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CONTROL ROOM INFILTRATION - FIELD TRIP TO THREE MILE ISLAND, 6/12/73

To better acquaint ourselves with the problems involved in measuring infiltration rate of an isolated control room, Dr. C. M. Hunt (NBS) and I toured the Three Mile Island Control Building, and entered into discussions with the following individuals from Gilbert Associates, Inc.:

P. J. Shipper (Electrical)
J. A. Hoke (HVAC)
W. A. Brannen (Fire Protection)

Our discussions were generic in nature. We were interested in learning the practical difficulties associated with conducting infiltration tests and the possible analytical problems associated with reducing the data. Enclosure 1 provides a summary of the items identified as a result of the trip.

Enclosure II is included for those interested in a description of the tracer technique that will be used to determine infiltration. This enclosure also discusses several possible uses of the technique in nuclear safety work. The technique is very sensitive and works on different principles than those used for conventional leak rate measurements. For these reasons the technique may be useful when special leak measurement problems are confronted. Leak rates of containment components or air exchange rates between zones within a containment building might be determined by the tracer method.

/S/

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Enclosure:
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Enclosure I

Three Mile Island Field Trip Summary
6/12/73

The following items were identified as a result of the Three Mile Island trip and meeting:

1. Scheduling of tests will require careful planning. It appears that the best time to conduct a test would be several months before fueling. At this time the control room ventilation system should be installed, balanced, and tested, the doors in place, and most of the penetrations sealed. Also there will be little evening or night work going on so we will not get in the way of the plant personnel (and vice versa). Approval from the A/E, contractor, and/or utility will be required. It would be best to meet with the responsible parties well in advance to assure that the control room will be ready for the test and that the necessary personnel will be on hand.

2. Assistance from the utility will be required to place the control room ventilation equipment into the proper mode for testing. It may be necessary to jumper controls to obtain the appropriate test configuration.

3. Charcoal filters will have to be completely isolated. This will eliminate tracer adsorption on the charcoal, a necessary precaution if accurate measurements are to be taken. In many cases filter isolation will require the temporary sealing off of the filters with plastic and tape (the dampers may be too leaky).

4. Wind speed, wind direction, inside and outside temperatures, and barometric pressure data must be obtained while the test is being conducted. The utility will be asked to supply as much of this data as possible.

5. The tracer, Sulfur hexafluoride (SF_6), is chemically inactive except at high temperatures such as found in electrical heating elements. It is harmless and very little is needed (parts per billion can be detected). At high temperatures it can decompose to produce harmful chemical products. However, since very little will be used noxious levels would not be approached. A check will be made to assure that heated surfaces are not present (e.g. heating coils will be shut off). Because of the small amount used, no adverse effects on humans or equipment is expected. Mice have been exposed for 24 hours to SF_6/oxygen

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mixtures containing nearly 80% SF_6 without apparent adverse effects.

6. The following factors must be recognized when planning infiltration tests or interpreting test results (most of the factors tend to make infiltration appear worse than actual):

   a. Tracer adsorption onto building surfaces - measurable adsorption does not take place on metals and rubbers. Concrete might adsorb but there are no test data. Water will adsorb tracer and therefore exposures to water will be minimized, e.g., humidifiers will be cut off.

   b. Dead Air Zones - The spaces above false ceilings and spaces not directly associated with the ventilation system will constitute zones of slow air exchange. They will slowly accumulate or discharge tracer. This may throw off the results. If a significant percentage of the control room volume is dead air space possible steps to be taken are:

      1. completely seal these spaces off
      2. open them up, or
      3. measure the tracer concentrations within these spaces and analytically adjust the results

   c. SF_6 is used as an arc arrester in high voltage/high current switches that are commonly installed in switch yards. Leakage of SF_6 from these devices might provide a high background concentration, and thus should be determined in advance.

7. Ventilation units supplying air to (or exhausting air from) zones adjacent to the control room may affect the infiltration rate of the control room. This possibility should be investigated and if found to be potentially significant then the test should be conducted with these systems in their "post accident mode of operation." The effect of loss of off-site power on the operation of these systems should be taken into consideration.

8. One plant selection criterion will be the total volume of the zone serviced by the emergency ventilation system. These zones can vary from 50,000 cf for a small control room to 700,000 cf for an entire control building. We would want to select several sizes to bound this variable.

Enclosure II

SF_6 Measuring Equipment and Some Possible Applications

1. SF_6 is a strongly electron-capturing gas. It is conveniently measured with an electron capture detector in the parts per billion range. Oxygen in air is also an electron-capturing gas, so the instrument used in these measurements includes a gas chromatographic column which separates oxygen from SF_6. Small samples of air are taken by means of a dosing valve, and the SF_6 concentration appears as a chromatographic peak. A standardizing mixture of SF_6 in air is also used to correct for any drift in the response of the detector.

2. Applications of SF_6 tracer technique:

   a. Determination of Air Infiltration Rates

   SF_6 has been used as a tracer for measuring air leakage in buildings. The principle of the method is that tracer gas is mixed as intimately as possible with air in the building and as the building exchanges air with its surroundings the concentration of tracer decreases. This is usually represented as a first order process. That is:

$$\frac{dC}{dt} = -kC \qquad (1)$$

   where C is the concentration of tracer, t is the elapsed time. It can be shown that k is the air exchange rate. This form of the equation assumes that tracer is absent from the incoming air. Equation 1 can be reduced to:

$$\log_e \frac{C}{C_o} = -kt \qquad (2)$$

   where C_o is the starting concentration. This is a convenient form of the equation from which to obtain k.

   b. Measurements of Flow Rates

   Under conditions where good mixing can be obtained, SF_6 measurements can be used to measure flow rates through fans or other flow devices. The principle of the method can be derived from the relationship:

$$C_1 V_1 = C_2 V_2$$

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$$\text{or} \quad V_1 = \frac{C_2}{C_1} V_2$$

where C_1 is the concentration of tracer coming from the test device, C_2 is the concentration fed upstream into the device, V_1 is the volume flow rate of gas downstream from the test device, and V_2 is the volume rate at which tracer is fed into the system. In case the air is recirculated C_1 must be corrected for the concentration in the air returning to the test device. The method is somewhat developmental, and can only be applied when there is no tracer laden air returning to the system or where the concentration of tracer in the return air can be measured. At present it is applied to high rates of flow, 1000-2000 cfm or greater.

c. <u>Determination of Air Exchange or Leakage Between Enclosed Volumes</u>

It is possible that the technique can be used to determine the leak rate or air exchange rate between two enclosed zones of known volume. As an example a penetration seal system can be tested for leakage by placing tracer of a known concentration on the pressurized side and detecting the buildup of concentration within a known volume on the unpressurized side. Similarly air exchange between two zones within enclosed building can be determined by dosing one zone with tracer and following the subsequent build-up and decay of the concentrations within the zones of interest.

C. M. Hunt

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