State of Connecticut Building at 25 Sigourney Street, Hartford
Results of Tracer Release Testing on November 11, 2005

Project S0588 - November 17, 2005

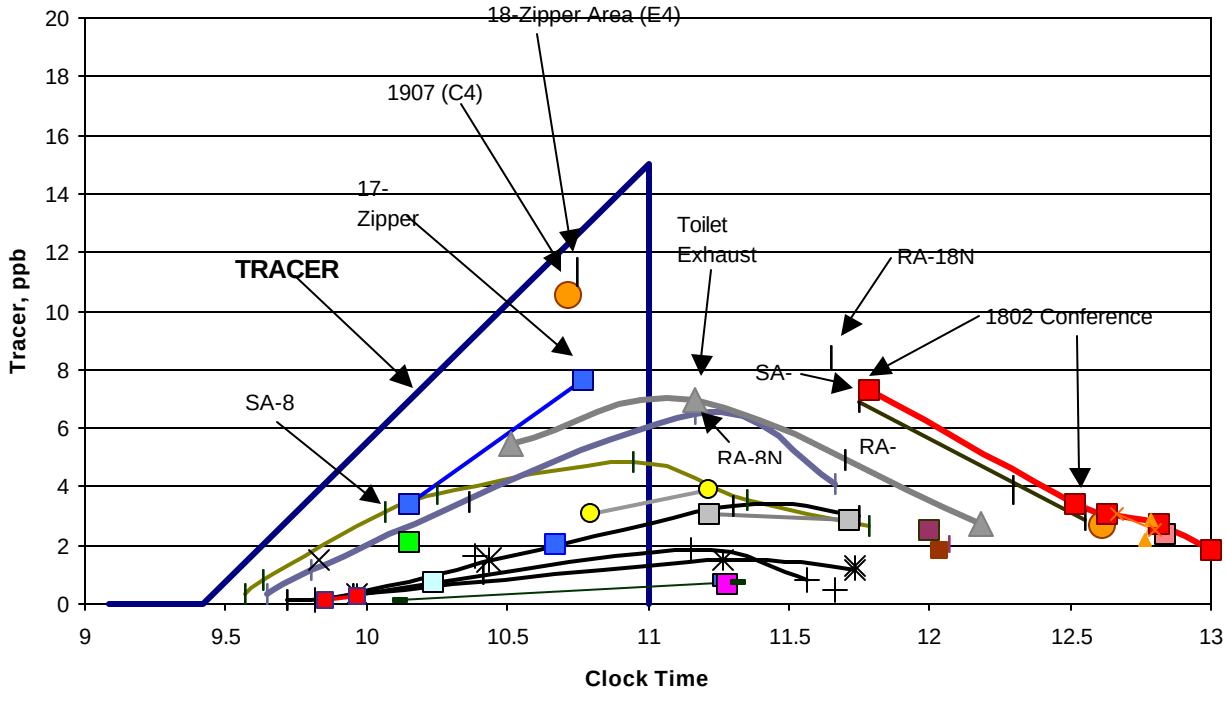
1.0 Introduction

In response to concerns that the release of air contaminants from high volume printing activities in this building were resulting in exposures to the occupants, a series of three tracer release tests were performed on Friday, November 11, 2005. This document summarizes the results of this testing effort. In this test procedure, after first documenting that there was no measurable tracer in the test location in the building, a controlled release of tracer was initiated in one of the high volume printing areas. This release was then following by sampling and analysis of air from around the building to assess whether the test location was receiving air from the release locations.
The three locations were: (1) the Print Shop on Floor 8, (2) the Computer Room (raised floor) on Floor 9, and (3) the Computer Room on Floor 16. The results from each tracer release test indicate how the area with potential air contaminants communicates with other areas of the building.

2.0 **Results from the Tracer Release in the Print Shop on Floor 8.**

The results from this tracer release test are presented in Figure 1.

Figure 1: Tracer Release in Print Shop on Floor 8



Results: In this tracer release test, the tracer release began shortly before 9:30 am and continued until 11:00 am. As can be observed in Figure 1, the tracer quickly began to be detected in the Supply Air (SA) delivered to the eighth floor. The areas where the tracer showed up, however, were not limited

to just this floor, with tracer being detected on the 17th, 18th, and 19th floors in concentrations exceeding that of those measured on the 8th floor. Shortly after 11:00 am, the time when the tracer release was stopped, the measured tracer concentrations in the building began to decrease.

The first locations checked in the first tracer test were the Return Air (RA) values in both of the Mechanical Rooms (MR) on the eighth floor, and the supply air (SA) on that floor of initial release as well. Once tracer was detected at these locations, other locations were sampled as well.

Of the two RA air streams sampled on the eighth floor, the tracer concentrations measured in the RA into the North MR exceeded the tracer values measured in the RA into the South MR. Specifically, the tracer concentration at this location increased slowly up to 6.46 ppb at 11:10. This tracer concentration value, however, was less than the tracer concentration value obtained at several other locations in the building. Prior to the measurement of this 6.46 ppb value, the tracer concentration had exceeded this value and reached 7.65 ppb on the 17th floor, 10.54 ppb on the 19th floor, and 11.305 ppb on the 18th floor.

It was therefore concluded, based on these results, where the anticipated peak values were NOT in the MR on the floor where the tracer was released, that there must be an alternative pathway for this dispersal of tracer and any air contaminants released above the suspended ceiling that did not involve these mechanical rooms.

These two components of tracer concentration behavior, the rapid presence of tracer in many areas of the building and a uniform rapid decrease after the release was stopped, indicate that the internal pathway of air movement between the release location and the measurement locations is fairly direct. The longer it takes for the measured tracer to decrease after the release is terminated, the more indirect the pathway and the larger the void space that the tracer has to move through.

In addition to the location indicated on the graph of the measured tracer results, many locations in the graph's legend indicate a letter and number notation. This letter and number notation corresponds to a grid superimposed on each floor designating the area bounded by four columns as a specific grid area. The eight letters used, A through H, begin at the north and proceed to the south. The numbers used, 1 through 8, begin at the west and proceed to the east. The frequently appearing notation of E4 is for the central portion of "Zipper" area of the building.

The tracer release rate over the hour and a half release interval was 48 cubic centimeters per minute. The tracer used, sulfur hexafluoride, is an inert chemical and the amount released to achieve measurement of less than 50 parts per billion (ppb) is orders of magnitude below the occupational exposure limit of 1,000 parts per million (ppm). This is equivalent to a permissible exposure limit of 1,000,000 parts per billion (ppb).

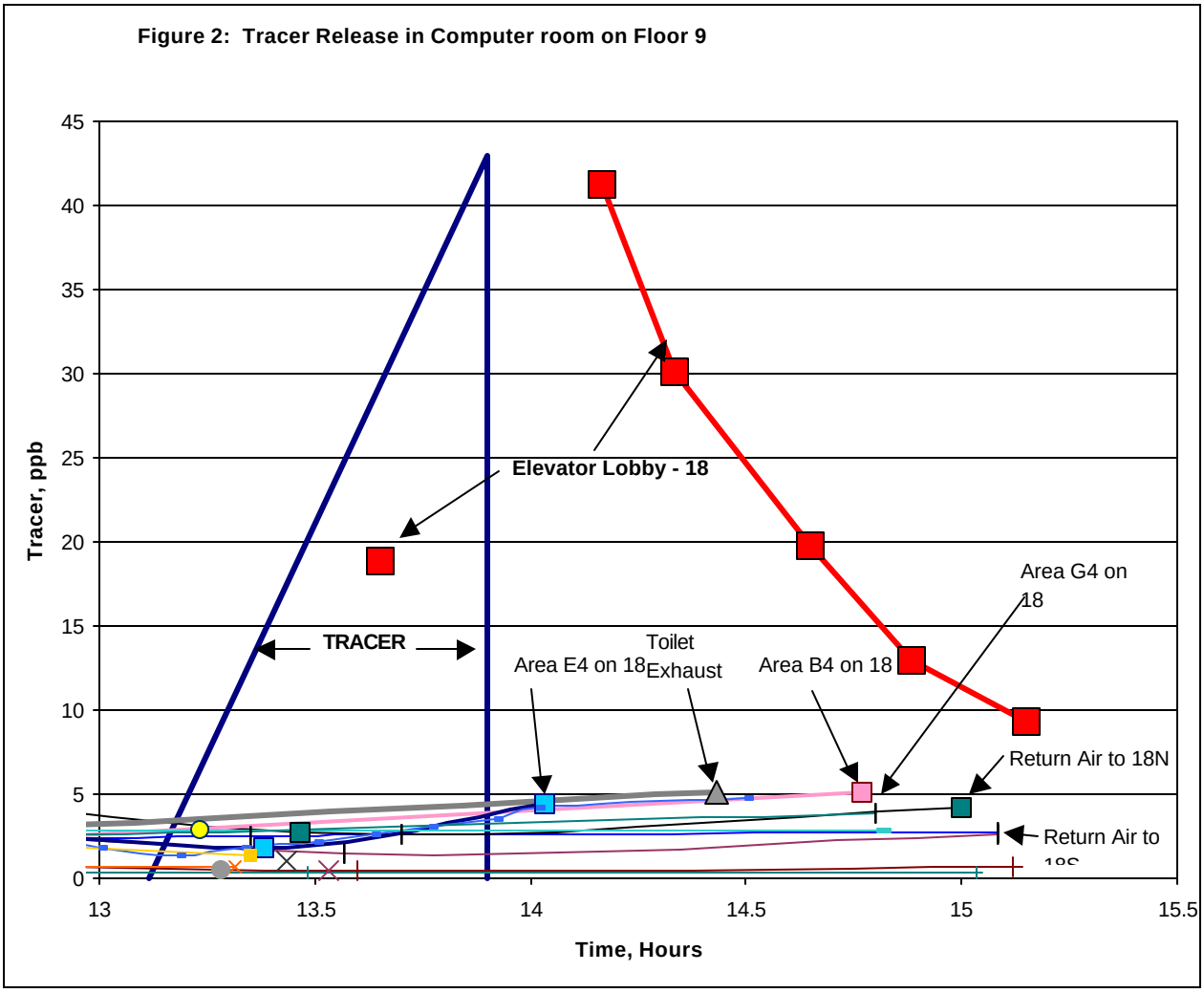
Conclusion: This initial tracer release test therefore documented that air contaminants released to above the ceiling plenum of the 8th floor Print Shop would be redistributed throughout the building, especially to the upper floors.

3.0 **Results from the Tracer Release in the Computer Room on Floor 9**.

Because the area of the building displaying the highest tracer concentrations in the first test was the 18th floor, the tracer measurement equipment was relocated from the 8th floor up to the 18th floor. Here the tracer release location was above the suspended ceiling in the raised floor Computer Room on the 9th floor. The results from this second tracer release test of the day are presented in Figure 2.

Results: In this tracer release test, the measured tracer concentration in the measured non-release areas of the building increased most rapidly in the elevator lobby on the 18th floor. From this location it was observed to spread slowly to the other measured locations in the building.

Figure 2: Tracer Release in Computer room on Floor 9



One possible explanation for the very rapid appearance of high tracer concentrations being measured in the elevator lobby of the 18th floor is that there is a direct pathway between the ceiling plenum above the 9th floor Computer Room and the northwest elevator shaft. On the 9th floor this E3 location

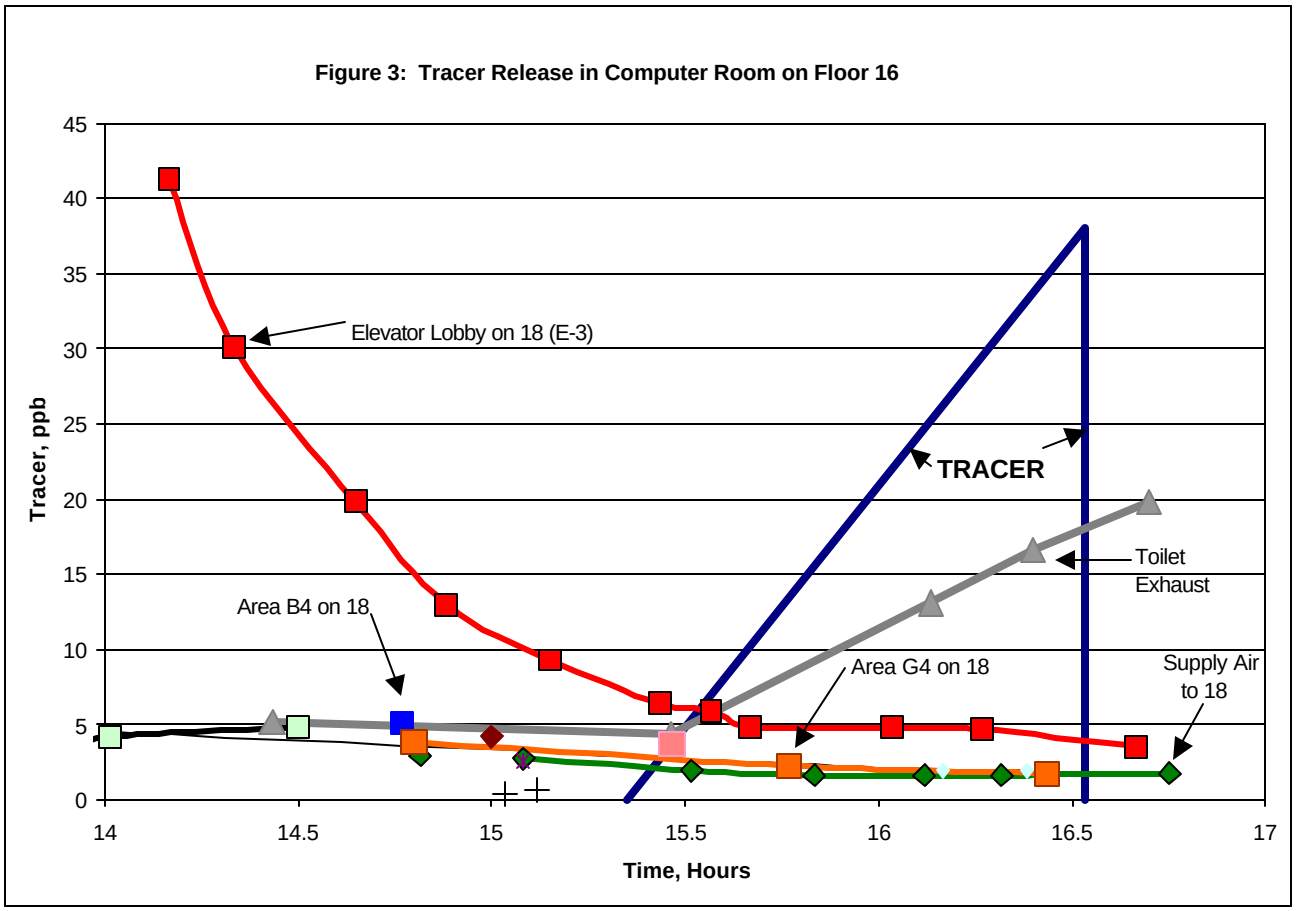
houses a "Smart Room" that backs up to the Computer Room where the tracer was released. Access to the "Smart Room" was not achieved during the day of testing so the possibility of penetrations through the wall could not be visually assessed. The tracer release rate for this second test was increased by 20% from 48 cc/minute up to 58 cc/minute. The duration of the release interval was basically halved, going from over 90 minutes for Test 1, to only 47 minutes for Test 2. Not only does the elevator shaft provide a pathway of air movement through the building, the operation of the elevator car becomes a piston to both suck air into the elevator shaft and push it into adjacent areas.

Also, small amounts of tracer were measured in the outdoor air coming back into the building indicating that some reentrainment was occurring. This external pathway, however, was much smaller than the internal pathway involving the elevator shaft. As it became windier as the afternoon progresses into the evening, the amount of reentrainment of building exhaust captured by the outdoor intake became less and less. The concern therefore exists that under calmer meteorological conditions, the amount of building exhaust reentraining into the outdoor air intake could increase.

4.0 **Results from the Tracer Release in the Computer Room on Floor 16**.

The results from this third tracer release test on November 11th are presented in Figure 3.

Figure 3: Tracer Release in Computer Room on Floor 16



Results: The results from this third tracer release test vary significantly from the other two locations tested. In this third test the isolation of the air space above the ceiling plenum of the Computer Room on the 16th floor is much greater than for the Print Room on the 8th floor or the Computer Room on the 9th floor. One significant physical difference is that both of the ceiling plenums that have pathways that connect to the rest of the building are contiguous with the westerly elevator shaft.

Two results stand out from a review of the tracer measurement data from the third tracer release test. For the previously elevated tracer concentration measured in the elevator lobby on the 18th floor, it continued to decrease even after this tracer release had begun. An equilibrium was then observed, most probably where the tracer outflow was equal to the tracer inflow for several areas being tested.

The one location where the tracer concentration clearly was increasing was for the Building Exhaust fan on the roof by the cooling tower. This increase is consistent with the desired condition of having the 16th floor Computer Room not only physically isolated from the rest of the interior spaces in the building, but also in effective communication with the building exhaust system.

5.0 Ventilation Rate Determination

Another piece of information that can be determined from tracer testing is a value for the ventilation rate. After a release has been terminated and if the tracer is well mixed within the building, the slope of the change in tracer concentration over time yields a value for the ventilation rate at that time in air changes per hour (ACH).

During the interval from 11:10 to 12:35 four sampled locations yielded similar tracer values and so these values were used to calculate a building ventilation rate. The specific locations and local ventilation rates are presented in Table 1.

Table 1. Calculation of Building Ventilation Rate in ACH.

Sampling Location	Tracer ppb	at Time 1	Tracer ppb	at Time 2	Slope ACH
Toilet Exhaust	6.97	11.167	2.72	12.181	0.93
1802 Conference	7.31	11.783	3.4	12.517	1.04
S.A. - 18	6.885	11.75	2.89	12.55	1.09
R.A. - 8N	6.46	11.167	4.08	11.667	0.92
Average					0.99

Averaging the ventilation rates calculated for these four locations in the building, an overall ventilation rate of 1.0 air change per hour was determined for the building.

6.0 **Conclusions and Recommendations**

Since it has been documented by the performance of tracer testing, the air from above the ceiling plenums above the Printing Room on the 8th floor and the Computer and Printing Room on the 9th floor, these activities should be clearly isolated from the return air and exhausted out of the building, or alternatively relocated out of this building as quickly as practical. It can be difficult to isolate areas in buildings as a retrofit project and the current activities lead to exposures within the building that could be acting as sensitizers or actually directly contributing to some of the health symptoms reported in this building.

The contributing factors in this situation are the high percentage of the respondents to the interview questionnaire that indicated that conditions in the building were too dry throughout the year. This reported condition goes against many of the humidity measurements taken that documented that the delivery of sufficient quantities of outdoor air to each floor resulted in elevated humidity levels in the building when the outdoor conditions were also humid. One explanation for this discrepancy is that people experiencing irritation of their eyes report this condition as conditions being too dry.

What this reported condition might suggest is that there are exposures in the building to both chemicals that are irritating to mucous membranes in combination with particulate matter. In this regard, the particle count measurements collected document the existence of particulate sources (reservoirs) in the building that are released into the air by agitation such as from vacuuming, people walking on the carpet, or the shuffling of paper.

While it would require a major (likely impractical) redesign of the functioning of the DRS to not involve the handling of paper, two steps that could or should be accomplished is the either the isolation and exhaust of emissions from the processes, or the removal of the process from this building as the very heavy printing/copying activities introduce avoidable air contaminants throughout the building.