

Energy Effects of ASHRAE Standard 62-1981

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During the last decade, escalating utility rates caused building owners and managers to take steps to lower their overall energy consumption. Among the measures taken for energy optimization was the reduction of the quantity of outside air used for ventilation. As a result, there were increasing levels of indoor exposures to potential harmful products such as radon, asbestos fibers, unvented chemical vapors and combustion products, tobacco smoke, formaldehyde, and chlorinated organic chemicals. These developments led to rewriting of the ventilation standard. This paper will investigate the energy consequences of ASHRAE Standard 62-1981[1] which is once again up for revision.

Ventilation Standards

ASHRAE Standard 62-73,[2] "Standards for Natural and Mechanical Ventilation," was the first set of guidelines developed by ASHRAE which recommended volumetric air flow rates per person of "acceptable outdoor air" for ventilation purposes. In this standard, the quantities of air were specified as minimum and recommended values. Then, as energy awareness increased, ASHRAE Standard 90-75[3] used only the minimum ventilation values.

These standards have been widely written into local and state building codes. Basically, this means that new and retrofit building HVAC designs need provide only 5 cfm of outdoor air per occupant.

After identifying the increased health risk problem with lower ventilation rates, ASHRAE re-evaluated and revised Standard 62-73 in order "to specify indoor air quality and minimum ventilation rates which will be acceptable to human occupants and will not impair health," using materials and methods which optimize efficiency of energy utilization. The new Standard 62-1981 was written and developed by an interdisciplinary group of engineers, physicians, chemists, and psychologists. Standard 62-1981 has a five-step ventilation rate procedure which prescribes:

1. The outdoor air quality acceptable for ventilation.
2. Outdoor air treatment when necessary.
3. Ventilation rates for residential, commercial, institutional and industrial spaces.
4. Criteria for reduction of outdoor air quantities when recirculated air is treated by contaminant removal equipment.
5. Criteria for variable ventilation when the air volume in the space can be used as a reservoir to dilute contaminants.

Higher ventilation rates are specified in areas where smoking is permitted, because tobacco smoke is one of the most difficult contaminants to control at the source. This means the minimum ventilation level recommended for an office building would increase from 5 to 20 cfm of outside air per person if smoking is permitted, a fourfold increase. For building owners, increased ventilation could result in increased heating and cooling requirements depending on location, existing internal and external loads, and methods chosen to meet Standard 62-1981.

Energy Research

This paper describes computer simulation research done on the energy effects of ASHRAE Standard 62-1981 on an office structure. Before the new ventilation standard could be studied, it was necessary to choose a suitable office building to use as a representative computer model. Equitable Life allowed the Dravo Building in Denver, Colo. to be used for the analysis. The building of roughly 150,000 sq ft, built in 1977, had mechanical systems which represented an energy efficient design. The central plants in the building were two centrifugal chillers with heat recovery condensers which were used in conjunction with a 40,000 gallon water storage system and an electric boiler for space heating. The fan systems included two main VAV fans, each 70,000 cfm and 75 HP, which served the top seven floors. The fans were of the variable pitch vane axial type and controlled by a duct static pressure sensor.

Table 1. Outdoor Air Requirements for Ventilation in Commercial Facilities (Standard 62-1981, Table 3)

Area	*Smoking* (*cfm per person*)	*Non-Smoking*
Offices		
Office Space	20	5
Meeting & Waiting Spaces	35	7
Food & Beverage Service		
Dining Rooms	35	7
Bars & Lounges	50	10
Cafeterias, Fast Food	35	7
Retail Stores		
Sales Floors & Show Rooms	25	5
Malls & Arcades	10	5
Specialty Shops		
Barber & Beauty Shops	35	20
Florists	25	5
Sports & Amusement Facilities		
Ballrooms & Discos	35	7
Bowling (Seating Area)	35	7
Spectator Areas	35	7
Theatres		
Ticket Booth	20	5
Lobby, Lounge, Auditorium	35	7
Education Facilities		
Classrooms	25	5
Training Shops	35	7
Music Rooms	35	7

Individual fan powered VAV boxes with low temperature HW reheat coils were used on the perimeters for cooling and heating requirements. Four pipe fan coils on the ground floor in individual retail and office spaces were used for space conditioning. The outdoor air was brought in through the main VAV fans. Modulating dampers on the outdoor air intake were controlled by pressure sensors to maintain the building at a slightly positive pressure. Time clocks and well calibrated local pneumatic controls maintained minimum run times on equipment and helped run equipment fairly efficiently.

Computed Data Base

To effectively simulate the representative office building, past utility energy records and occupancy data were compiled. Electrical metering was done on building mechanical systems and the receptacle and lighting systems for several months to identify equipment operating efficiencies and internal load profiles. Measurements were also made on the system supply and ventilation air flows. The resulting figures were compiled and averaged to represent an energy and building data base for the computer simulation.

The computer simulations were done on the building energy modeling program, ESP-II.[4] This software consists of four separate main programs which are as follows:

- Geographical weather data
- Building response factors (architectural materials)
- Building loads analysis
- Building systems analysis

The weather program processes the National Oceanic and Atmospheric Administration (NOAA) weather tape to take the necessary hourly weather data for the energy programs. The weather program also adds solar position calculations and adjusts for latitude, longitude and elevation differences between the weather station location and building site location.

The response program computes the response factors used in simulating heating flow as a function of time across the boundary of the wall or roof.

The loads program computes the hourly heating and cooling loads for each space simulated in the building. This program takes into consideration the geometry of the space, walls and roofs of the space, external exposures, and hourly internal gains from people, equipment and process loads.

The systems program simulates the actual HVAC equipment hourly operation as it reacts to the hourly space loads generated by the loads program. Many secondary and unitary systems and central plant configurations are available. The program will total the energy consumption of the simulated building.

The first part of the research involved simulation of the base office building as it presently operates, using hourly weather tapes for the test reference year (TRY) for Denver, 1955. The computer-calculated monthly energy consumption and demand were then correlated with the actual metered and measured data for the modeled building.

After obtaining a base representative building, changes were made to the ventilation rates. First, the energy for the minimum ventilation rate (5 cfm per person) was modeled; second, the energy for the new proposed ventilation rate was modeled (20 cfm per person in general offices and 35 cfm per person in a conference room). The energy difference between the two runs was calculated. This data was then used, along with the utility rates charged by Public Services Company of Colorado, to calculate the hypothetical monthly and annual dollar increase caused by the proposed ventilation standard.

The same computer model was then used to analyze the energy effects of ASHRAE 62-1981 in the following cities:

- Atlanta, Georgia
- Seattle, Washington
- Phoenix, Arizona
- Los Angeles, California
- Chicago, Illinois
- Dallas, Texas
- New York, New York

The TRY weather years used for each location were: Atlanta, 1975; Seattle, 1960; Phoenix, 1951; Los Angeles, 1973; Chicago, 1974; Dallas/Ft. Worth, 1975; New York, 1951. By changing the weather data used in the computer simulation it was possible to predict the energy effect of ASHRAE 62-1981 in the different geographical areas, on the office structure.

Current local utility rates were used to calculate the monetary effects of the new standard.

Computer Simulation Results

The electrical energy for the baseloads, fans, chillers, and boiler, plus the total monthly demand, were accumulated from the computer runs for each month for each geographical area studied. Table 2 is a summary of the electrical energy, demand, and cost.

Of the eight areas studied, the most significant effects of the new standard were in Chicago. This was largely because Chicago has much higher heating requirements in the winter than the other areas. Energy usage in Los Angeles was reduced by the higher ventilation standard, basically because of lowered chiller consumption from an economizer effect. Fig. 1 graphs the overall energy effects of the two ventilation standards from the computer simulations.

Local electrical utility rates were applied to the energy and demand figures to calculate the monetary effects of ASHRAE 62-1981. The total dollar cost for energy varied widely between a low in Seattle of around $70,000 to a high in New York of approximately $480,000. On a percentage basis, Chicago again had the most significant increase in energy charges, with a difference of $25,800 between the possible energy charges from the two ventilation standards.

Fig. 2 shows the overall dollar charges calculated from the computer-predicted energy and demand for the eight regions studied.

The computer simulations for the eight geographical areas provided seemingly normal expected results. The accuracy in buildings simulations of energy usage is estimated to be 10-20 percent. The accuracy of this research, where the energy differential is calculated between two computer simulations for one variable such as outside air, should be in the 10 percent range.

Psychrometric Description

The computer simulation results were verified by psychrometric analysis.

Fig. 3 is a psychrometric chart showing a summer temperature condition of a central VAV fan system during a summer cooling mode. As shown in Fig. 3, the amount of cooling required to go from point B (the mixed air condition going to the cooling coil) to point C depends on the percentage of outdoor air (point A) mixed with return air (point M). As more outside air is added to the mixed air stream, point B (mixed air) will move further toward point A

Table 2. Summary of Electrical Energy, Demand, and Cost

	Atlanta	Seattle	Phoenix	Los Angeles	Chicago	Denver	Dallas	New York
ASHRAE 90-75 Minimum Outside Air:								
Energy (KWH/YR)	3,637,000	3,489,000	3,676,000	3,456,700	3,776,400	3,785,000	3,680,000	3,663,000
Demand (KW/YR)	11,700	11,200	11,900	11,180	12,200	11,900	11,900	11,800
Cost ($/YR)	338,200	70,900	222,200	302,500	286,200	212,100	206,600	482,200
ASHRAE 62-1981 Maximum Outside Air:								
Energy (KWH/YR)	3,786,000	3,691,000	3,751,000	3,448,200	4,127,300	4,040,000	3,823,000	3,910,000
Demand (KW/YR)	12,400	11,800	12,200	11,240	13,200	12,400	12,700	12,600
Cost ($/YR)	351,700	76,000	226,700	302,300	312,000	223,900	217,400	512,400
COMPARISON:								
Energy (KWH/YR)	149,000	201,400	75,000	−7,500	350,900	25,500	143,000	247,000
Demand (KW/YR)	700	600	300	60	1,000	500	800	800
Cost ($/YR)	13,500	5,100	4,500	−200	25,800	11,700	10,700	30,200

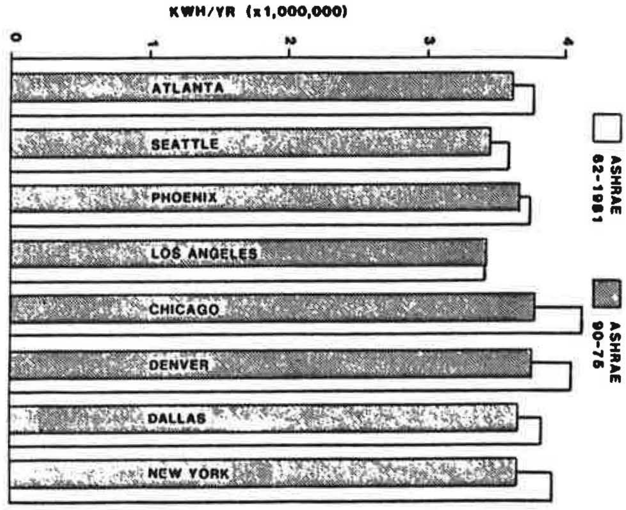

Fig. 1
Total Energy Usage
Comparison

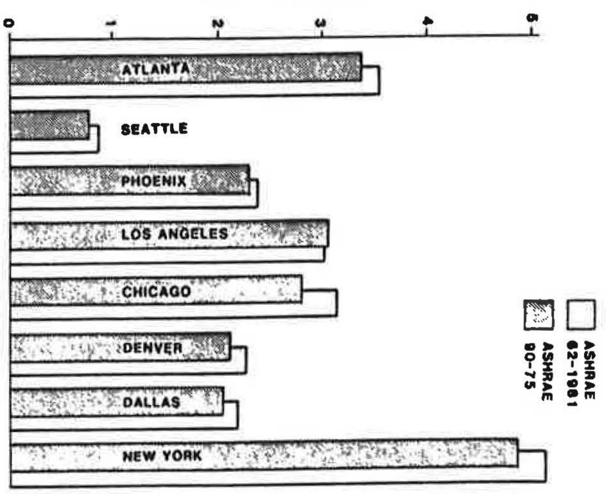

Fig. 2
Energy Cost
Comparison

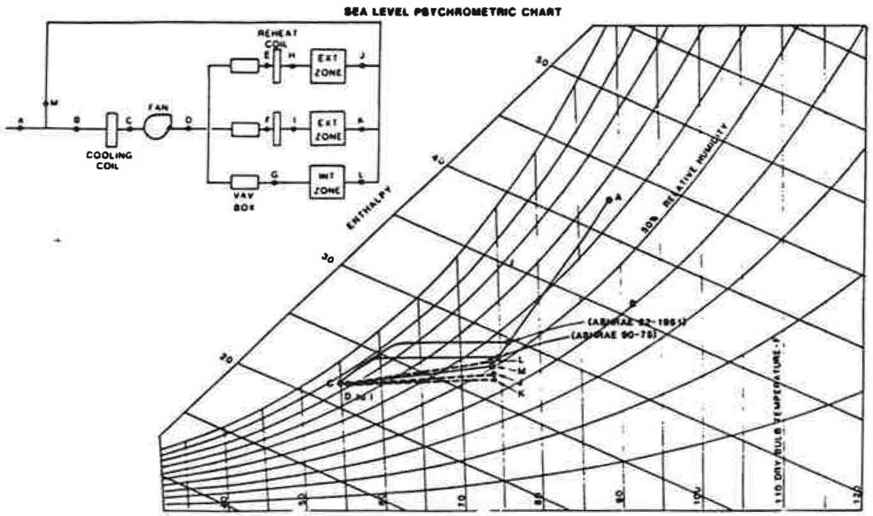

Fig. 3. Summer Conditions

(outside air). This represents a higher percentage of outdoor air to return air.

In this example, the difference in enthalpy (Δh) between the points represented by B will be the increased cooling required for ASHRAE 62-1981. The dashed lines running to points J, K, and L represent the part load sensible heat ratio (SHR) for the individual spaces. The solid line running to point M represents the full load SHR for the combination of all the spaces.

The same psychrometric effects can also be determined for a winter period. In this case, increasing the ventilation rate will help reduce the cooling load on the entire building. Fig. 4 shows the cooling decrease as represented by the enthalpy difference (Δh) between the points represented by B. The overall energy effect will be less than the enthalpy difference; the representative building is served by a heat pump type system, which uses the waste heat from the cooling to heat exterior zones. Therefore, the less energy is used for cooling because of higher winter ventilation rates, the more backup electric heating will be required.

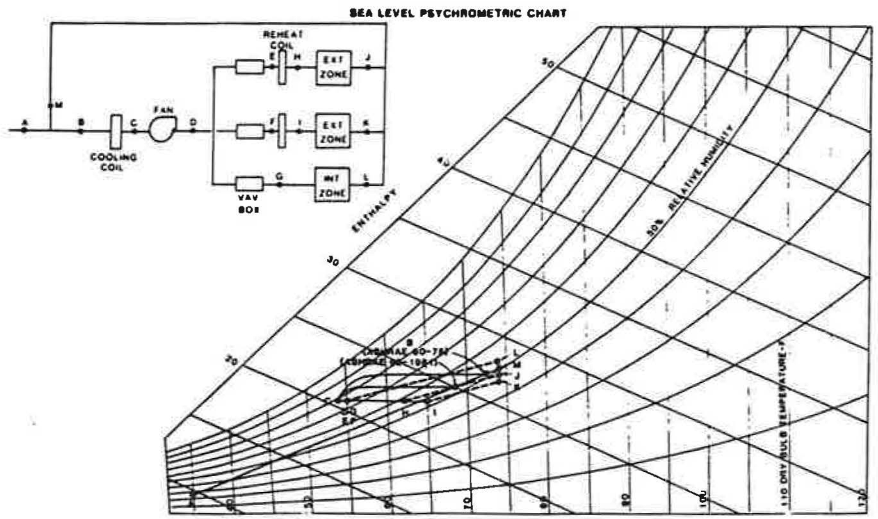

Fig. 4. Winter Conditions

Conclusions

This study involved only one aspect of the ventilation requirements for ASHRAE 62-1981 for only one type of commercial building. The building used to model existing conditions represented an energy efficient mechanical system, which means that energy and dollar figures calculated by computer simulations for the study represent the minimum effects to be expected with ASHRAE 62-1981.

Another important fact which must be considered is that ASHRAE 62-1981 was written to provide alternative methods of having acceptable indoor air quality. When ASHRAE 62-1981 was developed, a balance was struck between conserving energy and providing good health standards for building occupants.

According to computer simulations, ASHRAE 62-1981 could significantly affect energy consumption and costs if the standard is written into local and state building codes. Building owners and managers need to be aware of ASHRAE 62-1981, the requirement as it applies to different types of buildings, and the possible alternatives and approaches which can be taken to meet the ventilation requirement. In new and retrofit mechanical designs, outside air flows, filtering systems, and controls should be considered. Life cycle cost analysis should be done on the various design alternatives to determine the energy and dollar consequences of the ventilation standards.

The overall energy and physiological effects of ASHRAE Standard 62-1981 require significantly more research in order to refine the standard to provide acceptable indoor conditions with a minimum of energy expenditure.

This research was done to obtain some representative figures for the magnitude of effects the new ventilation standard will have on building energy if it is widely accepted and implemented. To determine the best approach to meeting ASHRAE 62-1981, each individual application will need to be analyzed as new and retrofit designs of HVAC are developed.

References

1. *ASHRAE 62-1981, Ventilation for Acceptable Indoor Air Quality;* American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.; Atlanta, Ga., 1981.
2. *ASHRAE 62-73, Standards for Natural and Mechanical Ventilation;* American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.; Atlanta, Ga., 1973.
3. *ASHRAE 90-75, Energy Conservation in New Building Design;* American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.; Atlanta, Ga., 1973, 1975.
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Innovative HVAC System Design Concepts and Challenges to Energy Efficiency

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The primary motivation for conceptual changes in contemporary HVAC design has been the demand of designers, facility managers and building code officials for improved energy efficiency in equipment performance. With provocation from the market, energy building codes and the HVAC system design community, the equipment manufacturers have been responsive and highly competitive. This competition has provided designers with a design arsenal for application to refrigeration, hydronic and air movement systems; controls, which represent the proliferating state-of-the-art in materials; solid state devices, and microcomputer control technology.

Innovations in HVAC systems have been created by the commercial office real estate speculators, realtors, and building management community. The increasing share of the rental dollar for HVAC fuel and power has been a great inducement to the selection of energy efficient equipment, competitively priced, which has minimum mechanical space requirements, and meets the needs of diverse future tenants with unique space/HVAC needs. (See Fig. 1.) In addition, modern cost-effective building systems must be capable of automated central management, off-hour HVAC at acceptable cost, reliable and quickly maintained by modular unit part replacement, and quiet and unobtrusive in the work environment. (See Fig. 2.)

Innovation in Type Specific Facilities

The HVAC designer faces all of these design problems in addition to problems peculiar to the facility type and its operating environment. Each hospital, industrial plant, school house, airport, store, and laboratory facility is unique and complicated by new and sometimes undefined load configurations.