WALK-THROUGH SURVEY REPORT:

CONTROL TECHNOLOGY FOR NEGATIVE PRESSURE ROOMS

AT

Wishard Memorial Hospital
Indianapolis, Indiana

REPORT WRITTEN BY:
Charles S. Hayden II

REPORT DATE:
July 15, 1994

REPORT NO:
ECTB 212-14a

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health
Division of Physical Sciences and Engineering
Engineering Control Technology Branch
4676 Columbia Parkway, Mailstop R-5
Cincinnati, Ohio 45226

PLANT SURVEY:	Wishard Memorial Hospital 1001 W. 10th Street Indianapolis, Indiana 46202
SIC CODE:	8062
SURVEY DATE:	November 18, 1993
SURVEY CONDUCTED BY:	Charles S. Hayden II Ova Johnston
EMPLOYER REPRESENTATIVE CONTACTED:	Stephen Bisch, Director, Facilities Engineering Services
EMPLOYEE REPRESENTATIVE CONTACTED:	No Union
MANUSCRIPT PREPARED BY:	Deanna L. Elfers Bernice L. Clark

DISCLAIMER

Mention of company names or products does not constitute endorsement by the Centers for Disease Control and Prevention (CDC).

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 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 Wishard Memorial 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 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.

RESULTS AND DISCUSSION

Data from the survey is shown in Table I. Three nursery isolation rooms (B354, B355, B356) and ten general isolation rooms (B424-6-7-8-9-30-1-2-3-4) were surveyed. Ventilation parameters were also collected from a pentamidine treatment area (Room #635).

Air was exhausted at constant volume from the general isolation rooms through 16" x 10" grills located on the walls, near floor level, and 6" x 6" grills mounted in the ceiling of the bathrooms. Each exhaust grill was provided with

TABLE I. Ventilation data collected at Wishard Memorial Hospital in Indianapolis, Indiana on November 18, 1993.

Negative Pressure Room/Treatment Area Survey						
Room Number		Supply (cfm)	Exhaust (cfm)	Room Volume (ft^3)	Air Changes Per Hour (ACH)	Differential Pressure (H_2O)[a]
B354	isolation	435	550	1032	32.0	-0.007
B355	isolation	95	365	1032	21.2	-0.04
B356	isolation	300	470	1032	27.3	-0.029
B424	isolation	285	285	1772	9.7	-0.002
	bathroom		40	174	13.8	
B426	isolation	280	325	1772	11.0	-0.002
	bathroom		44	174	15.2	
B427	isolation	260	265	1772	9.0	-0.002
	bathroom		37	174	12.8	
B428	isolation	215	250	1772	8.5	-0.005
	bathroom		44	174	15.2	
B429	isolation	260	285	1772	11.0	-0.015
	bathroom		24	174	8.3	
B430	isolation	230	250	1772	8.5	-0.001
	bathroom		inaccess	174		
B431	isolation	235	235	1772	8.0	-0.003
	bathroom		47	174	16.2	
B432	isolation	205	240	1772	8.1	-0.005
	bathroom		45		15.5	
B433	isolation	245	250	2046	7.3	-0.007
	bathroom		48	174	16.6	
B434	isolation	193	190	1772	6.4	-0.004
	bathroom		79	174	27.2	
635	treatment rm.	195	1020	1748	35.0	-0.017
	closet		31			

[a] - Indicates isolation room to corridor pressure relationship (negitive numbers implies air moves from the corridor into the isolation room).

medium efficiency fibrous filters (cut to fit, inside of each grill, from a roll). One hundred percent outside air was supplied at a constant volume to each room through 36" x 12" diffusers mounted on the wall near ceiling height. The exhaust from the isolation room and bathroom were ducted through a Heatex, Inc. air to air heat exchanger. Incoming supply air was passed through a 30 percent efficiency filter and then through the air to air heat exchanger where it was partially conditioned. The supply air then passes over steam/chilled water coils, passes through a 80 percent filter, then is distributed to the isolation rooms.

The pentamidine treatment area consisted of a three sided booth within a large room. The booth was furnished with a cushioned chair for the patient being administered the aerosolized treatment. Exhaust was provided for the booth from a hood which enclosed the entire top of the booth. Smoke tube examination of air flow patterns within the room, showed that all areas moved towards the booth.

The nursery isolation rooms were provided 100 percent OA, conditioned and filtered, through 72" x 3.5" slots. The slots were located in a wall, near the ceiling of the room. Exhaust from the rooms was provided by 10" x 10" grills on the wall near floor level.

CONCLUSIONS

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

REFERENCES

1. Pearson ML, Jereb JA, Freiden TR, Crawford JT, Davis BJ, Dooley SW, Jarvis WR [1992]. Nosocomial transmission of multidrug-resistant mycobacterium tuberculosis. Ann Int Med *117*:191-196.

2. Beck-Sague C, Dooley SW, Hutton MD, Otten J, Breeden A, Crawford JT, Pitchenik AE, Woodley C, Cauthen G [1992]. Hospital outbreak of multidrug-resistant mycobacterium infections. JAMA *268*:1280-1286.

3. Dooley SW, Villarino ME, Lawrence M, Salinas L, Amil S, Rullan JV, Jarvis R, Bloch AB, Cauthen GM [1992]. Nosocomial transmission of tuberculosis in a hospital unit for HIV-infected patients. JAMA *267*:2632-2635.

4. Edlin BR, Tokars JI, Greico MH, Crawford JT, Williams J, Sordillo EM, Ong KR, Kilburn JO, Dooley SW, Castro KG, Jarvis WR, Holmberg SD [1992]. An outbreak of multidrug-resistant tuberculosis among hospitalized patients with the acquired immunodeficiency syndrome. N Engl J Med *326*:1514-1521.

5. Haley CE, McDonald RC, Rossi L, Jones WD, Haley RW, Luby JP [1989]. Tuberculosis epidemic among hospital personnel. Inf Ctrl Hosp Epidemiol *10*(5):204-210.

6. CDC (Center for Disease Control) [1991]. Nosocomial transmission of multidrug-resistant tuberculosis among HIV-infected persons - Florida and New York, 1988-1991. MMWR *40*(34):585-591.

7. Nardell, EA [1990]. Dodging droplet nuclei. Am Rev Respir Dis *142*:501-503.

8. 58 Fed Reg 52810 [1993]. Draft guidelines for preventing the transmission of tuberculosis in health-care facilities. 2nd Ed. Notice of Comment Period. Centers for Disease Control and Prevention.

9. Yu X [1991]. Velocity and turbulence characteristics of some typical crossdrafts. Master of Science Thesis, University of Illinois at Chicago.

10. American Society of Heating, Refrigeration and Air Conditioning Engineers' Handbook [1991]. 1991 HVAC Applications. Health Facilities.