WALK-THROUGH SURVEY REPORT:

CONTROL TECHNOLOGY FOR NEGATIVE PRESSURE ROOMS

AT

Methodist Hospital
Indianapolis, Indiana

REPORT WRITTEN BY:
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Division of Physical Sciences and Engineering
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PLANT SURVEY:	Methodist Hospital 1701 North Senate Boulevard Indianapolis, Indiana 46202
SIC CODE:	8062
SURVEY DATE:	November 19, 1993
SURVEY CONDUCTED BY:	Charles S. Hayden II Ova Johnston
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INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) is the primary Federal organization engaged in occupational safety and health research. Located in the Department of Health and Human Services, it was established by the Occupational Safety and Health Act of 1970. This legislation mandated NIOSH to conduct a number of research and education programs separate from the standard setting and enforcement functions conducted by the Occupational Safety and Health Administration (OSHA) in the Department of Labor. An important area of NIOSH research deals with methods for controlling occupational exposure to potential chemical and physical hazards. The Engineering Control Technology Branch (ECTB) of the Division of Physical Sciences and Engineering has been given the lead within NIOSH to study the engineering aspects of health-hazard prevention and control.

The risk of nosocomial transmission of tuberculosis to health-care workers and patients alike is well documented.[1-6] Among the many commonalities in the case studies cited were that many of the isolation rooms used for acid-fast bacilli (AFB) isolation were not at a negative pressure (NP) to the surrounding areas. The overall purpose of this study is to evaluate effective ways of maintaining NP in AFB isolation rooms, to quantify the parameters associated with NP isolation rooms, and to evaluate the effectiveness of those parameters.

Fluids, which by definition include airflow along a path of least resistance; thus air will travel from a higher pressure to a lower pressure area. The lower pressure area is at a "negative pressure" relative to the higher pressure area. In negative pressure isolation room operation, the difference in the amount of air exhausted from the room and the amount of air supplied to the room sets up a difference in pressure (DP) between the isolation room and surrounding area. This DP should act to prevent the escape of potentially infectious droplet nuclei[7] (which might carry tubercle bacilli) from the isolation room. To achieve and maintain a negative pressure in an isolation room, it is currently recommended that exhaust flow rate be 10 percent greater than supply flow rate but no less than 50 cubic feet per minute (cfm). The actual level of DP achieved will be dependant on the flow area into the room (i.e., under-door opening, cracks, electrical and plumbing pass-throughs etc.). The DP should not, however, be less than 0.001" H_2O.[8]

A variety of factors aside from ventilation flow rates affect the DP. One factor is the airtightness of the isolation room. Variables which effect this factor are opening of room doors/windows, construction joints, cracks, and, to a lesser extent, the degradation of airtight seals over time. When the isolation room door is opened, the level of directional control provided by negative pressure is significantly diminished[9]. Workers (visitors, etc.) passing through the door, will further agitate the air currents at the doorway and create turbulence causing an exchange of air between the isolation room and the area outside of the isolation room door. Variables outside of the isolation room can also effect the DP between the isolation room and surrounding areas. Changes in barometric pressure and wind loads on the building can effect the DP as the pressure in areas surrounding isolation rooms could vary in response to these external forces. Variable air volume

(VAV) systems serving areas surrounding isolation rooms can also have an unpredictable effect on isolation room DP as the system adjusts flow rates to those areas in response to temperature changes.[10]

In November of 1993, a survey was conducted at Methodist Hospital to examine characteristics and parameters associated with isolation rooms and treatment rooms used to house and care for suspected or confirmed infectious tuberculosis (TB) patients. This survey is one part of a larger project, "Evaluation of Ventilation Parameters in Negative Pressure Isolation Rooms," whose objective is to evaluate the parameters necessary to effectively achieve and maintain NP in isolation rooms. The results of this survey will be compiled with the results of other negative pressure isolation room surveys. The compiled results will be used in the experimental design for the larger project. The results of this research will enable HVAC designers and technicians to construct, operate and maintain effective negative pressure rooms with a definitive degree of reliability.

METHODS

Flow rate measurements were obtained using a TSI, Inc. AccuBalance™ Model 8370 flow measuring hood. Using this instrument, airflow from an exhaust grill or supply diffuser can be read directly in cfm. The number of air changes per hour (ACH) were then calculated from Equation 1.

$$ACH = Q*60/V \quad (1)$$

Where: ACH = Air Changes per hour
Q = Exhaust Flow Rate (cfm)
V = Volume of Room Including Bathroom (ft^3)

The exhaust flow rate (ducted directly to the outside) was used in the ACH calculations since it was the predominate flow in the negative pressure room. Make up air to the room was provided through open areas under and around the doors and the ventilation supply. Pressure differentials between areas were measured using an Air Neotronics Model MP20SR digital micrometer. These pressure differentials were visually verified using Sensidyne® smoke tubes.

RESULTS AND DISCUSSION

Data from the survey is shown in Table I. Four isolation areas were surveyed. It wasn't ascertained how many isolation areas were available in this hospital. Concerns for patient privacy prevented the survey team from examining a number of rooms.

Each of the isolation rooms examined was supplied conditioned air from a diffuser located above the door to the anteroom. Exhaust was provided at floor level near the bed through a grill. Each restroom was exhausted through a grill located in the ceiling. The isolation rooms had the capability of being either positive or negative pressure rooms. A key switch located outside of the room was positioned to control the exhaust and supply flow

TABLE I. Ventilation data collected at Methodist Hospital in Indianapolis, Indiana on November 19, 1993.

Negative Pressure Room/Treatment Area Survey						
Room Number		Supply (cfm)	Exhaust (cfm)	Room Volume (ft^3)[a]	Air Changes Per Hour (ACH)	Differential Pressure (H_2O)
A3040	isolation	205	205	1581	10.3	
	bathroom		66			
	anteroom	45	85	340	15.0	+0.07, -0.04[b]
A3089	isolation	245	245	1581	11.5	
	bathroom		57			
	anteroom	100	72	340	12.7	+0.001, -0.003[b]
A3090	isolation	161	176	1581	8.5	
	bathroom		48			
	anteroom	60	86	340	15.2	+0.04, -0.03[b]
A4040	isolation	139	175	1581	9.5	
	bathroom		75			
	anteroom	39	75	340	13.2	+0.012, -0.005[b]

[a] - Includes isolation room and bathroom volume.
[b] - First number indicates anteroom to isolation room pressure relationship, the second number indicates anteroom to corridor pressure relationship.

rates to and from the isolation room and anteroom. Electro-pnuematic (EP) switches sensed temperature and airflow direction into or out of the isolation room. The EP's feedback a pnuematic signal to the exhaust damper controller, supply VAV box and reheat coils valve in the VAV box. The VAV box is controlled by the velocity sensors (direction into or out of the room). The VAV box acts to maintain either positive (airflow out of the isolation room) or negative (airflow into the isolation room) pressure by varying the volume of air supplied to the isolation room. The thermostat in the room controls the exhaust damper and the VAV reheat coils inlet valve via an EP switch. This acts to maintain a specified temperature in the room.

Three items of interest in this survey included:

(1) Floor sweeps used on the isolation to anteroom doors and anteroom to corridor doors.
(2) The two isolation rooms examined in the maternity unit were carpeted.
(3) Televisions in the rooms were located in wall recesses. The recesses were sealed from the room area behind plexiglass. Dedicated exhaust, for heat removal from the recesses was provided.

CONCLUSIONS

Four of four rooms examined had a minimum of 0.001" H_2O negative pressure to surrounding areas. All rooms provided at least six ACH. The exhaust from all rooms went directly to the outdoors.

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