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14. ABSTRACT Jet propulsion fuel 8 (JP-8) has recently been recognized by the Department of Defense as the single largest chemical exposure for its personnel. The primary aim of the project is to conduct an epidemiological field study to examine the relationship between JP-8 fuel exposure and adverse neurological health in military personnel. The research objectives include 1) determination of the individual service member's level of exposure to JP-8 components while carrying out his/her job tasks, as measured by specified biomarkers of exposure, and 2) examination of whether acute, or cumulative exposure to JP-8 over a work week is significantly associated with hypothesized neurobehavioral and neurophysiologic performance outcomes. The project has two phases: Tier I involves onsite exposure assessment of fully characterize JP-8 exposure parameters in the military occupational field setting required for study to examine predicted dose-response relationships. The field study is being carried out with military (Air Force) personnel. Data collected for the Tier I and Tier II phases have been completed. Tier I reports are being prepared; Tier II data analysis steps are underway.

15. SUBJECT TERMS
Jet fuel, JP-8, Neurobehavior, Neurological Health, Exposure Assessment

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Introduction

Jet propulsion fuel 8 (JP-8) has recently been recognized by the Department of Defense as the single largest chemical exposure for its personnel. The primary aim of the project is to conduct an epidemiological field study to examine the relationship between JP-8 fuel exposure and adverse neurological health in military personnel. The research objectives include 1) determination of the individual service member's level of exposure to JP-8 components while carrying out his/her job tasks, as measured by specified biomarkers of exposure, and 2) examination of whether acute, or cumulative exposure to JP-8 over a work week is significantly associated with hypothesized neurobehavioral and neurophysiologic performance outcomes. The project has two phases: Tier I is to conduct onsite exposure assessment techniques to fully characterize JP-8 exposure parameters in the military occupational field setting required for the planned field study; Tier II is the conduct of the full-scale neuroepidemiology field study to examine predicted dose-response relationships. The field study is being carried out with military (Air Force) personnel.

Body

Due to administrative delays that occurred at the beginning of this project, a request to modify the timeline of the study SOW was submitted in March 2007. Thus, the current, approved SOW (Table 1) represents modifications that more accurately reflect the timeline of required tasks.

Table 1. Modified SOW, approved June, 2007

Year 1	**Months 1-12**	***Task 1***	-Obtain all required administrative approvals.
		Task 2	-Conduct planning steps, which include field site exposure measurements and samples analyzed.
		Task 3	-Convene Working Groups.
Year 2	**Months 13-24**	***Task 4***	-Conduct Tier I phase.
		Task 5	-Carry out analyses of environmental/biological samples from Tier I phase.
		Task 6	-Perform data management tasks to integrate multiple data sources for data analyses.
		Task 7	-Convene Workshop.
		Task 8	-Initiate Tier II phase.
Year 3	**Months 25-32**	***Task 9***	-Complete analyses of environmental and biological samples (Tier II).
		Task 10	-Complete data analyses of exposure-outcome hypothesis relationships (Tier II).
		Task 11	-Prepare Final Report and manuscript(s).

The project was funded November 1, 2005. The progress made during the first 8 months of the project was reported in the 2006 annual report. Specifically, ***Task 1***, obtaining the required Army and Air Force administrative approvals, was completed. Also, progress on ***Tasks 2 & 3*** was described.

Progress made during months 9-20 of the project was reported in the 2007 annual report (30 June 2006 – 30 June 2007). Specifically, ***Tasks 2-5*** were completed; ***Task 6*** was in progress.

The progress made on tasks outlined in the modified SOW during this funding period (30 June 2007 – 30 June 2008) is described below. This funding period corresponds to Months 21 through 32 and reports the progress on ***Tasks 6 -11***.

The project is currently operating (approved June 2008) under an approved no-cost extension to 30 June 2009 to complete the remaining project tasks.

***Task 6:* Data management tasks and data integration processes– COMPLETED**
All Tier I phase-collected data (questionnaire responses, daily exposure and work practices log sheet information, and lab results for the Tier I samples) have been entered into individual datasets. Data integration processes have been completed.

***Task 7*: Convene Exposure Assessment Workshop– COMPLETED**
The Exposure Assessment Workshop was convened in Natick, MA on 3 Oct 2007. The goal of the workshop was to bring together a group of recognized experts from the field of exposure assessment, and with jet fuel specifically, to discuss epidemiologic methods issues.
The PI and her study team presented preliminary findings from the Tier I phase and discussed plans for the Tier II phase. A series of research questions were discussed in-depth with the 10-12 invited attendees.

***Task 8:* Initiate Tier II phase– COMPLETED**
Prior to the Tier II phase, the final protocol was submitted to the USARIEM and AFRL Research Offices for review (approved 12 Dec 2007). Tier II phase data collection was carried out with a total of 74 participants between January-April 2008 (Table 2). The study design involved recruiting participants from both high and low-no exposure groups (based on *a priori* job-type activities), where each participant was asked to participate over a period of 6 work days. For each participant, his/her study participation started on a Friday afternoon and continued Monday through Friday the following week. Biological and environmental samples were collected from each participant every day, along with daily questionnaires and scheduled neurobehavioral task and postural sway testing. Specifically, data collection was carried out at Grand Forks Air Force Base (GFAFB) 25 Jan- 1 Feb 2008; Fairchild AFB (FAFB) 28 Mar-4 Apr 2008, and Little Rock AFB (LRAFB) 18-25 April 2008.

Table 2. JP-8 Tier II Baseline Survey Descriptive Statistics (n=74)

	Overall Group (n=74)	High Exposure Group + (n=38)	Low Exposure Group (n=36)	Test statistic*	p-value
Age, mean years (SD) [range]	25.8 (6.25) [18.6-43.0]	25.4 (6.23)	26.18 (6.33)	0.51	0.61
Education, mean years (SD) [range]	12.5 (1.36) [12.0-20.0]	12.3 (0.88)	12.69 (1.72)	1.12	0.27
Years of AF service, mean (SD) [range]	5.8 (5.35) [0.5-20.0]	5.6 (5.07)	6.09 (5.68)	0.51	0.61
Male, n (%)	62 (83.8)	37 (97.4)	25 (69.4)	10.61	0.001
White, Caucasian, n (%)	53 (71.6)	27 (71.1)	26 (71.2)	0.012	0.91
Current smoker, n (%)	41 (55.4)	18 (47.4)	23 (63.9)	2.04	0.15

+ High and Low exposure groups from *a priori* categorizations based on job-type activities.
* Comparison between High and Low exposure groups; Student's t-test statistic for comparison of continuous variables or Chi-square test statistic for comparison of categorical variables.

***Task 9:* Complete analyses of environmental and biological samples (Tier II)-In PROGRESS.**
The environmental and biologic samples collected as part of the Tier II phase are currently being analyzed to determine personal exposure to JP8. Specifically, we collected area air,

personal air, urine, dermal, exhaled breath, and blood from each participant on multiple work days and these samples are being analyzed for total hydrocarbon, benzene, toluene, ethylbenzene, xylene, and naphthalene concentrations (at CDC and Harvard University Laboratories). Also, blood is being analyzed for a particular genetic polymorphism of the GST enzyme (at Brown University).

Task 10: **Complete data analyses of exposure-outcome hypothesis relationships (Tier II)-In PROGRESS.**
The data management steps to integrate the Tier II in-person collected questionnaire, neurobehavioral performance and postural sway data have been completed. We are awaiting the completion of the analytic results from the respective laboratories (described above). When these results are received, we will proceed with data analyses of the hypothesized exposure-outcome relationships.

Task 11: **Prepare Final Report and manuscript(s)-In PROGRESS.**
Tier I phase manuscripts are in preparation. Data analytic steps for the Tier II phase are in progress.

Key Research Accomplishments

Below is a bulleted list of the accomplishments over this study period:

- The Exposure Assessment Methodology Working Group, Neurology Working Group, and the Data Management and Logistics Working Group met on regular bases, and completed the planning required for the Tier II data collection phase of the project.
- An abstract describing the Tier I urine biomarker findings was presented at the EPICOH meeting in Banff, Canada in October 2007.
- The PI and several members of the study team visited GFAFB in December of 2007 to provide a briefing of the preliminary results from the Tier I phase.
- The PI briefed the pertinent Command Group at GFAFB on the upcoming Tier II phase of the study (December 2007).
- The PI briefed the pertinent Command Groups at FAFB and LRAFB on the upcoming Tier II phase of the study (February 2008).
- Tier II phase data collection was completed between January-April 2008.
- Manuscripts from the Tier I phase are in preparation.
- Biological and environmental samples collected during Tier II were sent to the Harvard University Organics Lab, CDC, and Brown University (under approved contractual arrangements), where analyses are in progress.
- The PI presented a summary of the study at the Toxicology and Risk Assessment Conference (TRAC 08) in April 2008, as part of her invited symposium presentation.
- An abstract focused on the Tier I air and dermal findings has been accepted for presentation at the upcoming International Society of Exposure Assessment (ISEA) meeting.
- Continuing Review Reports have been reviewed and approved by the USARIEM Human Use Research Committee (17 Apr 2008) and the AFRL/Wright Site IRB (13 Mar 2008).

Reportable Outcomes

1. Reports, manuscripts, abstracts

- Abstract presented at the 19th International Conference on Epidemiology in Occupational Health in Banff, Alberta, Canada in October, 2007 was published:
  Smith KW, Allen JG, **Proctor SP**, McClean MD. Repeated measures of urinary 1- and 2-naphthol among jet fuel exposed Air Force personnel. Published in Occupational and Environmental Medicine 2007; 64:21.
- Invited presentation:
  Proctor SP. Exposure Assessment in Occupational Epidemiology: Issues Related to Jet Fuels. Presentation given at DoD's Toxicology and Risk Assessment Conference (TRAC), Cincinnati, OH 16 April 2008.
- Abstract has been accepted for presentation at the upcoming International Society of Exposure Assessment (ISEA) meeting in October 2008 in Pasadena, CA.
  Smith KW, **Proctor SP**, McClean MD. Repeated measures of inhalation and dermal exposure to jet fuel among Air Force personnel.

2. Degrees and research training opportunities

- Two Boston University School of Public Health (BUSPH) doctoral students have received funding support over the past year, with each of them also serving as integral members of the Tier II field study team.
- A group of 16 graduate or undergraduate seniors from several US colleges/universities (University of North Dakota, Gonzaga University, Lyon College, University of Arkansas Medical School, and BUSPH) assisted in the Tier II data collection phase.

3. Collaborative funding applications related to work supported by this award

- Henk C. Trap, BSc, from TNO Defense Security and Safety (The Netherlands) completed a USAMRMC-funded project titled "Profiling Jet Fuel on Neurotoxic Components with 'Comprehensive Two-Dimensional GC'" (#W81XWH-07-1-0002). The PI served as a collaborator for this project, helping to advise on aspects related to neurotoxicity. Samples of JP8 fuel were provided to TNO for analyses. In this project, samples of jet fuel were screened for the presence and quantitative mixture composition of suspected neurotoxic compounds using a relatively new and effective instrumental technology, 'comprehensive two-dimensional GC', in combination with a Time of Flight Mass spectrometer (ToF-MS). Experiments were performed to monitor the vapor concentration time profile of a maximum of 20 compounds of interest specifically in JP-8.

3. Related projects and collaborations initiated

- The PI is currently serving as a member of the Naphthalene Dosimeter Advisory Group, chartered from the Office of the Secretary of Defense, Emerging Contaminants Directorate.

Conclusions

There has been substantial progress over this funding period. When completed, the study should be able to provide important occupational health and exposure assessment information concerning JP8.

As stated in the recent report (National Research Council, 2003), field research studies that combine the in-depth assessment of on-the-job exposure levels with concurrent assessment of adverse health effects are needed and will contribute significantly to the knowledge of the subclinical effects of both acute and chronic exposure to occupational solvent exposures.

References

Subcommittee on Jet-Propulsion Fuel 8, Committee on Toxicology, National Research Council. (2003). *Toxicologic Assessment of Jet-Propulsion Fuel 8*. Washington, D.C.: The National Academies Press.

Appendix

Biomarkers 1

C. G. Parks, E. C. McCanlies, D. B. Miller, R. M. Cawthon, L. A. DeRoo, D. B. Sandler, S. Peters, G. Talaska, B. A. G. Jönsson, H. Kromhout, R. Vermeulen, K. J. Aronson, M. Sanchez, A. Grundy, H. Richardson, J. Tranmer, M. Borugian, C. Graham, K. W. Smith, J. G. Allen, S. P. Proctor, M. D. McClean, D. J. McLean, A. Eng, C. Walls, E. Dryson, J. Harawira, A. 't Mannetje, M. Gray, P. Shoemack, N. Pearce and C. Brooks

Occup. Environ. Med. 2007;64;21-

Abstracts

Biomarkers 1

098 TELOMERE LENGTH AND WORK SCHEDULE CHARACTERISTICS IN THE NIEHS SISTER STUDY

C. G. Parks[1], E. C. McCanlies[1], D. B. Miller[1], R. M. Cawthon[2], L. A. DeRoo[3], D. B. Sandler[3]. [1]*CDC/NIOSH/HELD;* [2]*University of Utah;* [3]*NIH/NIEHS*

Objectives: Telomeres are protective DNA sequences on the ends of chromosomes, which can shorten with repeated cell replication and contribute to senescence. Shorter telomere length has been associated with chronic stress, age and obesity in women, and with metabolic and cardiovascular disease outcomes. In combination with lifestyle and socioeconomic factors, work schedule may be a source of occupational stress in women. We hypothesised that cumulative lifetime years of full-time and over-time work, rotating shift-work or irregular hours, may be related to shorter telomere length in women.
Methods: Average leukocyte telomere length was estimated by quantitative PCR on a sample of 677 women selected for a study of biomarkers and perceived stress in the NIEHS Sister Study cohort (median age 55, range 35–75). Questionnaire data included lifetime job history and work schedule for each job reported. Age-adjusted regression models estimated associations with telomere length. We also examined whether associations were mediated or modified by education, age, and risk factors such as inadequate sleep, elevated stress and body mass index.
Results: Currently holding a full-time job and years of full-time work were significantly associated with shorter telomere length ($\beta = -0.003$ per year, $p = 0.002$) independent of the effects of age ($\beta = -0.006$ per year, $p < 0.0001$). These findings persisted in women currently working at enrolment and were not confounded by education, current sleep, BMI, perceived stress, smoking and health status. The odds of being in the shortest quartile of telomere length increased with increasing years of full-time work among women over age 55 (OR 3.4; 95% CI 1.4 to 8.2; $\geq$24.5 years vs <5.2 years), those with higher than average perceived stress (OR 3.7; 95% CI 1.5 to 9.3) and those with some college or a bachelors degree (OR 5.7; 95% CI 1.9 to 16.7) but not higher levels of education. Years in jobs characterised as over-time, shift-work and irregular hours were not consistently related to telomere length.
Conclusion: Telomere length may be associated with lifetime years of full-time work in some women. Further investigation is needed to understand the contribution of job strain, work–life balance and socioeconomic factors. Telomere length may provide a novel biomarker for studies of chronic occupational stress.
Key words: telomere length; stress; occupational

099 PAH EXPOSURE, URINARY MUTAGENICITY AND DNA ADDUCTS IN RUBBER WORKERS

S. Peters[1], G. Talaska[2], B. A. G. Jönsson[3], H. Kromhout[1], R. Vermeulen[1]. [1]*Institute for Risk Assessment Sciences, Environmental Epidemiology Division, Utrecht University, Utrecht, The Netherlands;* [2]*Department of Environmental Health, University of Cincinnati, Cincinnati, OH;* [3]*Department of Occupational and Environmental Medicine, University Hospital, Lund, Sweden*

Objectives: Several studies have suggested that genotoxic risks might still be present in the contemporary rubber industry. Previously we observed elevated levels of urinary DNA adducts in rubber workers. In this study we investigated whether DNA adducts in lymphocytes and/or urothelial cells may be caused by PAHs or by other bioactivated genotoxic compounds.
Methods: Spot urine samples from 102 rubber workers were collected on Sunday and during the workweek on Tuesday, Wednesday, and Thursday at ~4 pm to determine 1-hydroxypyrene (1-HP) and mutagenicity levels. In addition, 24 h urine samples were collected from 52 non-smoking workers to measure the presence of urothelial cell DNA adducts. Lymphocyte bulky DNA adducts were measured in 65 workers.
Results: For all workers, urinary 1-HP levels were significantly higher in urine samples during the workweek compared to Sunday ($p < 0.0001$). The increase in 1-HP levels was, however, not uniform across tasks and factories and only reached statistical significance for the production functions mixing, moulding (both $p < 0.005$), and curing ($p < 0.0001$). The overall higher weekday urinary 1-HP levels might be mostly due to rubber fumes measured as cyclohexane soluble matter (CSM; $p < 0.005$), while among moulding workers dermal exposure to CSM seemed to be the main cause. Weekday urinary mutagenicity (corrected for cotinine) was significantly increased in the mixing (+5%) and curing (+6%) workers when compared to the Sunday urine sample. Mixing and curing workers also showed higher amounts of four identified urothelial cell DNA adducts compared to the other rubber workers. No pattern in lymphocyte DNA adducts was observed for the several production functions. Total urothelial cell DNA adducts were significantly related to urinary 1-HP ($p = 0.021$) and mutagenicity ($p = 0.027$). No significant relationships were found between the identified lymphocyte and urothelial cell DNA adducts or urinary 1-HP and mutagenicity.
Conclusion: The results indicate that mixing and curing workers are at the highest genotoxic risk among rubber workers. Increased levels of 1-HP, urinary mutagenicity and urothelial cell DNA adducts were found in these workers. Urothelial cell DNA adducts were not related to lymphocyte DNA adducts, hinting possibly at the presence of specific bladder carcinogens present in the rubber industry.
Key words: rubber industry; 1-hydroxypyrene; DNA adducts

100 LIGHT INTENSITY AND URINARY MELATONIN LEVELS AMONG NURSES

K. J. Aronson[1], M. Sanchez[1], A. Grundy[1], H. Richardson[1], J. Tranmer[1], M. Borugian[2], C. Graham[1]. [1]*Queen's University;* [2]*British Columbia Cancer Agency*

Objectives: To describe differences in light exposure and biomarkers of melatonin production among nurses, and to determine if light intensity during sleep and other variables are associated with peak melatonin levels.
Methods: 60 female clinical nurses at an acute care hospital who worked rotating day/night shifts consented to participate. During a 72 h period, nurses working either 2 days or 2 nights (age frequency matched) wore light intensity data loggers and completed a diary. The principal metabolite of melatonin, 6-sulfatoxymelatonin, was measured in a single urine void taken upon arising after sleep following their last shift.
Results: Nurses who worked the day shift experienced lower intensity of light during sleep than night workers, and night workers were four times more likely to have low melatonin levels than day workers (OR 4.35, 95% CI 1.43 to 13.20). Multivariable linear regression indicated that light intensity during sleep was inversely associated with urinary melatonin level ($p = 0.001$). Of the other variables included, only age was independently associated with the outcome, and no variable confounded this association.
Conclusion: Recent epidemiological studies suggest that higher frequency of night shift work and increased light at night exposure could increase cancer risk. One hypothesised pathway is through the hormone melatonin: the presence of light inhibits its production, and decreased melatonin may increase reproductive hormone levels that may in turn increase the proliferation of hormone sensitive cells, potentially enhancing tumour development. In this study, there was a statistically significant inverse association between light intensity during sleep and metabolites of melatonin, as hypothesised. If light at night is associated with increased cancer risk, the mechanism may be through melatonin; however, longitudinal studies are needed. Since it is necessary that some nurses work at night, occupational policies must give more consideration to the implications of exposure to light at night.
Support: CIHR Transdisciplinary Cancer Training Program; Breast Cancer Action Kingston; Programme of Research in Environmental Etiology of Cancer, NCIC.
Key words: nurses; biomarkers; shift work

101 REPEATED MEASURES OF URINARY 1- AND 2-NAPHTHOL AMONG JET FUEL EXPOSED AIR FORCE PERSONNEL

K. W. Smith[1], J. G. Allen[1], S. P. Proctor[2], M. D. McClean[1]. [1]*Boston University School of Public Health;* [2]*US Army Research Institute of Environmental Medicine*

Objectives: The primary objectives of this study were to evaluate jet propulsion fuel 8 (JP8) exposure by examining potential differences in urinary 1- and 2-naphthols (absorbed dose) between a priori designated exposure groups and assess the relationship between absorbed dose and concurrent measurements of inhalation and dermal exposure levels.
Methods: The study population included 24 Air Force (AF) personnel from six to eight different job types from an active USAF base. Based on a review of job activities, the participants were recruited from three a priori designated exposure groups (low: six workers with administrative or office roles;

moderate: nine workers with fuel distribution jobs, and high: nine workers from fuel systems maintenance). In January 2007, urine samples (n=144) were collected pre- and post-shift over three consecutive workshifts and analysed for 1- and 2-naphthol via gas chromatography mass spectrometry (GC/MS). Personal air (n=72) and dermal tape-strip (n=72) samples were collected concurrently from each worker and analysed for benzene, toluene, ethylbenzene, xylene (BTEX) and naphthalene via GC/MS. Linear mixed effects models were used to evaluate the exposure data.

Results: In post-shift urine samples, the mean urinary 1-naphthol measurements in the high exposure group were sevenfold higher than in the moderate group ($p=0.0005$) and ninefold higher than in the low group ($p=0.0004$). Similarly, the mean urinary 2-naphthol measurements in the high exposure group were fourfold higher than both the moderate ($p=0.0007$) and low groups ($p=0.002$). However, the 1- and 2-naphthol measurements in the moderate group were not significantly higher than in the low group. Exposure group and smoking status explain 62% and 63% of the between-worker variability for 1- and 2-naphthol, respectively. Analyses of personal air and dermal samples are forthcoming and will be used to evaluate the effect of inhalation and dermal exposure on absorbed dose.

Conclusion: The a priori exposure categories and smoking status are significant determinants of urinary naphthols. Based on absorbed dose levels, the fuel systems maintenance workers experience higher JP8 exposures than the fuel distribution and office workers, while levels among fuel distribution workers are not significantly higher than the office workers.

Key words: jet fuel; biomarkers; inhalation and dermal exposure

102 SERUM DIOXIN LEVELS IN FORMER SAWMILL WORKERS 20 YEARS AFTER EXPOSURE TO PENTACHLOROPHENOL (PCP) CEASED

D. J. McLean[1], A. Eng[2], C. Walls[3], E. Dryson[3], J. Harawira[4], A 't. Mannetje[2], M. Gray[2], P. Shoemack[5], N. Pearce[2], C. Brooks[2]. [1]*Massey University;* [2]*Centre for Public Health Research, Massey University;* [3]*Occupational Medicine Specialists;* [4]*Ngatiawa Social and Health Services;* [5]*Bay of Plenty District Health Board*

Objectives: From the 1950s to the late 1980s fungicides containing pentachlorophenol (PCP) were widely used in the New Zealand sawmill industry to prevent the proliferation of sapstain fungi. Workers involved in the treatment process or handling treated timber are known to have experienced significant PCP exposure. Commercial grade PCP contained contaminants including the 2,3,7,8-substituted polychlorinated dibenzo-p-dioxin (PCDD) and dibenzofuran (PCDF) congeners. The objectives of this study were to test serum dioxin levels in former sawmill workers 20 years after PCP use had ceased and to compare these with levels in the general population and also to establish whether elevated dioxin levels were the result of occupational PCP exposure.

Methods: Serum dioxin levels were analysed in two groups of former sawmill workers, 22 volunteers who had lodged claims for compensation (known as Sawmill Workers Against Poisons or SWAP) and 58 individuals randomly selected from surviving members of a cohort enumerated for a study of mortality and cancer incidence in former sawmill workers. This latter group was divided into 34 exposed and 24 non-exposed individuals based on work history. Age-adjusted serum dioxin levels in the general New Zealand population determined in a 1991 survey were compared with levels found in former sawmill workers with a correction based on a 7-year half-life. To establish the link with occupational exposure we compared dioxin congener profiles with those found in the general population and also in commercial grade PCP. We also tested the correlation between dioxin levels and known PCP in urine levels associated with different job titles.

Results: For SWAP members, both the WHO-TEQ and levels of specific hexa-, hepta- and octa-chlorinated congeners were at least 10 times those in the general population. Preliminary analyses of the randomly selected group suggest similar elevations in WHO-TEQ and the same specific congeners. Additional results of tests of the second group, and of the association with specific jobs, will be presented.

Conclusion: Serum dioxin levels in former sawmill workers in New Zealand are significantly elevated 20 years after the use of PCP ceased, and the congener profiles indicate that the source is past occupational exposure to PCP.

Key words: sawmill workers; dioxins; chlorophenols

TRAC08 Meeting presentation Abstract

Exposure Assessment in Occupational Epidemiology: Issues Related to Jet Fuels
SP Proctor (USARIEM)

This presentation will provide an overview of issues related to the assessment of exposure to jet fuel in occupational epidemiology, with specific focus on the factors related to selection of the appropriate marker(s) to use to measure exposure depending on the research question of interest.

First, a review of epidemiological design methods will be presented. Examples of different research designs, reflective of the particular research question of importance, will be described.

Next, principles of exposure assessment specific to jet fuel will be identified. Jet fuels are largely a mixture of hundreds of different chemical compounds (with thousands of different isomer forms). So, identification of the appropriate marker(s) to measure to provide an indication of degree of exposure or dose will depend on what is feasible given the state of the science and the research question of interest.

Then, aspects of previous and on-going research efforts designed to examine the relationships between exposure to JP8 as well as earlier jet fuel mixtures (JP5 and JP4) and human health effects in occupational settings will be presented as case examples. The examples will include a review of several earlier research efforts in Sweden and the more recent Air Force study, as well as our current research investigation examining exposure to JP8 over consecutive workdays.

[The views expressed are those of the authors and do not reflect the official policy of the Federal Government, including the Department of Defense.]

Accepted Abstract- at the upcoming International Society of Exposure Assessment (ISEA) meeting in October 2008 in Pasadena, CA.

Repeated measures of inhalation and dermal exposure to jet fuel among Air Force personnel

Smith KW, Allen JG, Proctor SP, McClean MD.

Objectives: The primary objectives of this study were to characterize inhalation and dermal exposure to jet propulsion fuel 8 (JP-8) based on measured levels of total hydrocarbons, naphthalene, benzene, toluene, ethylbenzene, and xylene (BTEX) in personal air and dermal tape-strip samples. We evaluated potential differences in exposure between *a priori* designated exposure groups, identified significant determinants of inhalation and dermal exposure to JP-8 constituents, and evaluated the relationships between total hydrocarbons, naphthalene, and BTEX.
Methods: The study population included 24 Air Force (AF) personnel recruited from an active USAF base. Based on job title and a review of job activities, participants were recruited from three *a priori* designated exposure groups (low: 6 office workers with no regular exposure to JP-8; moderate: 9 workers with fuel distribution jobs with intermittent exposure to JP-8, and high: 9 workers from fuel systems maintenance with regular exposure to JP-8). In January 2007, personal air samples were collected from the breathing zone of each worker over three consecutive work-shifts (n=72) and analyzed for total hydrocarbons via GC/FID, as well as BTEX and naphthalene via GC/MS. Dermal tape-strip samples were collected post-shift over three consecutive work-shifts (n=72) and analyzed for the same analytes. Linear mixed effects models were used to evaluate the exposure data.
Results: The geometric mean air concentrations for participants in the low, moderate, and high exposure groups were 0.3, 1.7, 5.1 mg/m^3 for total hydrocarbons and 0.3, 0.4, 0.9 ug/m^3 for naphthalene, while results for BTEX were similarly ordered. The correlations between THC and the other analytes were strong as indicated by correlation coefficients ranging from 0.83 to 0.95. Significant predictors of inhalation exposure to JP-8 included the *a priori* assigned exposure categories (low, moderate, high) and task (working in the hangar, hangar office, refueling maintenance, fuel handling, other). Among highly exposed workers, time spent in the hangar was a significant predictor of inhalation exposure to JP-8. In this group, inhalation exposure appeared to be affected by job (entrant, attendant/runner, other) and purpose of work (inspect, find leak, repair leak, other), though the results for these variables were not statistically significant. For all analytes, dermal tape-strip concentrations were below the limit of detection in >75% of the samples.
Conclusions: Total hydrocarbons exposure was strongly correlated with naphthalene and BTEX, suggesting that exposures came from the same source. Significant determinants of inhalation exposure levels were the *a priori* exposure groups and the worker's task.

[The views expressed are those of the authors and do not reflect the official policy of the Federal Government, including the Department of Defense.]