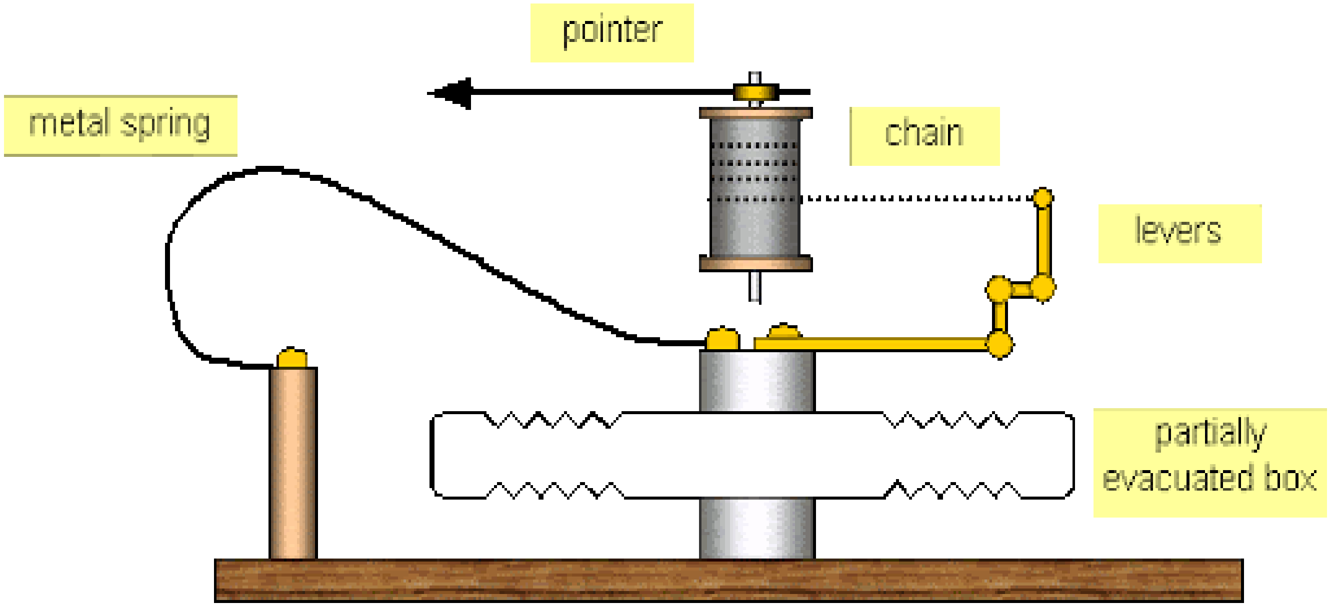


Mercurey Barometer



Pressure Survey

- *Aneroid Barometers*



The Aneroid barometer

Pressure Survey

- Atmospheric pressure is due mainly to elevation, with acceleration due to gravity and differences in air specific weight accounting for only about 10% of the total pressure.
- The significant influence of elevation on atmospheric pressure has led to the adoption of *altimeters,* aneroid barometers calibrated in terms of elevation for pressure measurements underground.

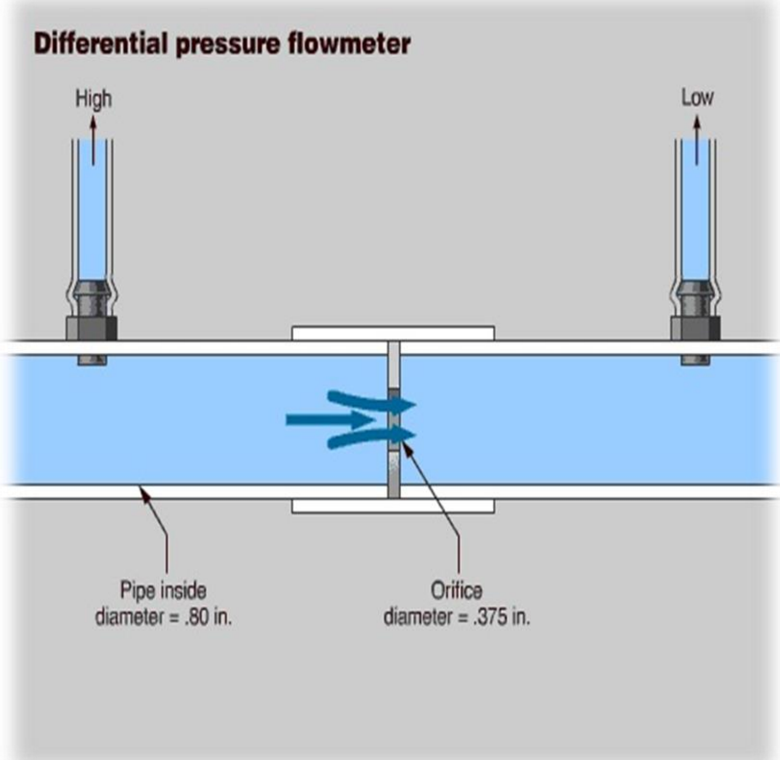
$$Z = 62{,}583.6 \log\left(\frac{29.92}{p_b}\right) \tag{6.8}$$

Pressure Survey

- Aneroid barometers should be calibrated periodically against a mercury barometer and certainly before a major survey, since their thermal-compensation characteristic changes, and a definite zero shift or drift can continue with time.

Pressure Survey

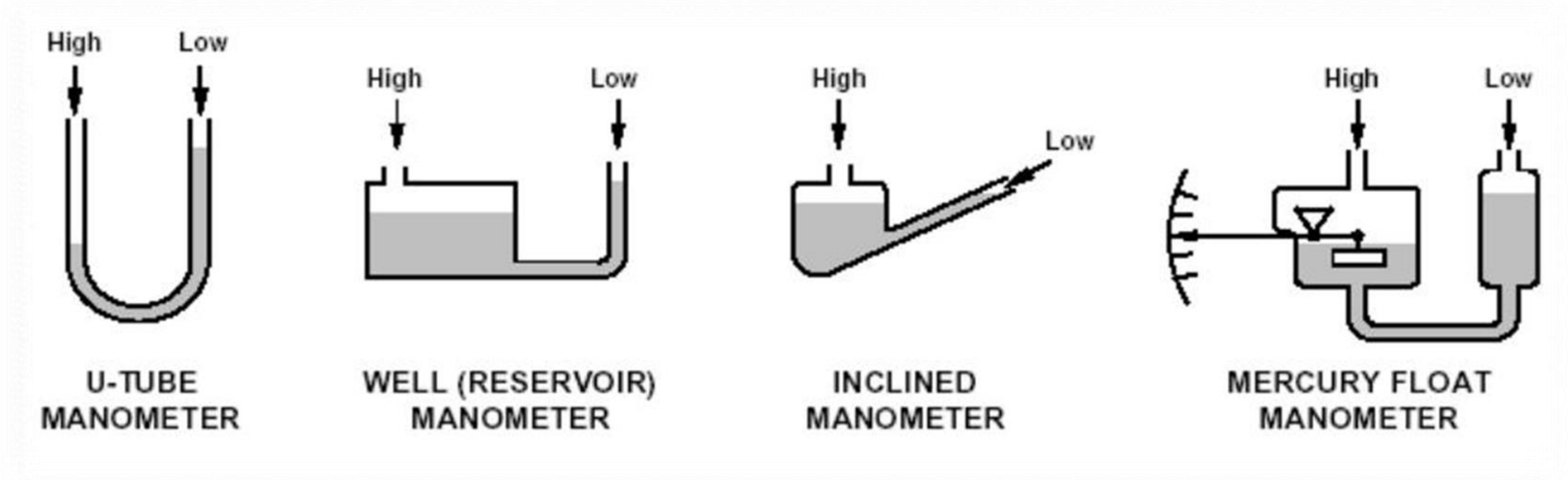
- **Differential-Pressure Measurement**



Pressure Survey

- **Manometer Types**

1. *vertical U-tube*
2. *well-type or reservoir-type*



Pressure Survey

- **Example 6.2 :**
- An oil of specific gravity s = 0.85 is to be used in an inclined manometer constructed with a magnification of 12. If the tubing bore *D0* is 0.15 in. (3.81 mm) and the reservoir diameter *D* is 1.50 in. (38.10 mm), find the required angle of inclination 9, the error in reading only the inclined leg, and the scale correction that must be made in compensation.

Pressure Survey

- **Solution Ex. 6.2. :**
- Using Eq. 2.18, substituting specific gravity for specific weight (water = 1.00):

$$H_2 = H_1 \frac{s_1}{s_2} = (1)\left(\frac{1.00}{0.82}\right) = 1.177 \text{ in. oil}$$

$$\sin\theta = \frac{\text{vertical rise}}{\text{magnification}} = \frac{1.177}{12} = 0.098$$

$$\theta = 5.6^\circ$$

Pressure Survey

- **Solution Ex. 6.2. :**
- For a range of 1 in. (25.4 mm) water, construct a manometer with a leg 12 in. (304.8 mm) in length, 1.177 in. (29.90 mm) vertical rise, and inclined at 5.6°.

$$\text{Error} = (\text{magnification})\left(\frac{D_0}{D}\right)^2\left(\frac{s_2}{s_1}\right) = (12)\left(\frac{0.15}{1.50}\right)^2\left(\frac{0.85}{1.00}\right)$$

$$= 0.102 \text{ in./in. water/12-in. length of inclined leg, or } 10.2\%$$

- To correct for error, calibrate the scale along the 12-in. (304.8-mm) inclined leg to read from 0 to 1.102 in. (0 to 28.0 mm) water.

Pressure Survey

- **Example 6.3. :**
- The following data are obtained in a trailing-hose survey (Fig. 6.11) in a vertical intake shaft The manometer is at the bottom of the shaft and reads 1.51 in. water. Calculate the correction to the manometer reading.:

Position	Elevation, ft	Pressure, psi	Temperature, °F	
			Dry-Bulb	Wet-Bulb
Top	−1748.70	12.594	59.4	50.0
Bottom	−4368.70	13.773	67.3	57.0

Pressure Survey

- **Example 6.3. :**

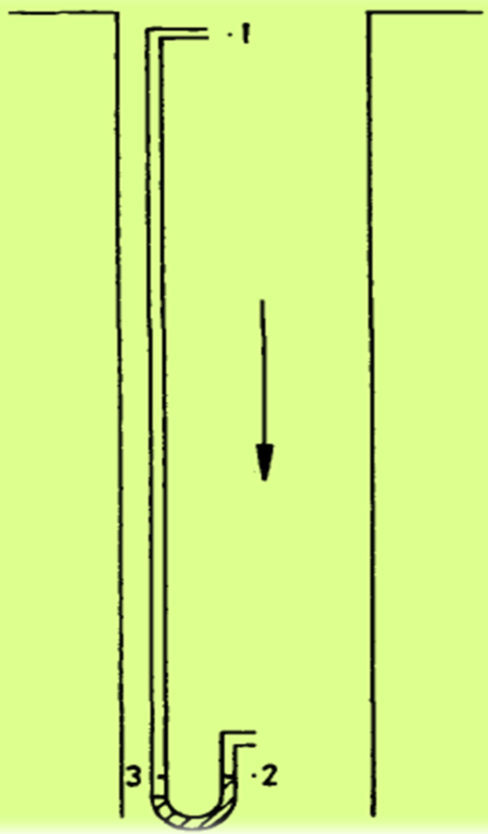


FIGURE 6.11 Gage-and-tube traverse in a shaft.

Pressure Survey

- **Solution Example 6.3. :**
- The manometer reading is the difference (ps - *p2)* in Fig. 6.11. To determine the correction, the mean specific weights of the air in the shaft (column 1-2) w_s, and the hose (column 1-3) w_h, must be calculated.
- Neglecting velocity head changes and using the appropriate mean specific weights, the head loss in the shaft resulting from flow from 1 to 2 is

$$H_{l_{12}} = (H_{s_1} - H_{s_2}) + (H_{z_1} - H_{z_2})$$

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Pressure Survey

- **Solution Example 6.3. :**
- Similarly, noting that $Z2 = Z3$, the head loss in the hose due to flow from 1 to 3 is

$$H_{l_{13}} = \frac{144\ (p_1 - p_3)}{5.2} + \frac{\overline{w}_h(Z_1 - Z_2)}{5.2}$$

$$H_{l_{12}} = \frac{144\ (p_1 - p_2)}{5.2} + \frac{\overline{w}_s(Z_1 - Z_2)}{5.2}$$

- Note that H_{l13}= 0 as there is no flow from 1 to 3.
- Subtracting *H/l}* from *Hi,,* the following expression is obtained for head loss in the shaft:

$$H_{l_{12}} = \left(\frac{144}{5.2}\right)(p_3 - p_2) + \left(\frac{1}{5.2}\right)(Z_1 - Z_2)(\overline{w}_s - \overline{w}_h)$$

Pressure Survey

- **Solution Example 6.3. :**
- In this equation, the manometer reading is represented by the first term on the right, and the correction, by the second term.
- Note that p3 = *p2* + manometer reading (converted to psi)

$$p_3 = (13.773) + \left(\frac{1.51}{27.69}\right) = 13.8275 \text{ psi}$$

- Using Eqs. 2.2, 2.3, 2.5, 2.7, and 2.8, the following data are calculated for the air in the shaft:

Position	Specific Humidity, lb/lb	Specific Weight, lb/ft^3
Top	0.0072	0.0655
Bottom	0.0082	0.0702

Pressure Survey

- **Solution Example 6.3. :**

$$\text{Average specific weight of air in the shaft } \overline{w}_s = \frac{0.0655 + 0.0702}{2} = 0.06785 \text{ lb/ft}^3$$

- Conditions at the top of the hose are the same as those at the top of the shaft. Known conditions at the bottom of the hose (point 3) are dry-bulb temperature = 67.3°F, barometric pressure = 13.8275 psi, and specific humidity= 0.0072 lb/lb. Using these data and Eqs. 2.5, 2.7, and 2.8, the specific weight of the air at point 3 is calculated as 0.0705 lb/ft3.

$$\text{Average specific weight of air in the hose } \overline{w}_h = \frac{0.0655 + 0.0705}{2} = 0.0680 \text{lb/ft}^3$$

Pressure Survey

- **Solution Example 6.3. :**
- Noting that (Zi - Z2) = 2620 ft, the head loss in the shaft due to flow is

$$H_{l_{12}} = \left(\frac{144}{5.2}\right)(13.8275 - 13.773) + \left(\frac{1}{5.2}\right)(2620)(0.06785 - 0.0680)$$

$$= 1.43 \text{ in. water}$$

Pressure Survey

- **Indirect Method (Leapfrogging method)**
- The indirect method uses a precision aneroid barometer or altimeter.
- The device indicates absolute static pressure at a point, and the difference in head between two points must be calculated from adjacent readings.
- Altimeter readings are recorded during the survey in ft (m) elevation and then later converted to head in in. water (Pa).
- The upstream instrument becomes the downstream instrument for each successive measurement.

Pressure Survey

- **Indirect Method (Leapfrogging method)**

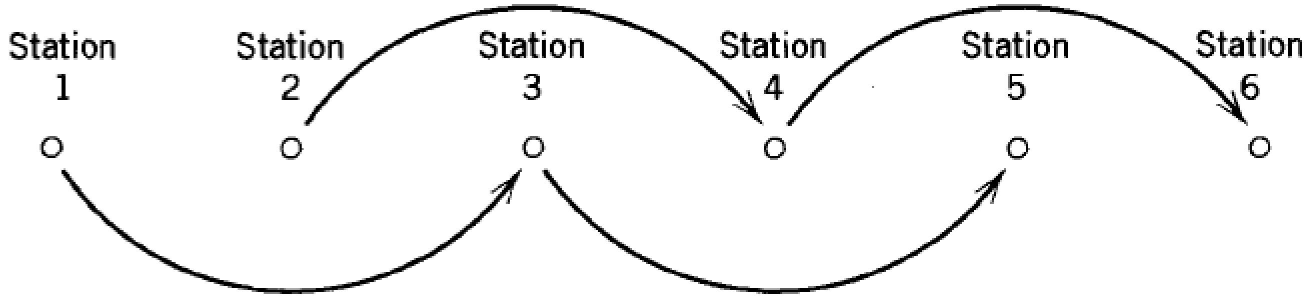


FIGURE 6.14 Leapfrogging method.

- Stations for pressure measurement should be located at splits, junctions, points of air direction change, and points of major physical change in air courses; across regulators; and at both sides of overcasts. These locations are poor for quantity measurements.
- Study of the map should be followed by a trip underground, at which time elevations and areas can be measured; and an inspection can be made for possible problems that may be encountered during the survey as well as for changes in station locations, if necessary.

Pressure Survey

- **Calculations**

$$H_{l_{21}} = (H_{s_2} - H_{s_1}) + (H_{v_2} - H_{v_1}) + (H_{z_2} - H_{z_1}) \qquad (6.9)$$

$$H_{s_1} = H_1 + H_{a_1} \qquad H_{s_2} = H_2 + H_{a_2} \qquad (6.10)$$

$$H_{l_{21}} = (H_2 - H_1) + (H_{a_2} - H_{a_1}) + (H_{v_2} - H_{v_1}) + (H_{z_2} - H_{z_1}) \qquad (6.11)$$

$$H_{l_{21}} = -\left[\frac{(p_{A_2} - p_{A_1}) - (p_{B_2} - p_{B_1}) - (Z_2 - Z_1)/DR}{\mathrm{CF}}\right] + \frac{V_2^2 - V_1^2}{(4009)^2} \qquad (6.12)$$

- DR : Density ratio

Pressure Survey

- **Calculations**

$$\mathrm{DR} = \frac{\left(\dfrac{1.325}{460 + 50}\right) p_b}{\left(\dfrac{1.325}{460 + t_d}\right)(p_b - 0.378 p'_v)} \qquad (6.13)$$

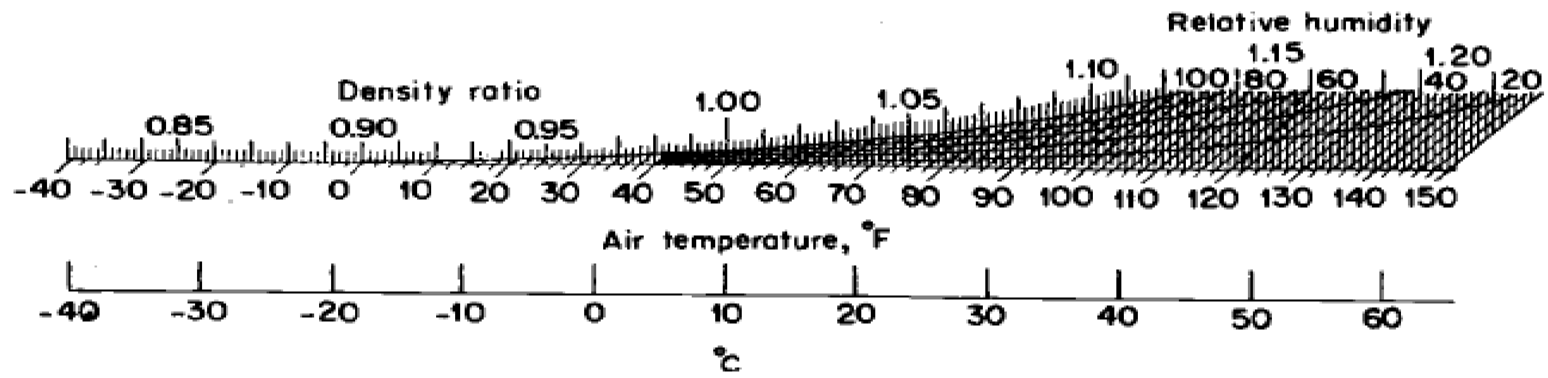


FIGURE 6.15 Ratio of altimeter-scale air specific weight to mine air specific weight. Correction factor for difference of elevation. (After McElroy and Kingery, 1957.)

Pressure Survey

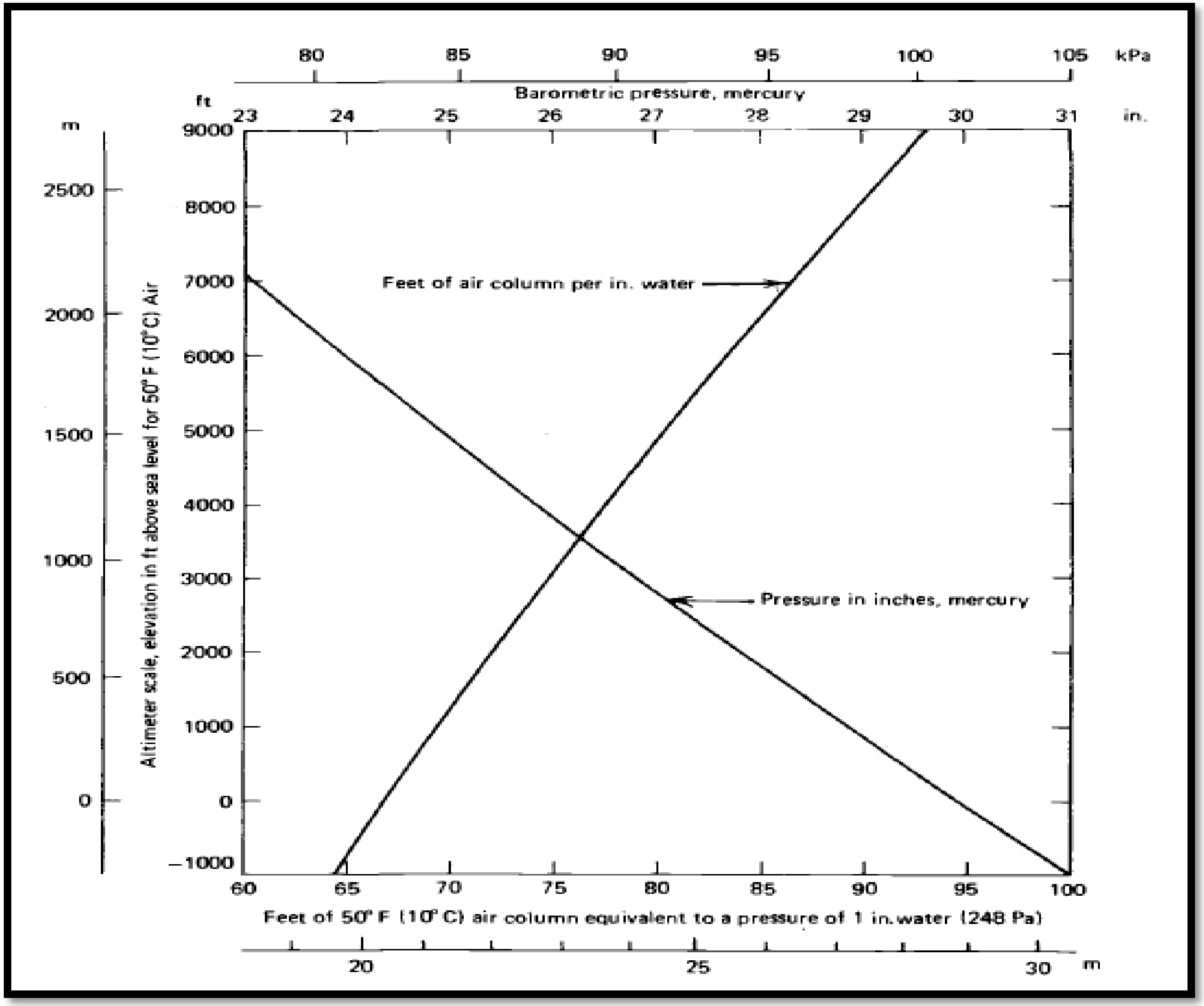
- Pressure differences due to air-velocity differences are calculated by assuming w=0.0750 lb/ft^3

$$H_{v_{21}} = \left[\frac{V_2^2 - V_1^2}{(4009)^2}\right]\left[\frac{(w_1 + w_2)/2}{0.0750}\right] \qquad (6.14)$$

- **CF** or *conversion factor* converts average altimeter readings to pressures in feet of air column equivalent to a pressure of 1 in. water

Pressure Survey

- **Fig. 6.16**



Comparison of Pressure Survey Instruments and Methods

Manometer	Altimeter
Portable, slow, inflexible, cheap	Portable, fast, versatile, costly
No lag, but fluctuates	Subject to creep or lag
Temperature change causes error	Temperature change correctable
No elevation correction	Must correct for elevation
No barometric correction possible	Must correct for barometer
Station interval limited	Station interval unlimited
Reads directly in in. (mm) water	Readings must be converted
Used for accurate measurements	Used for routine surveys

END OF PART-II