PERSONAL EXPOSURE OF AIRLINE FLIGHT ATTENDANTS TO ENVIRONMENTAL TOBACCO SMOKE

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I. GENERAL.

The objective of the research program proposed here is the determination of the exposure of airline flight attendants to environmental tobacco smoke during work in commercial flights. The exposure to environmental tobacco smoke will be monitored by determining the exposure of the personnel to gas phase nicotine and NO_2 be use of a personal exposure sampling device. The average time integrated concentrations of both gas and particle phase nicotine, gas phase vinyl pyridine, CO, NO_2, RSP, and solanesol at two locations in smoking and nonsmoking sections of the aircraft will also be determined over the same time period as the personal exposure measurements using a portable briefcase sampling system. The combined data will be used to estimate the exposure of airline flight attendants to environmental tobacco smoke under a variety of working conditions.

II. BACKGROUND.

Environmental tobacco smoke is a major contributor to indoor air pollution in environments where smokers are present. The identification and quantification of environmental tobacco smoke exposure for airline flight attendants is important because of irritant and suspected health effects (DHHS 1986, NAS 1986) associated with involuntary exposure to environmental tobacco smoke and the confined work space of the study group. Tracers of environmental tobacco smoke used in the past include respirable (or total) suspended particulate matter (RSP), CO, nitrogen oxides, nicotine, N-nitrosoamines, aromatic hydrocarbons, acrolein, and frequency of smoking (NAS 1986). Of these various tracers, only nicotine is unique to environmental tobacco smoke. The only tracer which has been used to estimate the exposure of airline flight attendants to environmental tobacco smoke in studies reported in the past is the body burden of nicotine as inferred from determining nicotine in urine (Foliart 1983).

Nicotine is present in air at relatively high concentration where smoking occurs. Nicotine may be used as a measure of exposure to environmental tobacco smoke since nicotine is found primarily in the gas phase in indoor environments (Eatough 1986, 1987a, Hammond 1987a,b). However, gas phase nicotine may be removed from the environment at a faster rate than aerosol nicotine or the particulate portion of environmental tobacco smoke (Eatough

1987a, Thome 1986). Thus, the concentration of gas phase nicotine may underestimate exposure to environmental tobacco smoke. However, it is probable, given the high air exchange rates which are commonly present in modern aircraft, that the deposition loss of gas phase nicotine in aircraft is less important then might occur in a home or office and nicotine can be expected to be a viable tracer for exposure to environmental tobacco smoke in the environment to be studied. We are currently conducting research to determine the appropriateness of nicotine as a tracer for environmental tobacco smoke exposure (Eatough 1987b). In connection with this research effort, we have shown that a simple passive sampling device provides an accurate and sensitive method for determining gas phase nicotine indoors (Eatough 1987a).

Other potential tracers of environmental tobacco smoke are gas phase vinyl pyridine (Eatough 1987a,b), particle phase nicotine (Eatough 1987a) and particle phase solanesol (Eatough 1987b). These tracers have the advantage that they are removed from indoor environments at similar rates and at rates which are much slower than the removal rate for nicotine (Eatough 1987a). However, of these tracers, only vinyl pyridine is a gas phase species and it is present in concentration too low to be determined using passive personal sampling devices. Vinyl pyridine, however, may be collected using a small active sampling device similar to that used by Muramatsu (1984) or currently being used by Reynolds (Ogden 1987) for collection of gas phase nicotine. The validity of these sampling systems will be further tested in a multi-laboratory intercomparison study of various nicotine sampling techniques currently being conducted by us.

While NO_2 and CO are not unique to environmental tobacco smoke, they may be suitable markers of exposure in aircraft if other sources of these compounds are not present. The concentration of NO_2 to which a person is exposed may be easily measured using passive personal monitors (Mulik 1986). While the major nitrogen oxide usually found in environmental tobacco smoke is NO, the high air exchange rates and the presence of high concentrations of ozone in the intake air of aircraft at high altitudes results in NO_2 being the dominant nitrogen oxide (Stedman 1987). At the present time available technology for sorbing CO from the atmosphere (Lambert 1987) is not developed to the point where it can be used in a passive sampling device. CO can,

however, be determined in an active sampling system with commercially available equipment (Ogden 1987).

III. Objectives.

1. Assemble and test a passive sampling device for the simultaneous determination of personal exposure to gas phase nicotine and NO_2.

2. Assemble suitcase-size monitoring equipment for the collection of gas and particle phase nicotine, particle phase solanesol, RSP, vinyl pyridine, NO_2 and CO.

3. Validate the sampling techniques by intercomparison of the systems assembled in 1. and 2. in chamber experiments and on a test airline flight.

4. Use the systems assembled in 1. and 2. to determine the exposure of airline flight attendants to the chemical species measured under a variety of flight conditions.

5. Based on the results obtained in 4., estimate the exposure of airline flight attendants to environmental tobacco smoke.

IV. Technical Approach.

The methods which will be used to accomplish the objectives given in Section II follow.

A. Passive Sampling Device for Gas Phase Tracers of Environmental Tobacco Smoke.

The high air exchange rates present in modern aircraft and the absence of other significant sources of nicotine will probably result in nicotine being a suitable tracer for environmental tobacco smoke in aircraft. In addition, the presence of a high concentration of ozone in the intake air of these aircraft during flight will result in the major nitrogen oxide being NO_2 rather than NO (Stedman 1986). The basic gas, nicotine, can be effectively collected on an acidic surface. We have used benzenesulfonic acid coated filters as the basis for a passive sampler for nicotine (Eatough 1987a) and have shown that it can be successfully used to determine personal exposure to nicotine in nonsmoking sections of commercial aircraft with flights times greater than about one hour (Eatough 1987c). The concentrations of NO_2 from environmental tobacco smoke are comparable to the concentrations of nicotine so it should be possible to determine personal exposure to both species. Passive samplers for NO_2 using a triethanolamine-saturated filter as the collection media for NO_2 have been described previously (Mulik 1986). We propose to use a passive sampling

device containing both of these collection media for the simultaneous collection of both gas phase nicotine and NO_2 in a passive sampling device. Proper operation of the dual passive device will be validated in experiments in our environmental test chamber where the results obtained with a dual passive sampling device will be compared to those obtained with individual passive samplers and active samplers for the two gases.

B. Active Sampling Device for Gas and Particle Phase Tracers of Environmental Tobacco Smoke.

The gas phase tracers used to determine exposure to environmental tobacco smoke in passive sampling devices will be further validated by comparing the concentration of these tracers to particle phase tracers in selected samples collected at two locations in the flight cabin during the time the passive samples are collected. The active sampling system will be battery powered and will be housed in a briefcase so that the sampling collection device is unobtrusive. The briefcase will contain three sampling systems. The first will have the following components in the order listed:

1. A small benzenesulfonic acid annular denuder or XAD to remove gas phase nicotine and vinyl pyridine.

2. A benzene sulfonic acid coated filter to remove particle phase nicotine and solanesol.

3. A triethanolamine coated filter to remove NO_2.

The final choice of component 1. will be made after completion of the intercomparison study now underway. The second system in the suitcase sampling equipment will have only a teflon membrane filter to collect particles for the determination of RSP gravimetrically. The third system will be a commercial CO monitor (Ogden 1987).

The flow through the samplers will be controlled by small personal sampling pumps at about 3 slpm.

C. Sample Collection.

Samples will be collected on commercial aircraft flights using the sampling systems outline in A. and B. after the sampling systems have been validated in sampling trials in our environmental test chamber.

Personal exposure samples will be collected using the passive sampling device (constructed so as to appear as a pendant worn around the neck) for all volunteering flight attendants during the duration of the flight studied. The

sampling device will be unobtrusive and will not interfere with normal flight duties. The device will be stored in air-tight containers up to the time of take-off when sampling will be initiated and the device will be returned to the container at the time of landing. A simple log will be maintained to give the size of smoking and nonsmoking sections for each flight and a log of number of observed smokers as a function of flight time.

The briefcase samplers will be located, one each, in the smoking and nonsmoking coach sections of the cabin. The samples will be collected at these fixed locations over the same time period as that for collection of the personal exposure samples.

Samples will be collected on both standard and wide body aircraft and on flights of short (1 to 2 hours) and long (4 to 5 hours) duration. It is anticipated that flights from San Francisco to Salt Lake, from San Francisco to New York, from New York to Chicago and from Chicago to Salt Lake will provide the desired variability. A total of approximately 12 flights will be sampled. Final details on the flights to be sampled and the sampling protocol will be worked out with cooperating agencies. It is anticipated that United Airlines and the Association of Flight Attendants will cooperate in the design and execution of the study.

D. Analytical Techniques.

We will use a battery of analytical techniques for the determination of the gaseous and aerosol constituents of environmental tobacco smoke. The analytical approaches which will be used include:

Nicotine. Nicotine collected by the briefcase sampling system will be determined by ion chromatography (Eatough 1986). Nicotine collected by the passive sampling system will be determined by capillary column gas chromatography (Eatough 1987a).

NO_2. The concentration of NO_2 collected by both the active and passive sampling systems will be determined by ion chromatography (Mulik 1986).

Vinyl Pyridine. Vinyl pyridine collected by the active and (if possible) the passive sampling systems will be determined by capillary column gas chromatography (Eatough 1987b).

Solanesol. Solanesol collected by the briefcase sampling system will be determined by capillary column gas chromatography (Tang 1987).

RSP. RSP will be determined gravimetrically using the material collected

on the Teflon filter in the suitcase active sampling system. The expected mass loading for the 1 to 6 hour samples of 10 to 200 μg will be estimated gravimetrically using an analytical microbalance.

V. Project Management.

The role of the various investigators in the proposed research program will be as follows:

Dr. Delbert J. Eatough. He will be the Principal Investigator for the project and will be responsible for the overall direction of the research program, for analysis of the data and for reporting of the results. Dr. Eatough is the Principal Investigator for the current study on **Development of Conservative Tracers of Indoor Air Quality** funded by Reynolds and he has extensive expertise in the development of analytical procedures for atmospheric chemistry problems and in the study of atmospheric chemistry.

Dr. Lee D. Hansen. He will be in charge of the analytical portions of the research program. Dr. Hansen and Dr. Eatough have worked cooperatively for over twelve years in the development of environmental analytical procedures and environmental chemistry studies.

Dr. Edwin A. Lewis. He will be in charge of the field sampling program and will be responsible for coordination of the research program between Hart Scientific and personnel from Brigham Young University. Dr. Lewis is currently involved in the on-going Reynolds study. In addition to being an Associate Research Professor in the Chemistry Department at BYU, Dr. Lewis is Chief Applications Scientist at Hart Scientific.

The expected milestone dates for the various research objectives (Section II.) follows:

Table I. Milestone Chart.

Month / Objective	2	4	6	8	10	12
1	X X X					
2	X X X					
3		X X				
4			X X X X X X			
5				X X X X		

VI. References.

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VII. Budget.

PERSONAL EXPOSURE OF AIRLINE FLIGHT ATTENDANTS TO ENVIRONMENTAL TOBACCO SMOKE

Proposed Budget for the Period 1 November 1987 - 31 October 1988.

1. Personnel.

Individual	Position	Mo. FTE[1]	
D.J. Eatough	PI	1.5	
L.D. Hansen	Co-PI	1.0	
E.A. Lewis	Co-PI	1.0	
L. Lewis	Research Sci.	1.0 *	
J. Crawford	Technician	2.0 *	
1	Research Assoc.	2.0	
1	Research Asst.	4.0	
	TOTAL	12.5	35,000

2. Payroll Taxes, 14.0% of 1.	4,900
3. Benefits, 11.5% of items marked by * in 1.	414
4. Travel	5,000
5. Supplies	
Chemicals and Lab Supplies	1,500
Sampling Supplies	3,000
Chromatography Supplies	2,000
6. Total Direct Costs, 1. - 5.	51,814
7. BYU Equipment Lease	6,500
8. BYU Laboratory Use Fee.	1,500
9. Indirect Costs, 22.0% of 6.	11,400
10. Fee, 5.0% of 6.	2,590
11. Financial Indirect Costs[2]	1,000
12. TOTAL	$74,804

[1]The total months (FTE, full time equivalents) marked with an * will have a benefits charge associated with the salary as indicated in 3.

[2]Financial indirect costs represent financing costs during the life of the contract and the amount shown in 11. is only an estimate. Actual financing costs will be billed at cost and may vary depending on the billing period (i.e. monthly or quarterly) and applicable interest rates. Hart Scientific is anticipating monthly billing.

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Equipment Lease Expenses for the Proposed Budget for the Period

1 November 1987 - 31 October 1988.

Item 7. BYU Equipment Lease, $6,500

Item	BUDGET
1. Lease of Existing Equipment, 3.0% of Item 6 in Budget.	$1,500

Major Equipment	Estimated Use, Mo.
Ion Chromatograph	4.0
GC and GC-MS	3.0

2. Lease of New Equipment Items, 10.0 Months Use.

Equipment	Lease	
Sampling Equipment	5,000	
TOTAL LEASE COST, New Equipment		5,000
3. TOTAL LEASE COST, Equipment, Budget Item 7.		$6,500

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