Central Systems

Central exhaust systems consist of one or more fans, a common suction plenum and branch connections to multiple exhaust terminals. Central systems are generally less costly than unitary systems in capital and maintenance cost, permit low cost stand-by exhaust fan provisions and are applicable to remote high stack discharge requirements. They are more difficult to balance and present the inherent difficulties of parallel fan operation when more than one fan is employed.

Filtration

Filtration facilities for exhaust systems are employed for the removal of hazardous and obnoxious air pollutants. A general application is the removal of radioactive particulates with disposable dry media absolute filters. The filter assembly for this purpose includes a pre-filter for coarse particle separation and a filter enclosure arranged for ready access and easy transfer of the contaminated filter to a disposal enclosure. For convenience of handling, replacement and disposal with minimum hazard to personnel the filter should be located outside the working area and on the suction side of the exhauster. A constant volume controller is required to maintain design exhaust rates as filter resistance increases with particulate accumulation.

Exhaust Fans

Fans handling contaminants should be located outside occupied areas of a building and close to the point of discharge to the atmosphere to avoid spread of contaminants through leakage by maintaining fume collecting ducts outside of equipment areas under negative pressure. Collecting duct branches may be of conventional joint construction providing appropriate allowance for leakage is applied to the fan rating. Discharge ductwork should be of airtight construction.

SUPPLY AIR INTAKE LOCATIONS

In the arrangement of the supply air equipment, it is essential that the locations of the fresh air intakes be carefully considered to avoid the possibility of recirculation of contaminated exhaust air.

Because concentration patterns are strongly influenced by wind direction, building shape and the location of the effluent source, exact air patterns are not predictable. A rough but conservative approximation of the dilution effect that might be expected for exhaust vents flush with the roof, based on wind tunnel tests, can be made by the following equation.[3] An increase of dilution can be expected if the exhaust discharge stack is increased in height.

$$D = [4.66 + 0.147(L^2/A_e)^{1/3}]^2[V/V_e]$$

where

- D = dilution, defined as the ratio of gas concentration at the exhaust opening to the gas concentration at any point near the building, dimensionless.
- L = shortest air distance between exhaust opening and any point, feet.
- A_e = area of exhaust opening, square feet.
- V = wind speed, feet per minute.
- V_e = exhaust speed, feet per minute.

The results should be compared with the expected concentration of the exhaust contaminants at the point of discharge and the maximum concentration of these contaminants that can be tolerated in the supply air system.

Discharge of effluent through exhaust stacks which extend over the area of influence of the structure will insure additional dilution.

SUPPLY SYSTEMS

The minimum unit which the air supply system serves is the laboratory *module*. In the overall design of the laboratory building, a module is the smallest repetitive unit in which research is performed and which is designed with provision for a full complement of services. Consequently air supply systems are designed with the module being the basic unit of space for which air is provided and temperature and humidity control is maintained.

Research programs are subject to change and the occupancy and arrangement of laboratory space is often altered with time. A successful laboratory system is one which can cope with these changes within the limits of the design with minimum major alterations and interference with adjacent areas. This does not mean that the system should have 100 percent of its ultimate capability installed initially, but the system should be arranged so that when changes must be made they can be accomplished efficiently within the overall system concept without relocation of or alterations to equipment which is not affected by the change.

Air supply may be by any one or a combination of systems which satisfy the laboratory thermal requirements and maintain the building air balance. The size and physical arrangement of the laboratory, as well as the features of occupancy and economic realities, are factors which determine the system to be used.

All air supply system types and arrangements are utilized for laboratory conditioning. Systems have been installed using high, medium, or low pressure air distribution or a combination of these methods. Single-duct, dual-duct, and terminal reheat type systems have been applied. Air supply may be introduced into the laboratory through ceilings, sidewalls, under-the-window and, in some instances, through the floor. The important factor is whether the system will satisfy the criteria efficiently and economically.

Unitary Systems

The most flexible form of air supply system consists of a separate air handling unit for each laboratory space. Each unit is made up of a fan and air treatment apparatus with a capacity equal to that required to maintain space temperature and balance the exhaust requirements. The unit contains a cooling coil, heating coil, humidifier, filter, and any other required air treatment device and is serviced with electricity, chilled water, and steam or hot water.

This system is capable of being operated only when necessary and can be designed to match the exhaust fan capacity and regulated to balance the exhaust quantities, if the latter are variable.

Each unit is capable of delivering sufficient heating, cooling, or both, to satisfy the peak requirements of the space it serves when necessary and is capable, too, of having its heating and cooling capacity reduced separately as the load in the laboratory space varies.

The unitary system, when constructed to high quality standards, is initially expensive, takes considerable space, and is often costly to operate and maintain. It finds its chief application for isolated laboratory spaces and in buildings where hours of operation are highly irregular and internal heat gains and ventilation air requirements are large and variable.

Unitary equipment with air treatment capabilities more limited than those required when it is the sole source of air supply is used to supplement central apparatus in areas where the base central system would be overloaded.

Central Systems

The simplest form of central system which can be successfully applied to a laboratory subjected to variations in internal heat gain is one where the supply air volume is constant and the air is conditioned to a dry-bulb temperature that will satisfy the maximum sensible heat release in any space and a dewpoint satisfactory to enable maintenance of room humidity within an acceptable range.

Variations in heat gain from space to space are balanced by thermostatically controlled reheat coils in the branch duct serving each space.

This system can regulate temperature well and is economical if close humidity control is not critical, if internal heat gains are moderate, fairly constant within a space and do not vary greatly from space to space, and if the exhaust air quantities are constant and in balance with the supply air necessary to maintain space conditions.

Hours of occupancy or operation for each laboratory space should be approximately the same since the central system must be in operation if any one space is being used. Many laboratories operate 24 hr a day so this requirement does not always impose a hardship.

Where heat gains are high and subject to variation and where the exhaust air quantities are greater or less than supply air requirements for cooling, variations of the simplest central system should be considered. These variations can broadly be considered: (1) central systems with supplementary conditioning, and (2) central systems with supplemental air supply.

Supplementary Conditioning

The purpose of supplementary conditioning is to provide the capability within or as an adjunct to the base central system for cooling, heating or humidification loads and special filtration which vary sufficiently with respect to intensity, frequency or duration or which occur in such a small percentage of spaces served by the central system to make inclusion within the central conditioning apparatus uneconomical.

High heat gains in limited areas may be more efficiently handled by providing additional cooling capacity in the portion of the system serving those specific areas, when required, than by cooling the air centrally to the temperature necessary and then reheating for all other spaces supplied by the system where the heat gain is not developed.

Many laboratories will have spaces which require systems having large cooling capability for irregular periods of time when certain experiments are being performed, but the duration of the need is often small when compared with the total hours of operation. For such a laboratory, a system with supplementary conditioning should be considered.

During the design and initial operation of the building, the areas requiring supplementary conditioning may not be known and during the life of the buildings these areas may be modified or relocated and new occupancy having this requirement added. Central systems can be designed with provision for the supplementary conditioning to be added at any time in the future in any space with a minimum interference with the operation of the rest of the building. In this case, central chilled water, hot water, or steam facilities should be made available to enable a percentage of all laboratory spaces to have supplementary conditioning installed ultimately.

It should be emphasized that supplementary conditioning equipment can be justified only to handle spaces whose requirements differ from those of the bulk of the spaces served by the central system, either in magnitude or frequency of occurrence. If the *special* requirements are in fact general, they might best be handled by providing the equipment with the necessary capacity in the central apparatus.

Although provision for addition of supplementary air treatment equipment is made generally throughout the system, the cooling coil, humidifier, and special filters or odor absorbing equipment are installed only if the base system cannot cope with the requirements. If the special need does not exist, the supplementary equipment should not be installed.

Supplementary conditioning may be applied to an individual area or a group of areas served by a central system and may be in the form of (1) separate unitary equipment, (2) additional apparatus within the central system.

In either case, the supplementary conditioning apparatus might be any combination of cooling coil, heating coil, humidifier, and sometimes supplementary filters and odor absorbers, located so as to be easily accessible for inspection and maintenance.

Supplementary Unitary Equipment

Separate unitary equipment may be installed adjacent to or within the laboratory space and may be in the form of a recirculating air handling unit containing a fan and the required conditioning apparatus.

Supplementary unitary equipment provides additional conditioning capacity by adding in effect a second air handling system to the space. This arrangement is quite flexible in that it can be operated when required and shut down if not needed.

Conditioning is accomplished without affecting the state of the base supply air and since high temperature differentials are usually not required, the thermodynamic efficiency is relatively high. Where the supplementary cooling required is largely sensible heat, judicious selection of apparatus can give cooling with a dry coil.

Since this arrangement provides an air supply in parallel with the base system and since this second air supply is often intermittent, great care must be exercised in arranging the distribution ductwork and selecting and locating the air outlets to preclude stratification on one hand or excessive turbulence on the other.

The automatic controls for both the base and supplementary conditions must be properly sequenced.

Supplementary Equipment in Central Systems

When installed within the central air distribution system, the air treatment components are located within the branch duct to the space being served.

Since the primary supply air conditions are modified to provide supplementary conditioning, the advantage of constant air quantity and a largely unchanged supply air distribution pattern results. This may be offset by larger temperature differentials and when no separate humidification facilities are provided, may bring about changes in room humidity. These variations are predictable and should be taken into account during the design of the system. Though they may be acceptable or can be corrected by humidification, they still may represent unnecessary latent cooling to accomplish the needed sensible temperature reduction.

Conditioning equipment added into a central system will, of course, impose additional static pressure losses on the system and when these cannot be economically absorbed, booster fans in the branch duct or separate unitary equipment should be considered.

The duct system which is to have provision for supplementary conditioning components should be constructed