WALK-THROUGH SURVEY REPORT:

CONTROL TECHNOLOGY FOR NEGATIVE PRESSURE ROOMS

AT

Veterans Administration Hospital
Indianapolis, Indiana

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SIC CODE:	8062
SURVEY DATE:	November 15, 1993
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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.). It 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 Veterans Administration 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 the survey will be compiled with results from other hospital 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. Since the ventilation supply was 100 percent outside air (OA), the supply measurements were used to calculate the OA ACH. Pressure differentials between areas were measured using an Air Neotronics Model MP20SR digital micrometer. These pressure differentials were visually verified using Sensidyne® smoke tubes.

HOSPITAL DESCRIPTION

The Veterans Administration Hospital is a 400-bed facility, first constructed in the 1950s with numerous renovations and upgrades since that time. Of interest in this study were seven areas used to house or treat TB patients.

RESULTS AND DISCUSSION

Data from the survey is shown in Table I. Five negative pressure isolation rooms and two negative pressure treatment rooms were examined. The patient isolation rooms were all single-patient rooms. Both treatment rooms were used for pulmonary techniques such as bronchoscopy. All areas examined used

TABLE I. Ventilation data collected at Veterans Administration Hospital in Indianapolis, Indiana on November 15, 1993.

Negative Pressure Room/Treatment Area Survey						Air Changes Per Hour (ACH)	Outside ACH	Differential Pressure (H_2O)
Room Number		Supply (cfm)	Exhaust (cfm)	Outside Air Supply (cfm)	Room Volume (ft^3)[a]			
B503	isolation	42	150	42	1209	7.4	2.1	-0.006[b]
	bathroom							
B504	isolation	38	153	38	1162	7.9	2.0	-0.008
	bathroom							
B513	isolation	34	122	34	1070	6.8	1.9	-0.008
	bathroom							
B514	isolation	40	130	40	1220	6.4	2.0	-0.008
	bathroom							
A609	isolation	221	235	221	2625	9.6	5.1	-0.004
	bathroom		183					0.024[c]
A610	isolation	240	245	240	2310	6.4	6.2	-0.002
A677	isolation	165	167	165	1473	12.9	6.7	-0.002
	bathroom		150					0.020
	anteroom	40						+0.004, -0.001[d]

[a] - Includes isolation room and bathroom volume (except Room A610).
[b] - Indicates isolation room to corridor pressure relationship (negative number implies air moves from the corridor into the isolation room).
[c] - Indicates isolation room to bathroom pressure relationship (positive number implies air moves from the isolation room into the bathroom).
[d] - First number indicates anteroom to isolation room pressure relationship, the second number indicates anteroom to corridor pressure relationship.

ultraviolet germicidal irradiation (UVGI) lamps. The UVGI lamps were mounted on the wall near the ceiling in two locations within each room (three locations in Room A609) and relied on air currents induced by the ventilation system within the room to direct the air through the lamp. One hundred percent OA was supplied to each room. The exhaust from the rooms went directly outside. The flow rates measured provided greater than six total ACH and greater than two OA ACH in all cases. The majority of the make-up air to the rooms comes from under and around the door.

The rooms on the B5 level all had fan coil units. These units were in-room recirculation units and were used for conditioning the room air only. They were mounted directly over the room-to-corridor door. The air was pulled into the units from the bottom in a vertical direction, conditioned, and then supplied horizontally at ceiling level. Supply air was provided from a 6" x 6" grill mounted on the wall near the room-to-corridor door. Air was exhausted directly to the outside through a 2' x 2' diffuser mounted on the ceiling over the patient's bed. Each room had a bathroom. The bathrooms had no exhaust because the exhaust grills had been blocked off during a recent renovation. Also, during the renovation the old supply diffusers in the room were connected to the new exhaust system and the old exhaust grills were connected to the new supply system. In Rooms B503, B504, B513, and B514, the ventilation systems were configured to provide some level of in-room directional control. With the supply grill located near the doorway to the corridor and exhaust diffuser located near the patient, there is potential to move the air in the room from a clean to a less-clean area; the less-clean area being a sneezing and coughing infectious TB patient.

Rooms A609 and A610 were provided supply air through two 2' x 2' diffusers located centrally on the ceiling of the room. Each room had a 2' x 2' exhaust grill located directly over the door. Room A609 also had a bathroom/cleaning room located adjacent to it which had a 2' x 2' exhaust grill.

Room A677 was located in the medical intensive care unit (MICU). The room had a sliding breakaway glass door along one wall and two doorways along another wall, one to the bathroom and the other to the anteroom. The anteroom and isolation room were each provided supply air through individual 2' x 2' plenums. Air was exhausted from the isolation room from a 18" x 18" plenum located on the wall at floor level near the bathroom door. Exhaust was also provided by a 4" x 4" plenum located in the ceiling of the bathroom. The isolation room exhaust was dedicated to an exhaust fan which was controlled by a switch in the nurses station next to the room. With the switch in the off position, the room had only bathroom exhaust and functioned as a positive pressure room. With the switch on, the room was at a negative pressure to the corridor (breakaway door) and anteroom. The anteroom was negative to the corridor with the isolation room exhaust fan on.

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