For balancing, air systems may be equipped with dampers in supply, return, and outdoor air ducts, splitter dampers, or dampers in outlets. In selecting the desired type of damper or balancing method, the following points should be kept in mind:

1. Unfavorable effect on air stream and noise level should be avoided. This will often rule out blank-offs or dampers in outlets, unless such dampers are of special design.

2. It should be possible to alter outlet volume without altering the direction of discharged air, and to measure the amount of air handled without difficulty. Blanking off part of the area of supply outlets makes this difficult.

Generally speaking, it is most satisfactory to install dampers at some distance back of outlets so as to avoid disturbing the air flow. Dampers in both supply and return ducts form the most flexible means of controlling supply of air to the room and static pressure within the room. (Refer to Chapter 30 for discussion of various air distribution control devices.)

Instruments for balancing include instruments for measuring air quantities, static pressure, temperature and humidity. Commonly used instruments are the rotating vane anemometer, deflecting vane anemometer, thermal anemometer, smoke gun, clamp type ammeter-voltmeter, sling psychrometer and thermometers. Pressure, humidity and temperature recorders are sometimes useful. The Pitot tube and a manometer may be used on higher velocities, but only with the technique prescribed for its use by the manufacturer for the tube used. (See Air Flow Measurement in Chapter 16.)

The following balancing procedure is recommended for air systems:

1. Open all duct and outlet dampers.

2. Measure fan capacity. This can most often be done with a rotating vane anemometer inside the fan inlet plenum. For exhaust fans the discharge outlet will often serve.

3. Measure fan motor input.

4. Begin balancing the supply system at the last outlet on the branch farthest from the fan (branch number 1). This is outlet number 1, number 2 is the next to last outlet.

5. Measure the air flow at outlet number 1 (Q_m) and compare with the design air flow for that outlet (Q_d), record the ratio, $(Q_m/Q_d)_1$.[25]

6. Measure the air flow at outlet number 2 and determine the ratio $(Q_m/Q_d)_2$. Compare $(Q_m/Q_d)_2$ and $(Q_m/Q_d)_1$.

7. If these ratios are not within 10 percent of each other, adjust outlet number 2 to bring ratios into closer agreement. . . . *Do not adjust outlet number 1.*

8. Measure and again determine $(Q_m/Q_d)_2$ and $(Q_m/Q_d)_1$ and compare. If these are within 10 percent of each other, no further adjustment is necessary. Proceed to outlet number 3.

9. Determine $(Q_m/Q_d)_3$ and compare with $(Q_m/Q_d)_2$. If necessary, adjust number 3 so that $(Q_m/Q_d)_3$ and $(Q_m/Q_d)_2$ do not vary by more than 10 percent. *Do not adjust outlets 1 or 2.* (Adjustment of outlet 3 automatically changes the Q_m/Q_d ratios of outlets 2 and 1. The ratios for all these outlets approach the same values. For this reason, once the outlet has been adjusted, it does not require further adjustment.)

10. Proceed to outlet number 4 and adjust to obtain agreement between $(Q_m/Q_d)_4$ and $(Q_m/Q_d)_3$.

11. After all outlets on branch number 1 are proportionately balanced to each other, proceed to branch number 2, etc.

12. Upon completion of proportionate balancing of all outlets the branches should be proportionately balanced.

13. Select typical outlets in branches 1 and 2. . . . Adjust number 2 branch damper to obtain agreement of the Q_m/Q_d ratios for the two branches. Proceed in like manner to obtain agreement between branches 2 and 3, 3 and 4, etc.

14. Upon completion of proportionate balancing, recheck the fan capacity. Adjust the fan speed to obtain a Q_m/Q_d ratio of 1.0 at the fan. Since the system has been proportionately adjusted, the Q_m/Q_d ratio throughout the system will be approximately 1.0 and the flow from each outlet will be the design air flow rate. (The fan laws apply when changing speeds; quantity varies directly with speed—power input as the cube of speed.) Use power input readings to check possibility of overloading the motor.

The procedure outlined may be shortened depending on the type of installation. For instance, where many outlets serve one room, exact balancing of each outlet may not be required, so long as drafts, noise, and temperature differences are checked. Experience and judgment are valuable in determining how carefully or thoroughly a system must be tested and adjusted.

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