TABLE 1. VARIOUS COOLING COIL ARRANGEMENTS

| SELECTION | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Total cooling capacity, tons | 100 | 100 | 100 | 100 |
| Sensible cooling capacity, tons | 69 | 69 | 69 | 69 |
| Latent cooling capacity, tons | 31 | 31 | 31 | 31 |
| Ratio total to sensible heat | 1.45 | 1.45 | 1.45 | 1.45 |
| Air quantity, cfm | 47,800 | 41,700 | 37,100 | 46,800 |
| Cfm per total ton | 478 | 417 | 371 | 468 |
| Face velocity, fpm | 325 | 423 | 500 | 600 |
| Resistance, in. water | 0.11 | 0.27 | 0.51 | 0.37 |
| Coil face area, sq ft | 147 | 99.0 | 74.2 | 78.1 |
| Coil rows deep | 4 | 6 | 8 | 4 |
| Coil evaporator temp. F deg | 45 | 45 | 45 | 38 |

arbitrarily specified, the corresponding duty sometimes cannot be obtained at all without the use of reheat. As with heating and sensible cooling coils, there are combinations of face areas, depth, air velocity and refrigerant temperatures which will give the required performance. This is illustrated in Table 1.

It is possible, as shown in Table 1, to perform approximately the same duty at a given refrigerant temperature with small face area and large thickness or vice versa. The large face area coil gives low air velocity and resistance, but high air quantities per ton. The coil of small face area and great depth requires small air quantities per ton of refrigeration, high resistance and high air velocities. As shown also in Table 1 the same sensible, latent and total cooling capacity may be obtained with various refrigerant temperatures by proper choice of coil. This makes it possible to keep the evaporating temperature high enough to carry the load with a chosen size of condensing unit. High evaporating temperatures with correspondingly small compressor operating expense can be attained, but at the expense of coil surface, air quantity or both. The choice will be determined by the necessities of individual installations.

For a given quantity and condition of entering air, the evaporating temperature of a volatile refrigerant coil is determined by a balance between the condensing unit and the coil. The total, sensible and latent cooling capacity can then be determined from the coil rating information. If the condensing unit and cooling coil have been properly balanced for the required load and, due to miscalculated duct resistance or improper choice of fan speed, the air quantity is reduced, the total cooling capacity will also be reduced. The decrease generally affects the sensible capacity. This is also true when the air by-pass or volume control is used.

It is necessary that not only the total capacity, but also that both sensible and latent cooling requirements be met. The installation of an excess of coil results in an increase in total capacity, but not in proportion to gain in latent heat capacity. On installations controlled from dry-bulb temperature, the operating time is shortened because of the added sensible cooling capacity. This results in less moisture pick-up and higher relative humidity than calculated. If an oversize condensing unit is installed, the opposite situation occurs. Generally, this is not a disadvantage, except that it results in a load from outside air greater than calculated, as well as in increased power consumption. If oversize equipment is furnished, a balance should be made to assure that the ratio of total to sensible capacity is the same as in the estimated load.

Sometimes, arbitrary air quantities are specified for ventilation or other



TABLE 2. CAPACITY BALANCES FOR MAXIMUM AND MINIMUM LOAD CONDITIONS

| CONDITIONS | CAPACITY IN TONS | | | RATIO TOTAL/SENSIBLE |
|---|---|---|---|---|
| | Total | Sensible | Latent | |
| Required at peak load conditions | 10.90 | 7.90 | 3.00 | 1.38 |
| Required at minimum load conditions | 6.62 | 3.36 | 3.26 | 1.98 |
| Peak load equipment balance | 10.90 | 7.90 | 3.00 | 1.38 |
| Same equipment balanced at minimum load conditions | 9.85 | 6.58 | 3.26 | 1.50 |
| Same equipment balanced at maximum load conditions with 40 per cent by-pass | 8.38 | 5.05 | 3.33 | 1.66 |
| Same equipment balanced at minimum load conditions with 38,800 Btu per hour reheat | 6.62 | 3.36 | 3.26 | 1.98 |

reasons independent of the selection of the cooling coil. As shown in Table 1, the coil selection can be altered to take care of various air quantities for the same duty.

Where coil and condensing unit are selected for the peak load condition, and the sensible load partially disappears due to fall of outside temperature or other cause, the condensing unit and coil will rebalance. This may obtain more sensible and less latent capacity than required at the light load condition, with an increased relative humidity in the conditioned space. Such a condition is shown in Table 2. If approximately 40 percent of the total air is by-passed, the condition is improved as indicated. The situation may be entirely avoided by using reheat, where it is possible to handle any ratio of sensible and latent loads and maintain the design temperature and humidity.[1]

Care should be taken to avoid freezing at light loads. In general, freezing occurs when the coil surface temperature falls to 32 F. With usual coils for comfort installations, this does not occur unless the evaporating temperature at the coil outlet is about 20 to 25 F. The exact value depends on the design of the coil and the amount of loading. Although it is not customary to choose coil and condensing units to balance at low temperatures at peak loads, there is danger of this occurring when the load decreases. This is further aggravated if a by-pass is used so that less air is passed through the coil at light loads. It may be even worse if the control is arranged for decrease of inside temperature with fall of that outside. Freezing can be avoided by making the full load balance a high evaporating temperature, and checking the balance at the minimum load.

Care should be exercised in the design of humidity control to minimize the cycling of the refrigerating compressor because of re-evaporation of moisture from the fins. It is sometimes necessary to by-pass air around a coil when the compressor is not operating.

## HEAT TRANSFER AND AIR FLOW RESISTANCE

The transfer of heat between the heating or cooling medium and the air stream is influenced by several variables:

1. The temperature difference.
2. The design and surface arrangement of the coil.
3. The velocity and character of the air stream.
4. The velocity and character of the medium in the tubes.

The driving force is usually taken as the logarithmic mean temperature difference for heating or cooling without dehumidification. For combined