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Methamphetamine Contamination on Environmental Surfaces Caused by Simulated Smoking of Methamphetamine

By

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Introduction:

Previous studies conducted by National Jewish Medical and Research Center have indicated that methamphetamine is a major contaminant associated with clandestine methamphetamine laboratories. A single cook using the red phosphorous method of manufacture may produce residual surface contamination of methamphetamine ranging from 1.5 ug/100 cm^2 to as high as 860 ug/100 cm^2. A single cook using the anhydrous ammonia method of production may result in surface area contamination ranging from 0.1 ug/100 cm^2 to 160 ug/100 cm^2. These contamination levels are caused by the aerosolization of methamphetamine during the cook with the highest levels being produced during the salting out phase of the cook. Airborne levels of methamphetamine may range from less than 2.0 ug/m^3 to as high as 5000 ug/m^3 and cause contamination of areas that are significantly removed from the manufacturing process.

The methamphetamine contamination of the cook area as well as adjacent areas makes it likely that individuals who live in the residence or who visit the residence become contaminated with methamphetamine. In fact, most (if not all) children associated with clandestine methamphetamine laboratories are contaminated with the drug and have positive urine levels for methamphetamine. Samples we have taken of individuals and pets leaving these clandestine laboratories have been positive for methamphetamine at levels that exceed the accepted contamination level of 0.5 ug/100 cm^2.

Reports from California law enforcement and child protective services have indicated that many children associated with parents using methamphetamine have been found to test positive for methamphetamine in urine samples. In many of these cases, the parents have indicated that they have never manufactured methamphetamine in the residence. We were asked if it was possible for children to be exposed to methamphetamine without the presence of a working laboratory in the residence. We were also asked to determine the expected exposures to methamphetamine in a residence that was only used for smoking the drug and the potential health effects associated with that exposure.

Health Effects of Methamphetamine:

Methamphetamine has been studied since the 1930's and has been available as a prescription drug for use in the treatment of attention deficit disorder (ADD) with hyperactivity and as a short-term treatment for obesity. Although there is much information regarding the use of the prescription drug and the abuse of the drug by adults, there is little information regarding long-term exposure to low levels of methamphetamine by children. Most data regarding childhood exposure to methamphetamine is derived from studies involving methamphetamine exposure to the fetus during pregnancy and the resulting physiological, developmental and psychological effects.

As a prescription drug, methamphetamine hydrochloride has been marketed under the name of Desoxyn by Abbott Laboratories in Chicago, IL. The drug is marketed in tablets for oral use that contain 5 mg of methamphetamine hydrochloride per tablet. For the

treatment of ADD, the effective dose is reported to be 20 to 25 mg daily, and for the treatment of obesity, the suggested dose is one 5 mg tablet prior to each meal. The drug is not suggested for the treatment of obesity in children under 12 and not suggested in the treatment of ADD in children under 6 years of age.[1]

There is a long list of contraindications and precautions listed for the use of Desoxyn that must be considered by the physician. The drug should not be used by patients that have glaucoma, advanced arteriosclerosis, cardiovascular disease, hypertension, or hyperthyroidism. Women that are pregnant are also cautioned from using the drug since it has been shown to have teratogenic and embryocidal effects in mammals given high doses. In addition, mothers that have been abusing the drug have been shown to have an increased incidence of premature delivery and children with low birth weight. Infants born to these mothers may also show symptoms of withdrawal including agitation and lassitude. Since the drug is excreted in the milk of nursing mothers, it is also important that nursing mothers not take this drug.[1]

The primary effect of methamphetamine upon individuals abusing the drug is its activity on the central nervous system. The drug has been shown to enhance the release of and block the re-uptake of dopamine in the body. This action can result in wakefulness and a decreased sense of fatigue as well as elation and euphoria.[2] An individual using the drug may have an increase in heart rate, blood pressure, body temperature and breathing rate. The individual may also have dilated pupils, hyperactivity, and tremors.[3] Nervousness, irritability, and paranoia may be attributed to the use of the drug and withdrawal from the drug frequently causes a severe depression. Chronic abuse of methamphetamine may produce schizophrenia-like symptoms such as paranoia, self-absorption, with auditory and visual hallucinations.[3] Violent behavior, anxiety, and homicidal thoughts have also been reported in users of methamphetamine. After a long period of use, weight loss, gaunt appearance, decayed teeth, and open sores may be observed in individuals using the drug.[4]

The health impacts of exposure to methamphetamine on children are relatively unknown. A number of studies have targeted infants born to women that have used methamphetamine during pregnancy. These studies have indicated that infants born to methamphetamine users had altered behavioral patterns and lower intelligence test scores than did non-exposed infants. Physical malformations such as cleft lip, cardiac defects, reduced head circumference, biliary atresia, cerebral hemorrhage, systolic murmur and undescended testes have also been attributed to the use of amphetamines and methamphetamines by pregnant mothers. Neonatal death and blindness have also been observed in children born to mothers using methamphetamine.[2]

No published papers were identified regarding the relationship between children exposed to methamphetamine surface contamination or methamphetamine manufacture and any resultant health consequences. Anecdotal reports of increased asthma, pulmonary fibrosis, and upper respiratory complaints have been received but no documented health statistics appear to be available at this time. Many of the reports that have been received involved exposure to a clandestine manufacturing laboratory were reactions that could

have been to the chemicals used to manufacture the methamphetamine and not to the methamphetamine itself.

Surface Contamination Standards:

A number of governmental agencies have begun to regulate the amount of surface contamination allowed in structures that were clandestine methamphetamine laboratories. The initial work in this area was conducted in the State of Washington where the state imposed a cleanup level of 5 ug/ft^2 in buildings known to have been a methamphetamine laboratory. This level was not based on specific health information but rather on the belief that this level was an achievable standard of cleanliness.[2] The belief was that in the face of an unknown risk to crawling infants, "the process of reducing levels of known contaminants to the lowest practical levels using current available methods and processes" made sense. Due to lower detection limits, the State of Washington recently lowered its acceptable level of contamination to 0.1 ug/100 cm^2 (approximately 1 ug/ft^2).[2]

A number of other surface contamination levels have been set by other regulatory agencies but most are similar to the Washington State Standards. Tacoma-Pierce County Health Department in Washington State set their standard at 0.5 ug/100 cm^2 (5 ug/ft^2) in March, 2001, although that level may have changed with a change in the Washington State Standards[5]. The level that is used by the Salt Lake City Health Department is 0.1 ug/100 cm^2, the same as the State of Washington.[6] Colorado has promulgated a suggested clean-up standard of 0.5 ug/ft^2 and Tri-County Health Department in Denver, Colorado has established a level of 0.5 ug/100 cm^2.[7,8] Since the long-term physiological actions of the drug are somewhat unknown and the routes of entry into the body are also unknown, the level that is protective for most individuals is also unknown.

Methods of Use for Methamphetamine:

Methamphetamine is a drug that can be administered in several different ways. It can be taken orally, injected into a vein, taken into the nasal cavity, and smoked. Smoking or injecting the drug may result in a fast high that lasts for a short period of time. Snorting methamphetamine results in a high that takes longer to occur and orally taking the drug may prolong the initiation of the high for 15 to 20 minutes without an intense rush.[4] A study conducted in California in a group of methamphetamine users indicated that two-thirds or more of the individuals snorted and smoked the drug. Less than 25% used the drug orally or injected the drug.[9] All of these methods of intake may lead to dependence on the drug.[10]

Several studies have attempted to determine how much of the methamphetamine taken into the body can be absorbed. Harris et al[10] used deuterium-labeled methamphetamine to determine uptake and bioavailability for the different methods of intake. They found that of all of the methamphetamine put into a pipe and smoked, approximately 37% was absorbed into the body. Approximately 50% of the methamphetamine was left in the pipe and approximately 67% of the methamphetamine that became airborne was taken

into the body. A similar study conducted by Cook et al (11) indicated that about 50% of the methamphetamine that was smoked was left in the pipe but that approximately 90% of the methamphetamine that was aerosolized was taken into the body. In both studies 30 – 40 mg of methamphetamine was put into the pipe and heated to between 265° C. and 300° C. electrically. The patients then inhaled all of the vapors produced and held them in their lungs for at least 15 seconds. The dose utilized was similar to those reported to be used by individuals using the drug in a clandestine manner. Based on these studies, the amount of airborne methamphetamine taken into the body from a 40 mg pipe full would range from 26 mg to 36 mg.

Methodology:

Our simulated methamphetamine "smoking" study was conducted in a room of an abandoned motel that had been bought by the City of Thornton, CO. (Figure 2.) The motel room was similar to many other motel rooms in that it had a main sleeping area with a table, a closet area, and a bathroom area. The ceilings were approximately 8 feet high and the room was a total of 253 square feet. The cook was conducted on the table located in the sleeping area approximately midway along the west side of the room. The table height was approximately 30 inches from the floor of the motel room. The heater was operated during the sampling effort in order to warm the room and to provide ventilation. The heater was a simple unit ventilator located on the south wall of the room, next to the entrance.

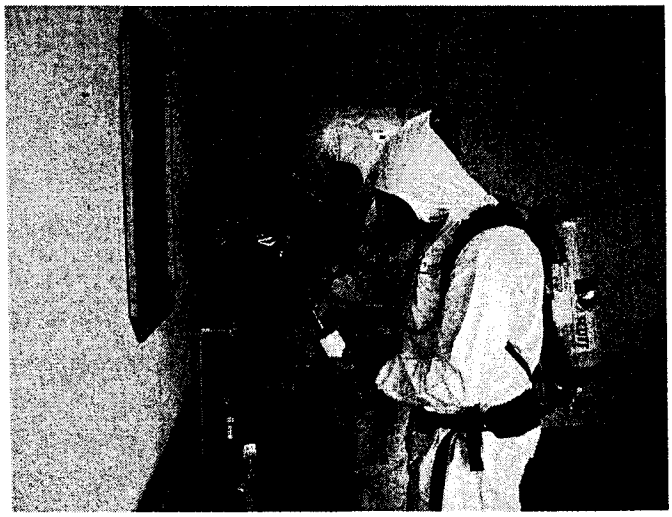
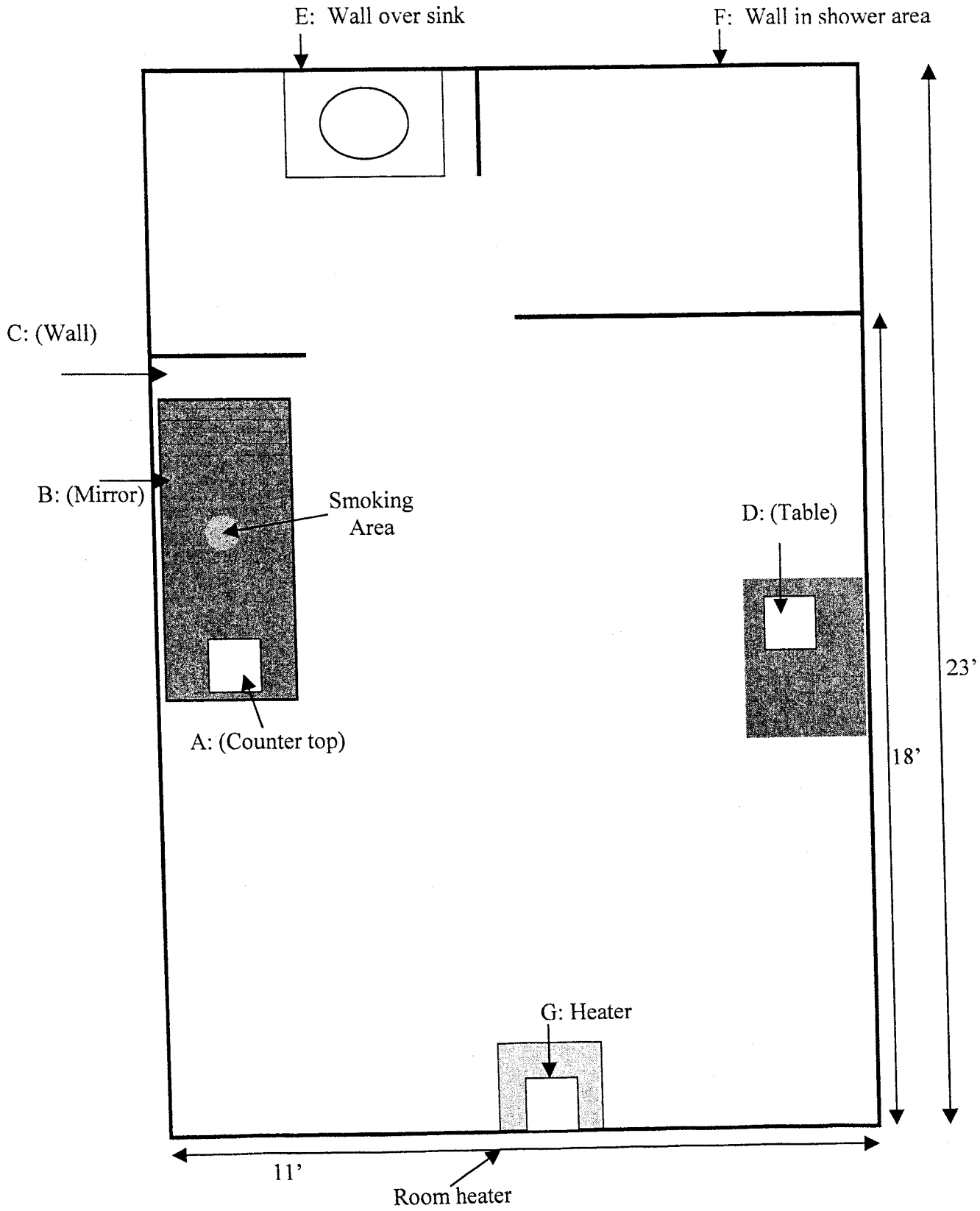


Figure 1. Location of the smoke generating area and the sampling location in the motel room.

Wipe samples were collected from seven locations within the motel room. At each location, four 100 cm^2 squares were drawn at the location. An initial sample was taken in the vicinity in order to determine pre-sampling methamphetamine levels. The locations of the samples are depicted in Figure 2. A description of the sampling locations are as follows:


E: Wall over sink
F: Wall in shower area
C: (Wall)
B: (Mirror)
Smoking Area
D: (Table)
A: (Counter top)
23'
18'
G: Heater
11'
Room heater

Location	Description	Height above floor
A	Counter top next to cook area	30 inches
B	Mirror 24 inches directly above cook area	54 inches
C	West wall 3.5 feet north of cook area	5 feet
D	Table between beds and 9 feet east of the cook area	30 inches
E	Wall over sink in bathroom 12 feet from cook area	5 feet
F	Wall in shower area 14.5 feet from cook area	5 feet
G	Top of unit heater 13 feet from the cook area	30 inches

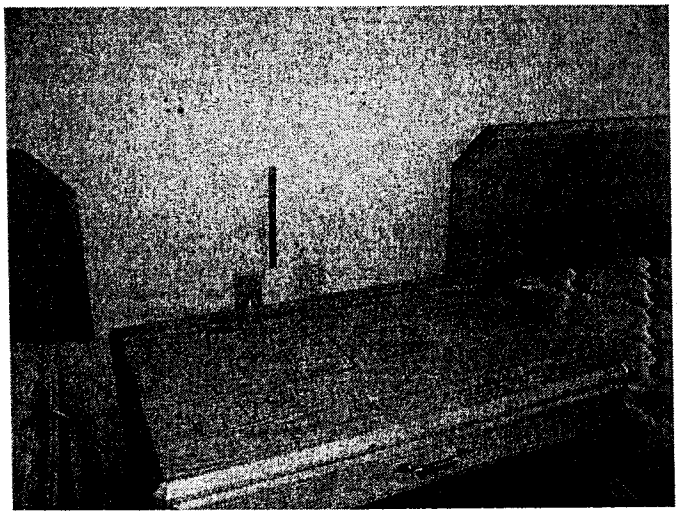


Figure 3. Horizontal wipe sample location D showing the 4 – 100 cm^2 sampling locations.

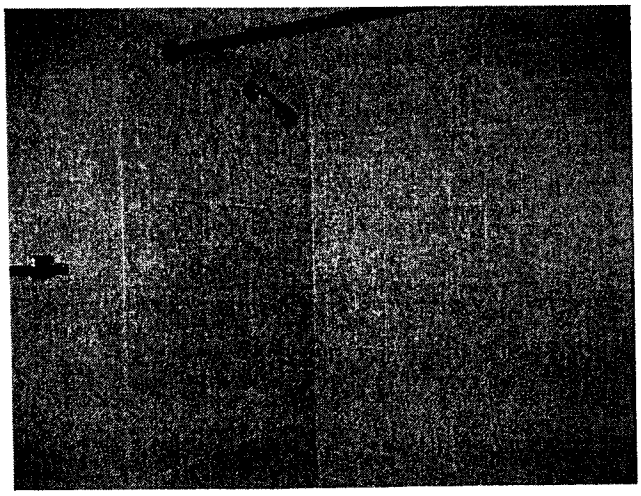


Figure 4. Vertical wipe sample location F located in Bathroom shower.

Our methodology of "smoking" the methamphetamine was suggested by members of the North Metro Drug Task Force in Thornton, CO after interviewing drug users in the Denver Metropolitan Area . A total of four separate "smokes" were conducted in the motel room on the tabletop. The first two smokes consisted of using a methamphetamine pipe filled with 100 mg of methamphetamine. The methamphetamine had been manufactured in a previous controlled cook and had been analyzed by GC/MS and found to be 91% methamphetamine. This level of purity is considered to be higher than most "street" methamphetamine, which is reportedly less than 50% pure. The third "smoke" was conducted using the pipe and a 250 mg amount of methamphetamine. The fourth "smoke" was conducted using a hot plate with an aluminum plate holding 2000 mg of methamphetamine. The first two "smokes" were considered to be commonly used amounts of methamphetamine while the last two "smokes" were designed to provide information on the results of a large number of "smoking"sessions.

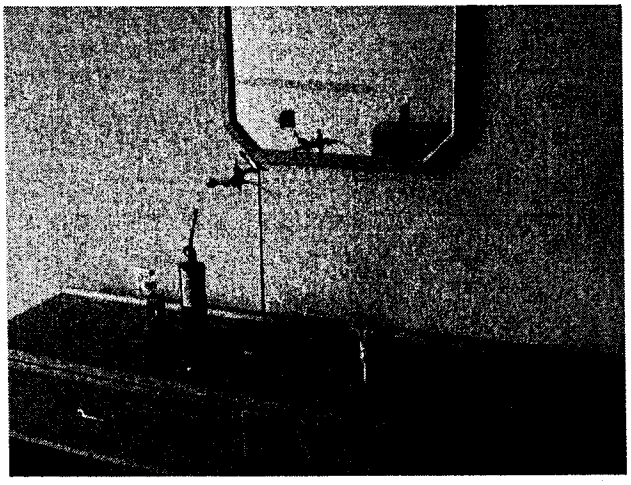


Figure 5. The sampling set-up for the "smoke" using the pipe showing the sampling setup.

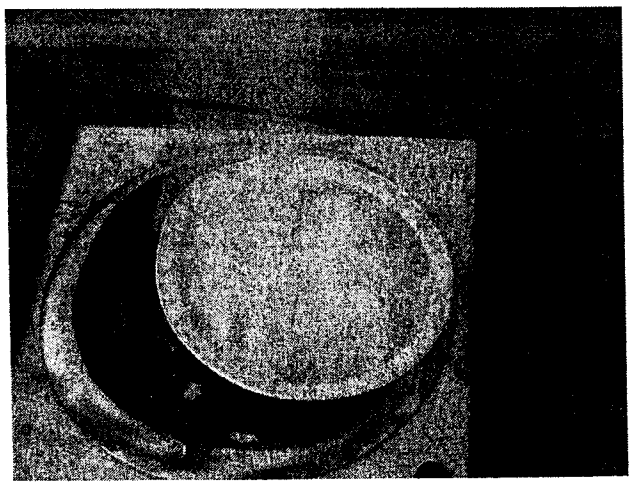


Figure 6. The setup for the 2000 mg "smoke" using the hot plate and an aluminum plate.

Air samples were taken for airborne methamphetamine using SKC Personal Sampling Pumps calibrated to a flow rate of 2 liters per minute. Samples were taken at four locations and for different intervals. The samples taken were as follows:

Sample ID	Location	Tests Sampled
A-1	At the smoke area	Test #1
A-2	At the smoke area	Test #2
A-3	At the smoke area	Test #3
A-4	At the smoke area	Test #4
D-1	At the table on the east side of the room	Test #1
D-2	At the table on the east side of the room	Tests #2 thru #4
E-1	At the bathroom sink	Test #1
E-2	At the bathroom sink	Test #2 thru #4
G-1	At the heater	Test #1 thru #4

In addition, wipe samples were taken on the clothing of the primary "smoker" after Test #1, Test #3, and Test #4. Wipe samples were also taken on three linoleum tiles that were located on the floor of the hotel room. The samples were taken after all of the "smokes" had been conducted.

All of the wipe samples were taken using sterile 4 x 4 wipes that were wetted with isopropanol prior to use. The wipes were packaged in sealed centrifuge tubes prior to being brought into the room. The tubes were opened, the wipe removed and wetted with the isopropanol. The wipes were then used to wipe the marked 100 cm^2 surface area, folded and put back into the centrifuge tube. Gloves were changed between samples to reduce the chance of cross contamination.

All of the samples were sent to DataChem Laboratories for analysis using a methodology developed for the National Institute for Occupational Safety and Health. The samples were analyzed using a gas chromatograph and mass spectrometer.

Results:

As was expected, the simulated smoking of methamphetamine produced levels of airborne methamphetamine within the motel room. The levels of methamphetamine produced in the air depended upon the amount of methamphetamine aerosolized in the simulated smoke. The first two "smokes" were designed to simulate the amount of methamphetamine that might be used in a single smoke by a single user. The amount of methamphetamine utilized was 100 mg/pipe with the purity being 91%. The amount used by an addict smoking the drug will depend upon how long the individual has been using the drug and the kind of high that he/she wants. The purity of the drug may also not be as high since most street-available methamphetamine is less than 50% pure. It is expected, however, that the amount used in the first two "smokes" is likely to be similar to the amount used by an addict under actual conditions.

Airborne levels of methamphetamine found during the first two "smokes" ranged from 300 ug/m^3 to 520 ug/m^3. The highest levels were found at the smoke generation area, however, the levels in the rest of the motel room were similar. The results for the first "smoke" were as follows:

Sample Area	Test #	Airborne Methamphetamine Level
"Smoke" Area	1	520 ug/m^3
"Smoke" Area	2	300 ug/m^3
Table on East side of room	1	340 ug/m^3
Bathroom Sink	1	330 ug/m^3

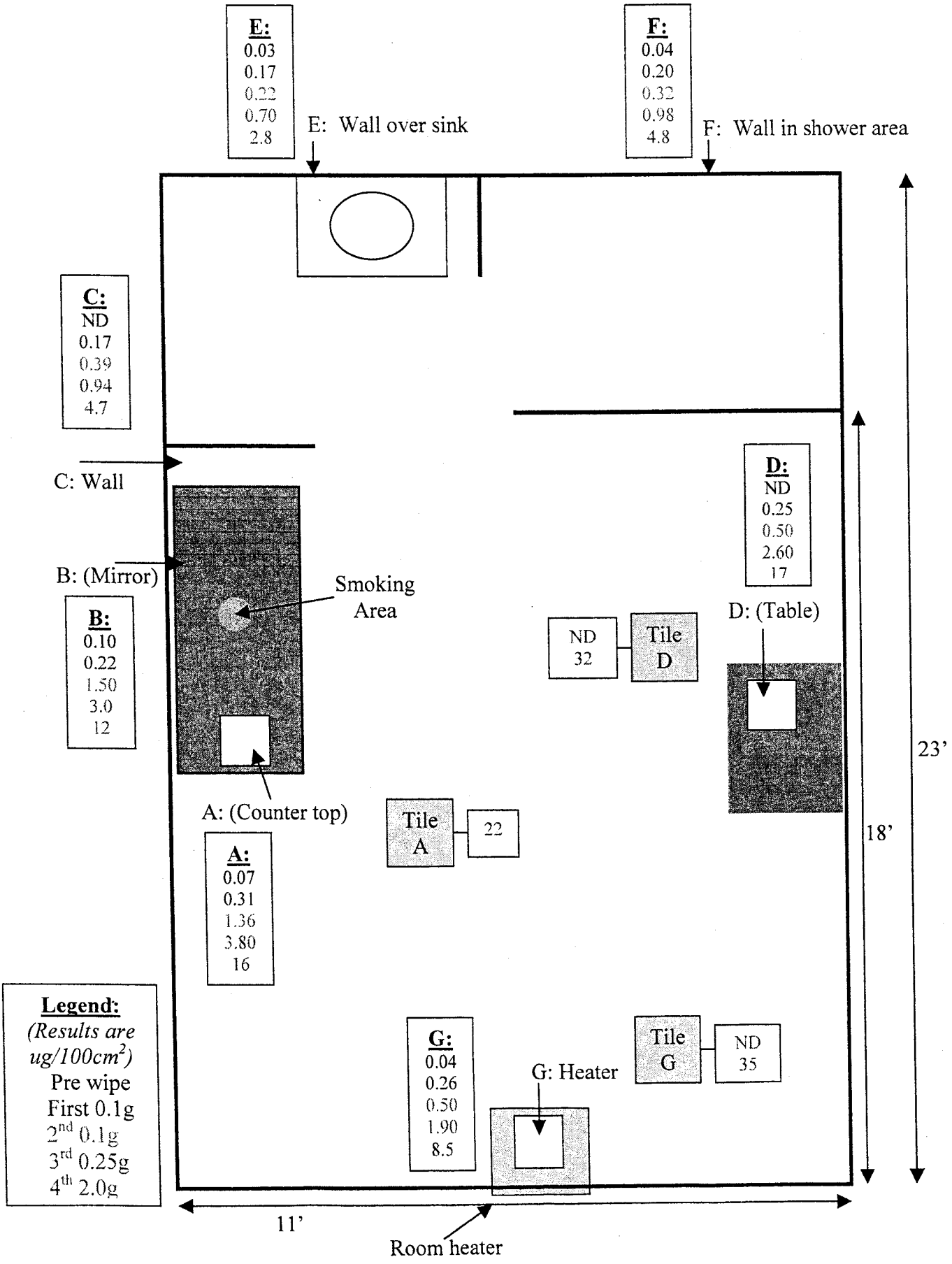
These levels would suggest that from a single "smoke" of 100 mg of 91% pure methamphetamine, the levels of airborne methamphetamine in the room would average approximately 373 ug/m^3. This does not, however, factor in the amount of methamphetamine expected to be absorbed into the body of the user under actual smoking conditions. Both Harris[10] and Cook[11] found that between 67 % and 90 % of the methamphetamine aerosolized was absorbed into the body of the smoker, under normal conditions. Using these results, the expected mean level of methamphetamine found in the air should range from 37 ug/m^3 to 131 ug/m^3 for a single "smoke" under the conditions noted. (373 ug/m^3 – 0.67 x 373 ug/m^3 to 373 ug/m^3 – 0.90 x 373 ug/m^3)

The level of airborne methamphetamine found at the "smoke" area during the "smoke" that utilized 250 mg of methamphetamine was found to be 1600 ug/m^3 and the level observed during the 2000 mg "smoke" was 1200 ug/m^3. Both of these levels were much higher than the initial "smokes". The levels calculated to be present if an actual smoke had occurred would have ranged from 120 ug/m^3 to 528 ug/m^3, based on the absorption rates reported by Harris[10] and Cook[11].

The mean levels of methamphetamine observed at the different testing locations and the likely ranges if a smoker had been smoking the material are as follows:

Sample Area	Tests Sampled	Measured Airborne Level (ug/m^3)	Predicted Low Airborne Level* (ug/m^3)	Predicted High Airborne Level^ (ug/m^3)
Smoke Area	1	520	52	172
Smoke Area	2	300	30	99
Smoke Area	3	1600	160	528
Smoke Area	4	1200	120	396
East Wall	1	340	34	112
East Wall	2,3,4	1400	140	462
Bathroom Sink	1	330	33	109
Bathroom Sink	2,3,4	1500	150	495
Heater Area	1,2,3,4	1400	140	462

* = Predicted airborne level assuming 90% uptake by user.
^ = Predicted airborne level assuming 67% uptake by user.


E:
0.03
0.17
0.22
0.70
2.8
E: Wall over sink
F:
0.04
0.20
0.32
0.98
4.8
F: Wall in shower area
C:
ND
0.17
0.39
0.94
4.7
C: Wall
B: (Mirror)
B:
0.10
0.22
1.50
3.0
12
Smoking Area
D:
ND
0.25
0.50
2.60
17
D: (Table)
ND
32
Tile D
A: (Counter top)
A:
0.07
0.31
1.36
3.80
16
Tile A
22
G:
0.04
0.26
0.50
1.90
8.5
G: Heater
Tile G
ND
35
Legend:
(Results are ug/100cm²)
Pre wipe
First 0.1g
2nd 0.1g
3rd 0.25g
4th 2.0g
23'
18'
11'
Room heater

Prior to the "smoking" experiment, all of the wipe sampling points were checked for residual methamphetamine. Of the seven locations sampled, five had very low positive results ranging from 0.04 ug/100 cm^2 to 0.10 ug/100 cm^2. These low levels may indicate that at some past date methamphetamine had been used in the room however, the levels are at the level of detection and may also be false positives. After the first "smoke" the levels ranged from a low of 0.17 ug/100 cm^2 to a high of 0.31 ug/100 cm^2. We would again expect that these levels would be much lower if a smoker had been present to absorb most of the methamphetamine. We would expect that the drop in the wipe methamphetamine levels would be proportional to the drop in airborne levels. The measured mean methamphetamine level of 0.23 ug/100 cm^2 might range from 0.02 ug/100 cm^2 to as high as 0.08 ug/100 cm^2, if user absorption had occurred.

Each sample location had four squares, with one square sampled after each "smoke". Square A was sampled after the first smoke and represents only Smoke #1. Square B was a combination of the first 2 "smokes", square C was a combination of the first 3 "smokes", and square D was a combination all four of the "smokes". As anticipated, each "smoke" resulted in a higher deposition level. In the open room, there was not a significant difference between the areas sampled suggesting that the methamphetamine is deposited relatively uniformly throughout the motel room. The bathroom and sink levels appeared to be somewhat lower than the main room but both had detectable levels of methamphetamine that rose with the number of "smokes". As the number of "smokes" increased, the general level of contamination increased. It is likely that the methamphetamine contamination due to four actual smokes would be less than we measured, due to methamphetamine absorption by the smoker and the larger amounts of methamphetamine used in the Smoke #3 and Smoke #4.

Wipe samples were also taken from several tiles that we put on the floor in order to determine contamination of the floor area. The methamphetamine levels were measured after all four of the cooks had taken place. Contamination on the tiles ranged from 22 ug/100 cm^2 to 35 ug/100 cm^2. These levels are higher than we found on the other surfaces (both horizontal and vertical). It is not known why these samples were so much higher, however the surfaces of the tiles were very smooth and easy to wipe and we may have been able to remove more of the methamphetamine from the surface. It is also possible that the methamphetamine aerosol settled more on the floor than on the vertical surfaces.

Wipe samples taken from the person doing the "smoking" were found to be 0.03 ug/sample on the front for the 1st "smoke" and 0.04 ug/sample on the back of the "smoker" after the 1st "smoke". After the 3rd "smoke", the level on the front had increased to 0.59 ug/sample and the level on the back was 0.51 ug/sample. These levels again suggest a relatively uniform distribution throughout the room during the "smoking" process. A sample taken from the face of the smoker was the highest at 10 ug/sample. This was likely due to the smoker's proximity to the pipe and his bending over the actual "smoke".

Discussion:

Based on our experiment, it is likely that persons smoking methamphetamine within a structure cause airborne methamphetamine to be released into the environment resulting in a general contamination of the environment. This is not a surprise since we have observed methamphetamine on surfaces in residences where "cooking" of the methamphetamine has not been conducted. In those cases in which we have been involved, residences where methamphetamine has only been smoked have much lower residuals of the drug on environmental surfaces than do residences where cooking has been conducted. A single "smoke" with the smoker inhaling and capturing 90% of the methamphetamine may result in methamphetamine contamination levels in the range of 0.02 ug/100 cm^2. As more smoking is conducted, levels may exceed 30 ug/100 cm^2. It may, however, take a significant number of methamphetamine smokes before these high levels are reached.

Levels observed during "smoking" are in contrast to those levels observed during cooking where levels for a single cook can result in airborne levels of methamphetamine exceeding 5000 ug/m^3 and wipe sample levels exceeding 860 ug/100 cm^2 in the vicinity of the cook. In addition to the lower levels of methamphetamine due to "smoking" it should also be noted that the use of the other hazardous chemicals associated with cooking are not present. With respect to expected medical concerns, it may be unreasonable to compare methamphetamine surface contamination levels in areas where only smoking has occurred, to levels in areas where a cook has been conducted since the other chemicals associated with the cook are not present in the smoking-only area. The potential for children or others to be contaminated in a home where methamphetamine has been smoked is, however, highly likely. The potential effects of this exposure to children present within these residences are unknown at this time.

Conclusions:

Based on the information that we have obtained during this study, the following conclusions can be made:

- The smoking of methamphetamine in a structure results in airborne methamphetamine being released into the environment.

- The airborne levels will depend upon how much methamphetamine is smoked and the efficiency of the smoker's technique in capturing the drug and depositing it in the lungs.

- An average smoke involving approximately 100 mg of methamphetamine will likely result in airborne methamphetamine levels ranging from 37 ug/m^3 to 131 ug/m^3 in the air. These airborne levels will likely result in average surface deposition levels in the vicinity of the smoke that approach 0.02 ug/100 cm^2. As the number of smokes increase or the total amount of methamphetamine smoked increases, the levels will increase.

- The levels of methamphetamine found on surfaces within a house where it has only been smoked and not manufactured, will likely be much lower than in a residence where it has been manufactured.

- If methamphetamine has been smoked in a residence, it is likely that children present within that structure will be exposed to airborne methamphetamine during the smoke and to surface methamphetamine after the smoke.

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