EQUIPMENT COOLING

CONTENTS — PAGE

Figures

CONTENTS — PAGE

Figures (Contd)

CONTENTS PAGE

1. GENERAL

1.01 This section discusses and provides standards for Equipment Cooling. These standards are provided for use in the design of new buildings or building additions that are intended to house telephone equipment that meets the requirements of Section 800-610-164, "New Equipment-Building System (NEBS), General Equipment Requirements."

1.02 This practice supersedes Section 9.1 of Specification X-74300, "NEBS Building Engineering Standards (BES). Whenever this section is reissued, the reason for reissue will be listed in this paragraph.

2. SCOPE

2.01 Environmental control of telephone buildings serves primarily to provide an environment that permits good equipment performance. The environmental control system should be engineered for appropriate degrees of reliability and adaptability to changing conditions, and should provide adequate performance during an emergency. Both initial costs and operating costs should be reasonable.

2.02 In the past, electromechanical systems occupied large areas and the equipment cooling system requirements were modest. Since the advent of more compact electronic communications equipment, there has been an increase in the heat dissipated per ft^2 of floor space in more compact equipment rooms, eg, No. 5 Crossbar dissipates about 2 watts/ft^2, No. 1 ESS about 10 watts/ft^2, and the No. 4 ESS will dissipate about 40 watts/ft^2 of floor space averaged over an area that includes necessary aisles. Equipment heat dissipated by various telephone equipment systems is shown in Fig. 1. Building heat transmission, ventilation (sensible and latent), lights, and personnel heat loads are in addition to these equipment heat loads. Also, the variation in equipment heat loads throughout the equipment room has increased considerably resulting in some very high-heat areas.

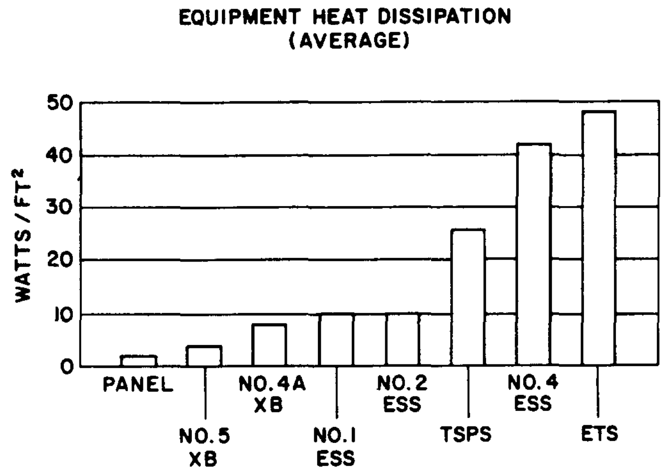


Fig. 1—Heat (Average) Dissipated by Telephone Equipment Has Increased from Less Than 10 Watts/Ft^2 for Electromechanical Equipment to Over 40 Watts/Ft^2 for the New Toll Electronic Switching Systems

2.03 Trends in future switching system design indicate higher component densities and circuit speeds, resulting in increasing power density (wattage per square foot) even though total system heat is expected to be reduced. Similarly, higher data rates and greater application of integrated circuits are increasing dissipation density levels in switching and transmission systems presently in development to the point that natural convection cooling may not be adequate. In fact, a new circular waveguide transmission system being developed uses chilled water to cool the repeater equipment frames.

2.04 Component density in data processing type equipment has increased from 25 bits/$in.^3$ in the early 1950s to millions of bits/$in.^3$ in equipment now being developed. Consequently, power density within frames has increased to the point that heat transfer mechanisms other than natural convection must be considered. Thus, the basic trend (as shown in Fig. 2) in telephone digital switching and transmission equipment is toward high heat dissipation levels requiring other methods of cooling.

3. DESCRIPTION

A. PRESENT EQUIPMENT DESIGN

3.01 In considering cooling of telephone equipment there are two basic problems: (1) heat removal from the equipment components, and (2)

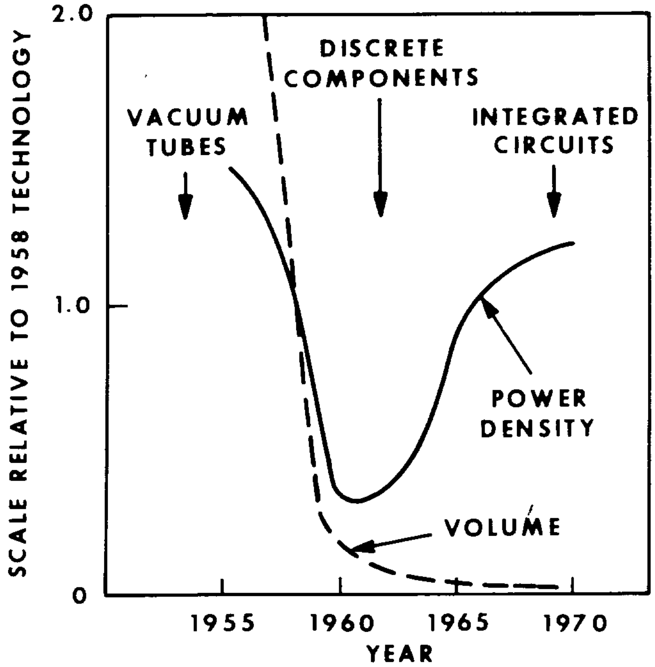


Fig. 2—Increases in Power Density of Data Processing Type Equipment Have Created Heat Transfer Problems that Require New Cooling Methods

heat removal from the equipment room. Bell Laboratories physical designers rely on natural convection within the equipment frame for cooling most electronic equipment. Present design requirements are that equipment operate normally within an aisle-temperature range of 40°F. to 100°F. The short-term range (72 hours) is 35°F. to 120°F. In contrast to this, an acceptable environment for people in the equipment area under normal conditions is 70°F. to 80°F. The building engineer can readily satisfy cooling requirements for a single equipment bay that dissipates less than about 600 watts per 7-foot-high, 2-foot 2-inch-wide frame by maintaining these aisle temperatures. Here, the main task is problem (2), heat removal from the equipment room, cited above.

3.02 However, the newer telephone equipment that dissipates more than 600 watts/frame, or more than about 25 watts/ft^2 over one or more building bays, requires additional local air movement to limit cumulative heat buildup and hot spots. This equipment may occupy a considerable part of the building. It is important to know where the additional air movement will be needed for planning of the air-conditioning.

B. FUTURE EQUIPMENT DESIGN

3.03 Although telephone equipment designers will continue to use cooling by means of natural air convection, it is very possible that forced air convection within equipment cabinets or forced liquid conduction to cold plates will be an integral part of future equipment designs. If this is the case, building engineers will be called upon to provide greatly increased capacity for removing equipment heat from a given space and must position overhead air diffusers over the forced-air-cooled equipment to provide correct air ingestion. Also, for systems employing cold plates, the building engineer will be responsible for providing chilled-water distribution in the equipment area.

3.04 Four basic types of cooling systems are available to the physical designer; namely, low-velocity air, high-velocity air, modular cooling system (MCS), and cold plates. The effective design range for these systems measured in equipment heat dissipation as determined for equipment room floor area is shown in Fig. 3.

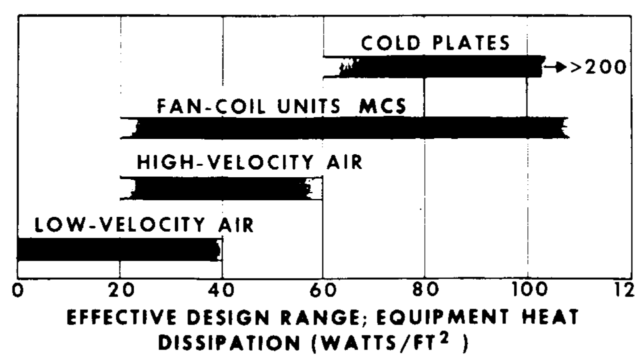


Fig. 3—As Heat Dissipation Increases for Contemporary Equipment, Cooling Systems Using Chilled Water Have Become More Economical Than All-Air Systems. The Effective Design Range of the New Modular Cooling System (MCS) Extends from Below 30 Watts/Ft^2 to More Than 100 Watts/Ft^2

C. COOLING SYSTEM DESIGN

3.05 Heat removal from a low-heat area (less than 20 watts/ft^2) is relatively straightforward and air distribution can be furnished by a conventional

Class I system.* However, with the newer high-heat-density electronic equipment, increased quantities of air are needed. Air distribution and local heat removal become more difficult problems. Attempting to utilize Class I air-conditioning systems for high-heat levels over large equipment areas would require very large ducts, which sets a physical limitation on this technique. Heat removal from a high-heat area (greater than 30 watts/ft^2) can be achieved with either (1) a Class II system** or (2) a modular cooling system, described below. A study comparing Class I and Class II systems with modular equipment cooling, ie, chilled water to local fan-coil units with local air distribution from units to equipment, for a 20,000 ft^2 equipment room, has led to the following conclusions:

(a) Class I low-pressure air distribution is not economical for equipment heat loads above approximately 30 watts/ft^2.

(b) A Class II system can be used for equipment heat loads from 30 watts/ft^2 to 60 watts/ft^2.

(c) Modular equipment cooling provides effective local air distribution with a low pressure system—less than 2 inches of water total static air pressure. High-heat-removal capacity, low noise, and flexibility to changing conditions are also provided. These advantages are provided at competitive cost for offices having equipment heat dissipation from 25 to 100 watts/ft^2. Estimates of the total cost of heat removal per ft^2 of equipment room area is compared in Fig. 4 for heat dissipation between 20 and 80 watts/ft^2. Classes I and II all-air systems are compared with modular cooling system costs.

*A Class I air-conditioning system is usually designed for a total pressure up to 3-3/4 inches of water with air velocities inside ducts of less than 2000 ft/minimum.

**A Class II air-conditioning system is usually designed for a total pressure up to 6-3/4 inches of water with duct air velocities between 2000 and 5000 ft/minimum.

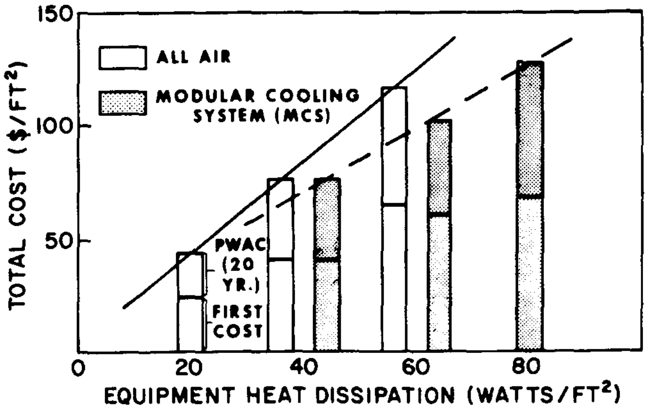


Fig. 4—Estimates of the Total Cost of Heat Removal per Square Foot Indicate a 20-Year PWAC (Taxes, Operation, and Maintenance) Which Is Comparable to the First Class (Air-Conditioning System and Building Space). The MCS Shows Economies at Equipment Heat Loads Above 20 to 30 Watts/Ft^2

D. DETERMINATION OF TOTAL HEAT LOAD

3.06 In designing a cooling system it is necessary that accurate heat dissipation information for new equipment and systems is available in terms of watts per frame. This information is converted by the building engineer to watts per square foot of equipment-occupied floor area or per maintenance aisle and is used to design the air-distribution system and to determine the size of the cooling plant.

3.07 The total air-conditioning load is the building heat load plus the aforementioned equipment heat load. Included in the building heat load are the heat transmission from walls and roof, outside ventilation air (sensible and latent), internal lighting, body heat, and mechanical equipment.

Basic Heat Load

3.08 The procedure for determining the heat load resulting from the external environment is presented in detail in ASHRAE documents. Lighting heat release is approximately:

Offices and operating rooms 4 watts/ft^2

Equipment areas 1.5 watts/ft^2.

Where possible actual lighting plans should be consulted. The above figures can be used when this information is not available. Also design should consider lights on in the maintenance and control area and lights out in the other maintenance aisles. In addition, heat load from occupants and mechanical equipment must be included. Refer to the ASHRAE Guide and Data Book for detailed information.

Equipment Heat Load

3.09 The total heat dissipated from equipment can be determined from a complete office floor plan, Floor Plan Data Sheets, specific heat release data given in Section 760-555-xxx series, or from the Telephone Office Planning and Engineering System (TOPES).

3.10 For newer systems not yet covered by heat release data can be obtained from Engineering Letters, General Letters, from the AT&T Building Manager concerned with the equipment, or TOPES.

E. MODULAR COOLING SYSTEM

3.11 A new standard cooling plan is described in Section 760-550-300. Designated as the Modular Cooling System (MCS), it employs chilled-water distribution rather than air as the prime heat removal medium from the room, but maintains air as the local medium. The MCS is intended primarily for areas where high-average equipment heat dissipations will occur or where large variations occur. Fig. 5 presents, for comparison purposes and relative dimensioning, vertical sections of the conventional cooling system (CCS) and modular cooling system (MCS).

3.12 As presently conceived, the basic features of the MCS are: (1) process coolers located in the equipment room, (2) a suspended ceiling air plenum or duct work connected to the process coolers, and (3) pre-engineered supportwork and deck with an underdeck distribution of chilled water, cable, electrical conduit, and an air return plenum connected to the process coolers. Total pressure is low, less than 2 inches of water. A separate ventilation system must also be included to satisfy code requirements. The MCS provides an effective ceiling-to-floor air-distribution system, and offers flexibility since airflow and the number of process coolers can be varied with changes in the equipment area. The pre-engineered, floor-ceiling system will provide an office interior that is attractive, flexible, can be used for interim office space, and economical to maintain. Equipment layout, cabling, lighting, and equipment cooling are inherently coordinated by the initial MCS layout.

F. GENERAL PLANNING INFORMATION

3.13 In order to design a cooling system for a particular heat load and to maintain comfortable aisle temperatures, the building engineer must have accurate heat dissipation information and must know the environmental requirements for the electronic equipment that is involved. General requirements for new equipment are described in Section 800-610-614, "New Equipment—Building System (NEBS)—General Equipment Requirements," and can be summarized as follows for the MCS (values for the Conventional Cooling System are one-half the values in (a) and (b) below):

(a) Total system heat dissipation shall not exceed 80 watts/ft^2 averaged over the entire equipment room.

(b) Within the system area, any one building bay area may average up to 100 watts/ft^2.

(c) Any individual item, such as a single equipment frame, may dissipate up to 120 watts/ft^2 for either conventional or modular cooling systems if air outlets provide terminal velocities of approximately 100 ft/minimum.

Guidelines for Choice of Heat Removal System

3.14 In an air-conditioned equipment floor area, a conventional Class I system may be used for equipment heat dissipation up to 40 watts/ft^2 (averaged over the entire equipment room), but it is a system basically intended for levels of less than 30 watts/ft^2. A conventional Class II system may be used for heat dissipation up to 60 watts/ft^2. The MCS is primarily intended for areas with average equipment heat dissipation from 30 to 80 watts/ft^2. In the range from 30 to 60 watts/ft^2 either conventional or modular cooling could be employed depending on the equipment floor area, the average heat dissipation, and the cost of the environmental control plan. The larger the equipment floor area is, the more attractive the MCS becomes.

Conventional Cooling Systems

3.15 The space allocation for conventional air-conditioning systems has been treated quite thoroughly in many other documents. Section 760-550-208, "Engineering Guide for Ventilation and Air-Conditioning Design Parameters," indicates preliminary refrigeration loads, space requirements, and location of mechanical equipment rooms. Section 760-550-212, "Engineering Guide for Ventilation and Air-Conditioning—Refrigeration Systems,"

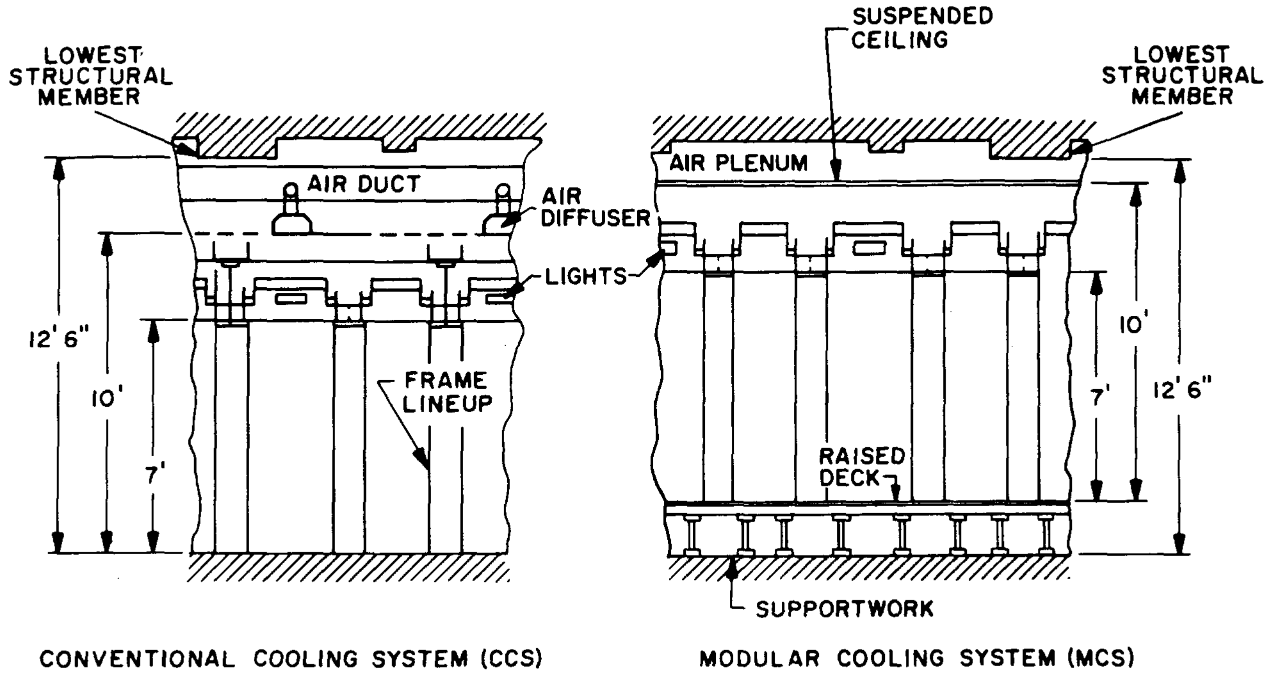


Fig. 5—The MCS Includes Process Coolers Connected to a Ceiling Air Plenum Supply, to a Floor Air Return Plenum, and to Chilled-Water Distribution Under a Raised Deck. Conventional Cooling Is Achieved With an Overhead Supply and Return Duct System With Fans in a Remote Mechanical-Equipment Room

presents the requirements for alternative refrigeration systems.

3.16 Recommendations for maintaining proper aisle conditions for local hot equipment areas, such as the store frames in the TSPS and ETS systems, are detailed in EL 529.

Modular Cooling System

3.17 Specifications for a standard MCS are outlined in Section 760-550-300. General characteristics of the system are as follows:

(a) ***Process Coolers:*** The basic elements of a process cooler are a finned-tube coil and a fan section. The fan recirculates air continuously from within the equipment area through the coil which is supplied with chilled water. Recirculated air is cooled and filtered as it is drawn through the unit. The cooling scheme is a two-pipe fan-coil system (process cooler) with separate ventilation, where two-pipe refers to a chilled-water supply and return. Units of nominal size, 5 and 10 tons with 3300 and 6000 cfm, will be located to handle all equipment heat configurations. Specific location and capacity of each unit is a function of the particular layout and heat dissipation of the equipment in the area. The 5- and 10-ton units, however, may be located in the column line and will have dimensions approximately 1 foot 6 inches by 3 feet 3 inches and 6 feet 6 inches, respectively. Location of 5-ton process coolers in the column line is shown in the plan view (Fig. 6). The two 5-ton units shown in the figure near the column could be replaced by one 10-ton unit. The one 10-ton unit may cool two or more building bays depending on the heat dissipation and the air circulation required.

The elevation view of the MCS also shows the location of the process cooler in the column line with access from both sides of the unit. Access to the fan and motor is from the maintenance aisle. The process cooler can be arranged to pick up return air from beneath the raised floor or through the front of the unit.

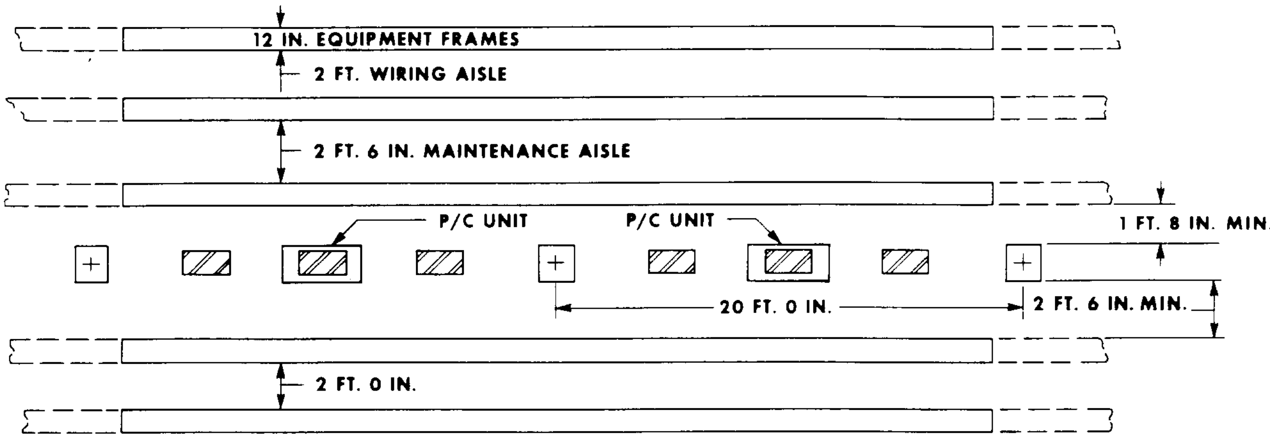


Fig. 6—Location of 5-Ton Process Coolers on Standard Floor Plan

(b) ***Air Distribution:*** In the MCS system, air is distributed locally along the aisle through rectangulor slots located in the ceiling plenum and is returned, through openings in the floor panels, back to the process coolers through the raised floor plenum. As noted above, if the raised floor is not used air can be returned through the front of the process cooler. The elevation view in Fig. 7 shows the airflow pattern that assures distribution of the coldest air to the hottest equipment near the top of the equipment bays. An almost uniform aisle temperature from floor to top of the equipment results. Local air distribution can be provided to equipment areas with high heat dissipation as needed. Also there is the ability to balance airflow by closing and opening the ceiling slots.

(c) ***Water Distribution:*** The chilled water piping is a closed-loop system from the chiller to the process coolers and return. It is installed under the raised deck and provisions are normally made for drainage and water-proofing of the floor slab. The water distribution includes insulated main supply and return piping with insulated condensate lines, and local piping from the main lines to the process coolers.

Flow control valves are installed in series with each unit as well as shutoff valves to isolate the unit from the rest of the system. Primary water pumps recirculate water between the chiller and process coolers.

(d) ***Ventilation System:*** Required ventilation and dehumidification are provided separately by drawing outside air into a peripherally located low-velocity air system or fan-coil unit. This approach affords good control of the office environment during periods before all of the equipment space is used. The ventilation requirements should be based on the expected people load and kept to a minimum consistent with local codes regulating the region in which the office is located.

(e) ***Economizer System:*** Although the MCS is an air recirculation system without provision for bringing in 100 percent outside air for equipment cooling, a chiller-bypass economizer heat exchanger typical of that shown in Fig. 8 and 9, may be installed to take part or all of the load depending on outside temperature. Fig. 10 shows the equipment heat dissipation pattern in a proposed No. 4 ESS installation using an MCS.

Emergency Conditions and Reliability

3.18 In the event of a power failure or failure of the air-conditioning system itself, the short-term (72 hours) maximum room temperature of 120°F. must not be exceeded. Determination of the rate at which office temperatures will rise in the absence of air-conditioning is a complex problem that depends on many parameters, such as equipment-heat dissipation, area affected, building construction, maximum time system will be out,

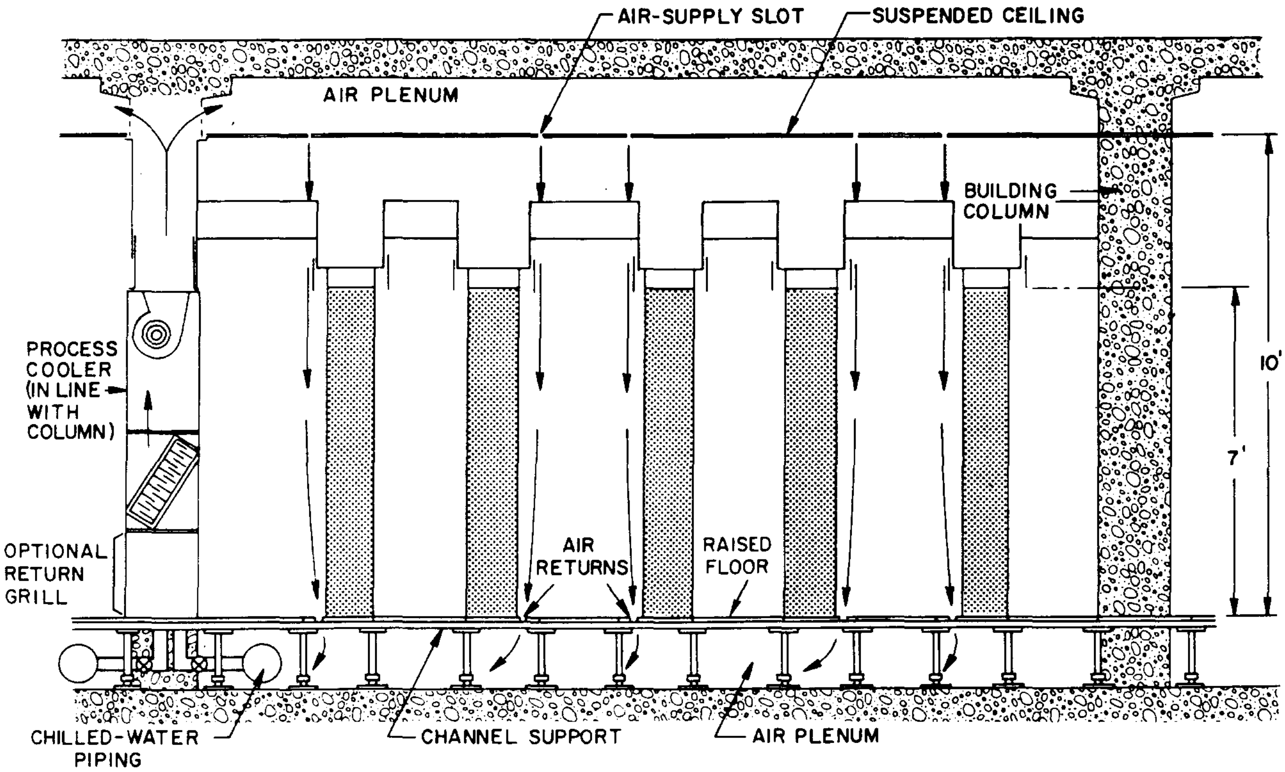


Fig. 7—Modular Cooling System, 20-Foot by 20-Foot Building Bay Elevation Air Distribution. Arrows Show the Direction of the Airflow

and outside environment. Recent studies, however, have indicated the following:

(a) For portions of systems where average equipment heat dissipation is less than 10 watts/ft^2, no emergency power will be required to keep the short-term maximum temperature below 120°F.

(b) In equipment areas having 10 to 40 watts/ft^2 heat dissipation, the need for emergency cooling is a function of the aforementioned factors; however, maintaining the ventilation system fans on emergency power and providing outside air makeup subject to humidity limitations will satisfy the short-term emergency requirement.

(c) For heat dissipation greater than 40 watts/ft^2 in an equipment area, a portion of the refrigeration system as well as the fans must be on emergency power for both CCS and MCS systems.

4. REFERENCES

Section 760-510-150—Piping Identification, March 1959

Section 760-510-151—Piping Exposed and Concealed, October 1967

Section 760-550-151—Ventilation of Building Mechanical Equipment Areas and Power Rooms, October 1960

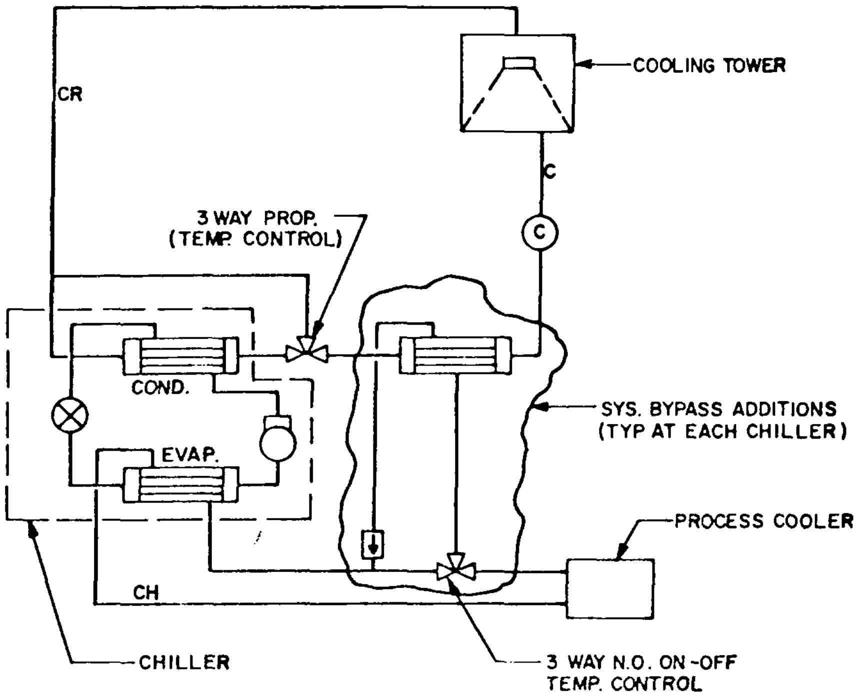
Section 760-550-223—Engineering Guide for Ventilation and Air-Conditioning—Design Parameters, August 1971

Section 760-550-212—Engineering Guide for Ventilation and Air-Conditioning—Refrigeration Systems, August 1971

Section 760-555-150—Atmospheric Environment for Telephone Equipment Space—General Considerations and Heat Release Data, December 1969

Section 760-555-151—Atmospheric Environment for Telephone Equipment Space, November 1969

Section 760-555-152—Specific Heat Release Data for 2-Wire No. 1 ESS, June 1968



ROOM TEMPERATURE CAN BE MAINTAINED AT 80° F. BY BYPASS SYSTEM WHEN OUTSIDE WET BULB TEMPERATURE ≤ 35° F. PARTIAL LOAD COOLING CAPABILITY AT HIGHER TEMPERATURES.

Fig. 8—Chiller Economizer System

Section 760-555-153—Specific Heat Release Data for Transmission Equipment, October 1966

Section 760-555-154—Specific Heat Release Data for 4-Wire No. 2 ESS (Autovon), October 1966

Section 760-555-155—Specific Heat Release Data for Radio Equipment, October 1966

Section 760-555-156—Specific Heat Release Data for Telegraph Equipment, October 1966

Section 760-555-157—Specific Heat Release Data for TSPS No. 1, June 1968

Section 760-555-158—Specific Heat Release Data for 4A and 4M Toll Crossbar ETS Equipment, February 1969

Section 760-550-300, Engineering Switch for Modular Cooling System (formerly EL3873)

EL 1654—Environmental Limits—Electronic Systems, AT&T, April 19, 1972

EL 401—Buildings: Heat Release and Air-Conditioning—No. 2 ESS, AT&T, June 30, 1970

EL 463—Buildings: Air-Conditioning for Electronic Data Processing Systems, AT&T, July 31, 1970

EL 529—Buildings: Air-Conditioning—TSPS No. 1 and ETS Areas, AT&T, July 6, 1970

EM 1558—Buildings: Air-Conditioning Electronic Switching Systems (Raised Floors), AT&T, September 3, 1969

EM 1472—No. 1 ESS Environmental Limits, AT&T, June 24, 1970

ASHRAE Guide and Data Book—Fundamentals and Equipment, published by ASHRAE, 1970

ASHRAE Guide and Data Book—Applications, published by ASHRAE, 1970

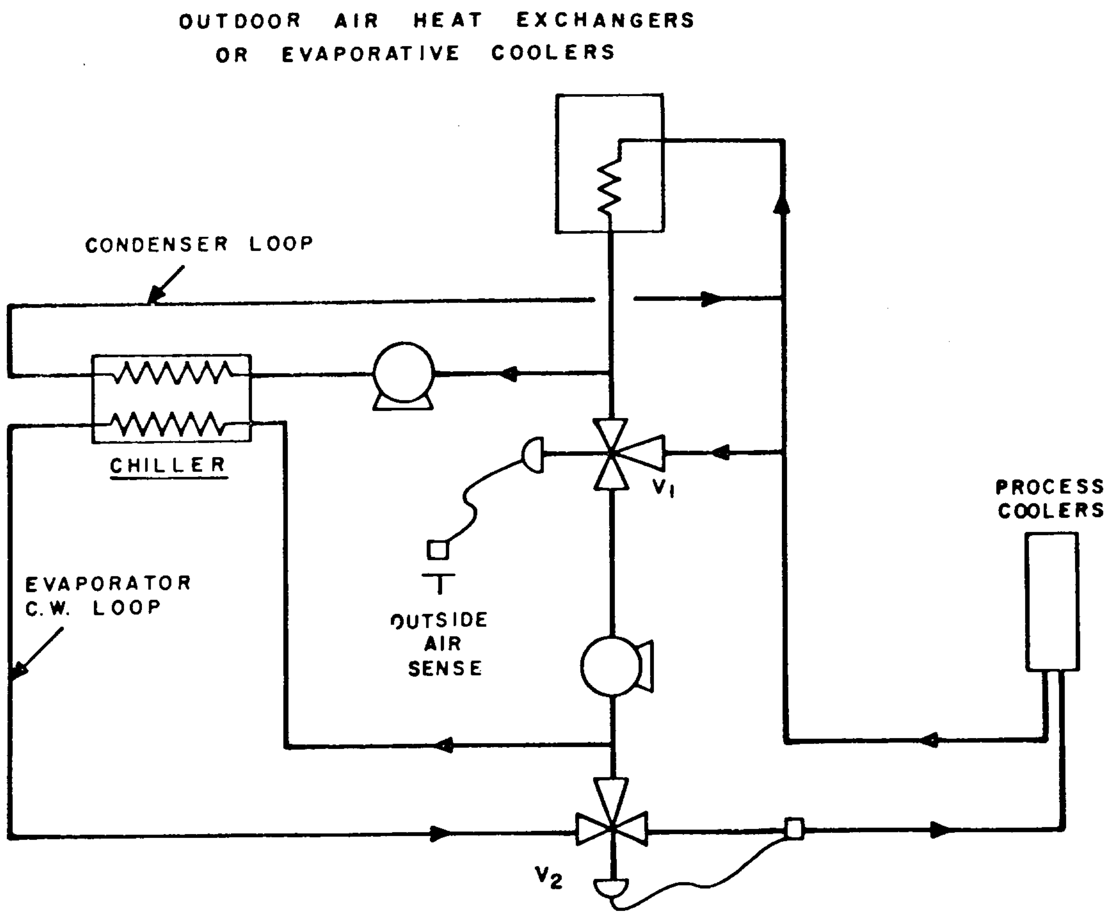


Fig. 9—Chiller Economizer System With Water-Glycol Loop

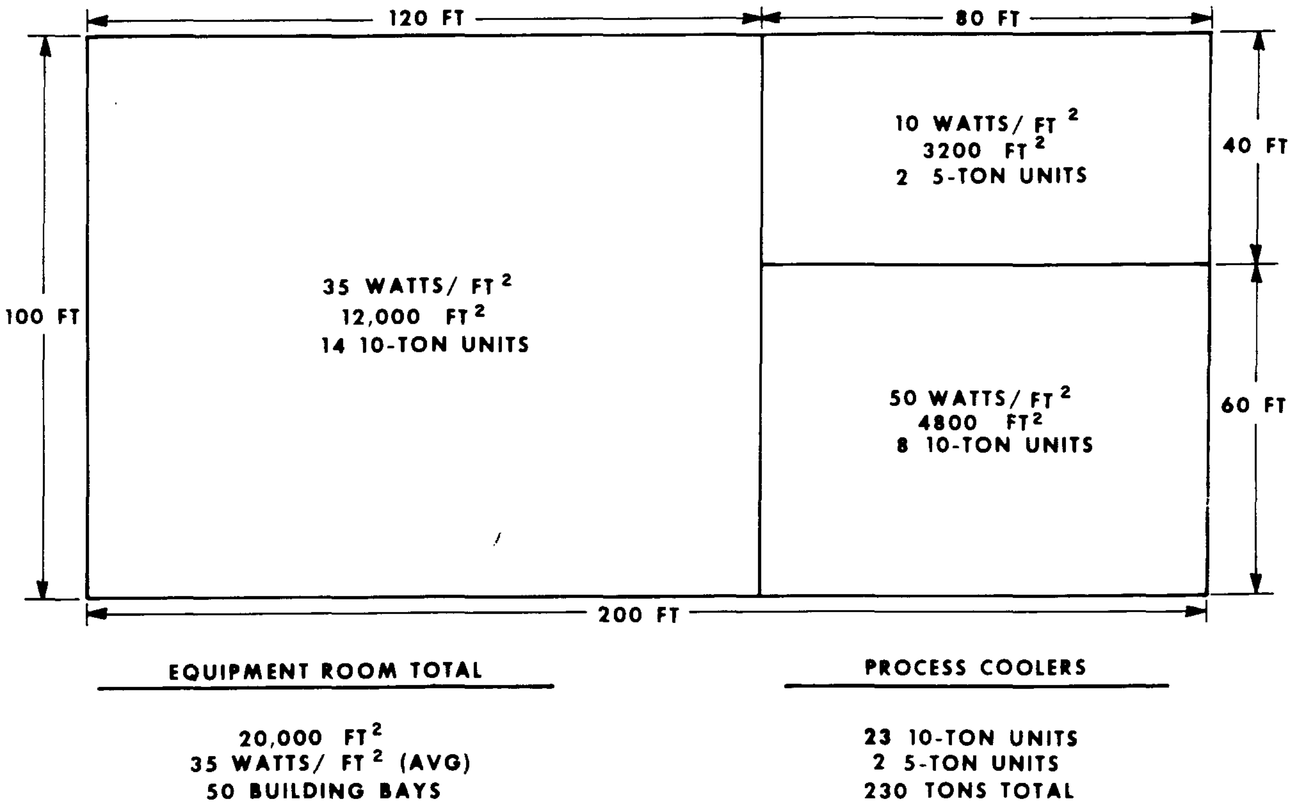


Fig. 10—The Equipment Heat Dissipation Pattern in a Hypothetical No. 4 ESS Installation Indicates an Average of Over 35 Watts/Ft^2. Equipment Cooling Can Be Achieved With Twenty-three 10-Ton Process Coolers. Building Solar Load, Ventilation, Dehumidification, and Personnel Heat Loads Are in Addition to These Equipment and Lighting Loads

5. EQUIPMENT COOLING STANDARDS

1. Provide the following conditions in equipment rooms:

Temperature	68°F. to 80°F. (nominal conditions)
	40°F. to 100°F. (long-term limits)
	35°F. to 120°F. (short term, up to 72 hours)
Relative	20% to 55%
humidity	20% to 80% (short term)

2. Aisle conditions are defined at a point 5 feet above the floor and centered 15 inches in front of the equipment. These conditions provide an environment well within the normal operating range of telephone equipment of 40°F. to 100°F.

3. Provide higher than normal terminal air velocities with nearly vertical flow in front of the hot frames that dissipate more than 600 watts (normal design velocities are 40 to 50 ft/minimum) as needed to control local temperature.

4. Use the following guidelines for heat removal from standard buildings (12-foot 6-inch ceiling height):

Equipment floor area	Heat removal system
>20,000 ft^2	Use MCS or Class II system for equipment heat dissipations >25 watts/ft^2
10,000 ft^2	Use MCS or Class II system for .equipment heat dissipations >30 watts/ft^2
<20,000 ft^2	Use MCS or Class II system for equipment heat dissipation >40 watts/ft^2.

5. Ensure reliability during emergency conditions as follows:

   (a) Conventional Cooling System: Ventilation system must be able to handle 100 percent outside air and must have fans on emergency power if the average equipment heat dissipation exceeds 10 watts/ft^2.

   (b) Modular Cooling System: A portion of the refrigeration (approximate 1/3 total refrigeration) and all process coolers must have emergency power, depending on economizer, smoke removal systems, and ventilation capabilities.

6. Allot 12 feet 6 inches of vertical clear space (distance from floor to underside of upper floor or roof slab) for either Conventional or Modular Cooling System as follows:

   (a) Equipment lights and cabling—10′

   (b) Conventional cooling system air ducts and diffusers—2 feet 6 inches

   (c) Modular Cooling System suspended ceiling

- 1 foot ***minimum*** between suspended ceiling and underside of lowest projecting structural member, ie, column capitals or girders.

- 1 foot 4 inches ***minimum*** in vicinity of process cooler (4-Foot radius for 5-ton and 6-foot radius for 10-ton process coolers).

(d) Modular Cooling System raised deck—1 foot 6 inches. (The raised floor may be reduced to 1 foot 2 inches if required to provide the above 1 foot 4 inches minimum ceiling plenum depth, but 1 foot 6 inches is very desirable. If a 1-1/2 inch raised floor height is used, high performance thin C.W. pipe insulation should be used to minimize airflow restriction.

7. Limit distributed live load of MCS elements (raised deck, suspended ceiling, process cooler) to 15 psf.

8. If the MCS is employed, provide waterproofing and drainage of the floor slab near piping and process coolers.

9. Provide ventilation for personnel in the area being cooled in accordance with local codes of the region in which the office is located. These ventilation requirements will be small compared to the amount of equipment cooling provided.