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Workplace Safety and Health

Occupational Energy Research Program

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

NIOSH

Occupational Energy Research Program

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Preface

This *Occupational Energy Research Program* book presents an overview of the occupational health research program conducted under the 2000 Memorandum of Understanding between the Department of Energy (DOE) and the Department of Health and Human Services (DHHS). The Centers for Disease Control and Prevention/National Institute for Occupational Safety and Health (NIOSH) Health-Related Energy Research Branch (HERB) within DHHS conducts a program of independent occupational research with funding from DOE. The reader will find information addressing studies conducted internally by NIOSH staff; studies conducted externally through NIOSH-supported contracts, grants, and cooperative agreements; DOE worker surveillance projects with NIOSH involvement; and administrative and programmatic details. The time frame presented includes current and proposed occupational research activities through Fiscal Year (FY) 2000. The information in this document is current as of December 1, 2000, and replaces the previous *Occupational Energy Research Program* book dated October 1998.

The DOE Office of Health Studies (EH–6) serves as the primary DOE liaison to NIOSH. This office also oversees the DOE worker surveillance cooperative agreement projects.

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List of Acronyms, Abbreviations and Symbols

ACERER	Advisory Committee on Energy-Related Epidemiologic Research
ATSDR	Agency for Toxic Substances and Disease Registry
Bq	Bequerel
	Centers for Disease Control and Prevention
	Comprehensive Epidemiologic Data Resource
CI	Confidence Interval
CNS	Central Nervous System
DHHS	Department of Health and Human Services
DOE	
FTE	Full-Time Equivalent
FY	Fiscal Year
	Health Hazard Evaluation
	International Agency for Research on Cancer
K–25	Codename for Oak Ridge Gaseous Diffusion Plant
mSv	Millisievert
	Sample Size/Number of Subjects
	National Center for Environmental Health
	National Cancer Institute
nCi	
NIOSH	
NORA	
ORAU	Oak Ridge Associated Universities
ORISE	Oak Ridge Institute for Science and Education
ORNL	Oak Ridge National Laboratory
P	(Probability) Value
	Battelle Pacific Northwest Laboratory
Po	Polonium
Pu	
REM	
RR	Rate Ratio, Risk Ratio, Relative Risk
SMR	Standard Mortality Ratio
SRR	Standard Rate Ratio
SRS	Savannah River Site
WWII	World War II
X–10	
Y–12	Codename for Oak Ridge Y-12 Plant
Zia	Zia Company, a Los Alamos National Laboratory contractor

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Research Agenda

Background

Despite the research conducted over the past several decades, essential data are lacking for assessing health risks from radiation exposures. The magnitude of risks associated with chronic low-level radiation exposure is the subject of much scientific and policy debate. The results from many occupational studies provide evidence that the current occupational limit of 5 roentgen equivalent man (rem) per year may not adequately protect workers exposed to chronic, low-level radiation. Further studies are needed on workers exposed to low-level ionizing radiation to better understand attendant health risks and provide greater protection of workers' health.

Reasons for an Energy-Related Health Research Program

1. Current 5 rem occupational limit may be inadequate to protect workers.
2. Worker cohorts are more relevant to occupational exposure limits than atomic bomb survivor cohorts.
3. Past cohort studies did not include minorities or women.
4. Latency in DOE cohorts is now sufficient to study cancer and other chronic health effects.
5. DOE records and institutional memory are currently available.
6. Multiple exposures and other demographic and lifestyle factors can be addressed in study design and analysis.
7. Application of the linear nonthreshold risk model for low-level chronic exposure warrants further study.
8. Findings are relevant to 300,000 nuclear facility workers and the 1.5 million radiation- exposed U.S. workers and to all stakeholders.

A number of worker cohorts at U.S. Department of Energy (DOE) sites have been previously studied. Results from these cohorts, although somewhat inconsistent and uncertain, have lead many scientists to believe that workers' health has been affected. Most notable is the substantial evidence of excess cancer risk.

For many important reasons, the next decade is the best possible time to continue epidemiologic studies of DOE workers. The workers are dying at increasing rates as this population ages. Larger numbers of deaths in mortality studies mean greater power to detect meaningful changes in risk that might be associated with radiation and chemical exposures. Also, DOE site workers were monitored for radiation exposure and, over the past decade, many methods have been developed to better account for bias and uncertainty in monitoring data. Risk estimates based on continuing analysis of these mature cohorts will substantially reduce the current uncertainty and perhaps suggest the need for changes in exposure limits. Futhermore, risk estimates based on survivors within these cohorts may lead to the development of more accurate and precise exposure estimates. In contrast to external radiation monitoring, available information about other forms of radiation exposures

and chemical exposures is much more limited. Workers' memories of practices and exposure potentials may be used to increase the precision and accuracy of exposure estimates. The capacity to characterize significant exposures associated with DOE operations will continue to diminish as more and more of these workers die.

The reliability of epidemiology studies is greatly improved by incorporating detailed and accurate exposure metrics into analyses. Advanced data systems are now available that increase the ability to combine records from an array of sources and perform analyses that were previously impractical.

NIOSH Research Program Agenda

The agenda for the National Institute for Occupational Safety and Health (NIOSH)/Health-Related Energy Research Branch (HERB) radiation research program has been developed and updated with input from experts in relevant research fields, representatives of labor and community organizations, and American Indian Tribes. The Department of Health and Human Services' (DHHS) Advisory Committee for Energy-Related Epidemiologic Research (ACERER) has reviewed and evaluated the NIOSH research agenda. In addition, the DOE Office of Health Studies (formerly the Office of Epidemiology and Health Surveillance) has recommended research topics that have been adopted in most cases.

Who is HERB?

HERB is the Health-Related Energy Research Branch at the National Institute for Occupational Safety and Health in Cincinnati, Ohio. The Branch, which was organized in 1991, is staffed with scientists in health physics, epidemiology, and exposure assessment and experts in record management and data analysis. Research is conducted under a Memorandum of Understanding with the U.S. Department of Energy which provides funding.

HERB is currently engaged in more than 25 research projects to characterize exposure and health effects in current and historical DOE site work forces. This research is being conducted intramurally by HERB researchers and through extramural contracts, grants, or cooperative agreements. Each of these studies (Table I) addresses vital health issues related to chemical and radiation exposures at DOE facilities.

The NIOSH epidemiology research program described in this booklet will lead to more reliable risk estimates for exposures to radiation and chemicals not only for DOE workers, but for all workers. Because no single study can remove all uncertainty from the current risk estimates, multiple studies are included in this agenda.

Current limits on occupational exposures to ionizing radiation are based on data from the atomic bomb survivors and from medical patients in radiation treatment programs. These populations are largely not representative of U.S. workers. The atomic bomb survivors are of Japanese ethnicity and the studies of this population continue to revise exposure estimates because of the absence of monitoring data. Importantly, both the bomb survivors and the medical patients

received relatively high radiation doses over short time periods. In contrast, workers are typically exposed to low levels of radiation over decades, and personal monitoring data are available for most study subjects.

Recent occupational studies completed under HERB's sponsorship and direction have shown evidence that the 5 rem per year occupational limit may not provide adequate protection to workers. Multisite retrospective studies currently underway will provide the additional information to evaluate the adequacy of the current limit.

Study Designs

Most epidemiologic studies of radiation workers have been cohort mortality studies that, until recently, were limited largely to relatively crude overall measures of death rates (SMRs comparing the monitored working population with the general U.S. death rates). NIOSH has developed or sponsored several research projects to improve the limitations of the cohort mortality study, including a cancer incidence study at the Rocky Flats plant. NIOSH is implementing current analytic methods in multisite case-control studies of leukemia, multiple myeloma, and lung cancer. The combined cohorts in these multisite studies increase power by comparing populations with similar exposures, or with different exposures. Cohorts of female workers employed across twelve DOE sites have also been combined for a mortality study that has been completed.

Current Radiation Workers

The National Council on Radiation Protection and Measurements estimates that 1.5 million U.S. workers are occupationally exposed to ionizing radiation each year. Of this number, approximately 120,000 workers are monitored each year for radiation exposure at DOE facilities. In addition, the results of the NIOSH research program will be relevant to the approximately 300,000 workers potentially exposed to radiation each year at commercial nuclear facilities.

Most previous studies of DOE workers have focused exclusively on the occurrence of cancer. Though this is clearly a major health problem in evaluating the effects of radiation, it is not the only adverse health outcome of concern in this population. NIOSH has funded studies of neurologic impairment among mercury-exposed DOE workers, as well as chronic beryllium disease (a serious debilitating lung disease) among workers at DOE facilities. Although it is difficult to conduct traditional studies of clinically recognized pregnancy outcomes among DOE workers (because of the number of women required for these studies), the reproductive health of male and female DOE workers may be assessed using appropriate biomarker studies with much smaller numbers of workers. NIOSH is proposing studies of this type.

Exposure Assessment

In addition to radiation exposures, workers at DOE facilities have also experienced exposure to a variety of physical agents and chemicals, some of which are unique to these facilities. The contribution of these exposures to worker health risks is being determined in many studies. In some cases, the chemical exposures may actually be the primary concern for certain health outcomes. For example, studies on the effects of beryllium and mercury have been or will be completed. Additionally, exposure data are being collected for use in all of the case-control studies and several of the cohort studies underway.

Principal objectives in the NIOSH studies are (1) to develop and use improved methods to estimate uncertainties and biases in exposure assessments, and (2) conduct more comprehensive exposure assessments of internal and external radiation, as well as chemicals. A wide variety of chemical and other physical hazards has been prevalent at DOE facilities. Many workers have been exposed to solvents, metals, and other substances, as well as excessive noise, heat, and non-ionizing radiation.

All epidemiology studies being performed or funded by NIOSH attempt, to the extent possible, to quantify exposure to these hazards since many cause a variety of health effects, including cancer. In addition, NIOSH is funding three activities whose purpose is to provide improved exposure assessment methodologies for use in epidemiologic studies.

Hanford worker handles plutonium residues in a glovebox. *200 West Area, Hanford Site, Richland, Washington. December 1995. Photo courtesy of the U.S. Department of Energy.*

New Study Sites

Many of the workers at approximately 20 major DOE sites have been studied epidemiologically, some of them for decades. NIOSH continues to update these studies as warranted by public health and scientific considerations. As these cohorts age, and as more powerful epidemiologic study designs become available, new studies of these workers should provide better information about health risks associated with radiation exposure.

On the other hand, workers at several DOE sites have not been well studied. These sites include five of the national laboratories and the Nevada test site. Based on the preliminary evaluations of exposures experienced at these facilities, studies of these sites have not been initiated; however, NIOSH is currently conducting the first analytical epidemiology study of one of the largest DOE facilities, the Idaho National Engineering and Environmental Laboratory, which has employed over 70,000 workers since construction began in 1949.

Current DOE Workers

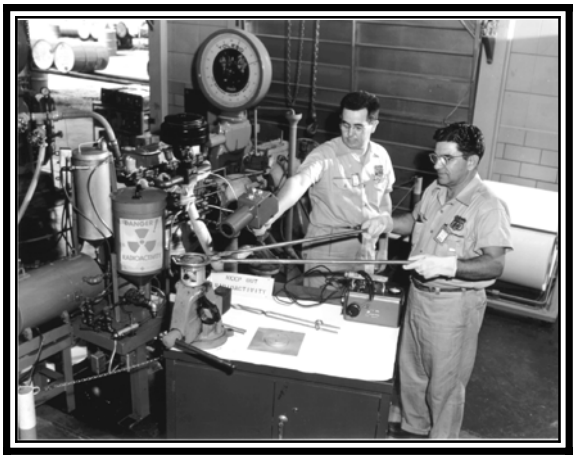
As the primary mission at DOE changes from production and testing of nuclear weapons to decontamination and decommissioning (i.e.,"cleanup"), the challenges facing its workforce have also changed dramatically. NIOSH investigators are conducting a phased approach to define and characterize exposure hazards encountered by workers who handle wastes or are otherwise involved with cleanup activities within the DOE complex.

Another substantial concern faced by current DOE workers is the potential adverse health effects of re-organization and downsizing. These health consequences may affect not only those workers whose jobs are lost, but also those remaining on the job. A recently completed NIOSH cooperative agreement identified health problems related to downsizing, and suggested multiple prevention and intervention strategies.

The composition of the ongoing epidemiologic studies at NIOSH and elsewhere helps to ensure the public health of workers and communities, not only in the United States, but around the world.

National Occupational Research Agenda (NORA)

NIOSH - HERB's research program also addresses several of the NORA priority research areas. These include: mixed exposures, organization of work, special populations at risk, fertility and pregnancy abnormalities, cancer research methods, exposure assessment methods, and surveillance research methods. For more information on NORA, see (DHHS) NIOSH Publication No. 96-115.



Automatic Count recorder for Radioactive Test Engine. *Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho. 1955. Photo courtesy of the U.S. Department of Energy.*

Vision/Mission/Goals

Vision

Through scientific research, promote the health and well-being of all workers.

Mission

To conduct thorough and unbiased research on the health risks from exposure to physical, chemical, and other stressors for current and former DOE workers using the best available methods to promote adequate protection for all workers.

Purposes

To more fully understand radiation cancer risk factors in occupational cohorts.

To evaluate the significance of health outcomes in the DOE and other radiation exposed workers.

To inform workers, the scientific community, and the public of the health risks associated with exposures to radiological, chemical, and other stressors.

Program Goals

Assure that energy-related health research addresses pertinent occupational health questions and provides a framework for intervention.

Conduct research in an open environment with meaningful communication among all interested parties.

Capture the vanishing opportunities to study groups of people with unique exposure to radiation, chemical, and other stressors.

Develop improved methods for associating occupational exposures and consequent health risks.

Recommend improved protective measures for workers if scientific evidence indicates that regulations or practices are inadequate.

Research Goals

Epidemiologic Research

Evaluate possible relationships between workplace exposures and injury or disease using the best available methodologies.

Analyze combined populations to assess whether certain rare cancers are related to past occupational exposures.

Examine the relationships of mixed exposures and worker health.

Provide epidemiologic research findings which enhance the understanding of the effects of low-level protracted exposure to ionizing radiation in Department of Energy workers and others.

Exposure Assessment

Improve exposure assessment methods to reduce uncertainty in mortality and morbidity studies.

Characterize the combined exposures experienced by Department of Energy workers for use in epidemiologic analyses.

Emphasize quantitative (vs. qualitative) relationships between exposure and health outcomes.

Evaluate the quality and validity of the available worker exposure data.

Communication Goals

Develop better mechanisms for generating research hypotheses by expanding the involvement of partners and actively seeking their input.

Conduct research in an open environment with attention to clear and accurate education of workers and the public.

Provide information that enhances the understanding of risks associated with radiation-induced health effects.

Solicit and consider worker interests and the public’s concerns.

Provide relevant occupational exposure and health outcome information for public health research and policy.

NIOSH Energy-Related Health Research Branch

Performance Measures

The number of novel research methods and applications conceptualized, developed, and used to enhance understanding of exposures and health effects in the DOE workforce.

The extent to which program findings are considered in developing of recommendations for intervention and prevention.

The extent to which recommendations for intervention and prevention are used to protect worker health.

The use of program findings in risk assessments by standard setting organizations.

The timeliness and cost efficiency of scientifically appropriate and feasible health research studies.

The timeliness of presenting study findings, publication of significant results, and effective communication of study conclusions.

The quality and range of research projects, partners engaged in the research program, and the nature of interactions with stakeholders.

Research Issues and Needs

Relevant to Department of Energy Workers
and Applicable to All Radiation-Exposed Workers

The following research issues and needs were identified by HERB staff, stakeholders, and NIOSH research partners:

Health risks associated with low-level protracted exposure to ionizing radiation need to be identified, fully examined, understood, and effectively communicated.

The exposure-response relationship between health effects and low-level ionizing radiation, including dose rate, needs to be characterized to determine whether practical thresholds can be derived.

Forms of radiation (e.g., external vs. internal) associated with specific cancer types need to be clearly established.

The effect of exposure to multiple physical and chemical agents needs to be addressed in the design and analysis of radiation health effects studies.

The contribution to health effects from nonoccupational radiation exposures, including medical treatment or diagnostic procedures, needs to be evaluated.

Exposures and stressors experienced by the current DOE workforce, including site remediation workers, need to be characterized.

Health effects other than cancer mortality warrant study (including chronic beryllium disease, pulmonary fibrosis from plutonium and other nonmalignant respiratory diseases, and reproductive, neurobehavioral, psychological and organizational stress effects).

Complete (minorities and both genders included) and mature (adequate latency) occupational cohort studies that include well designed internal comparison strategies are needed. Within these studies, case-control designs allowing for detailed exposure assessment and analysis are warranted.

Efforts to record workers' institutional memories of past practices, activities, exposures, and record systems are essential for retrospective epidemiologic studies. Sources for the information are rapidly diminishing as the cohort ages and the DOE sites change mission or are shut down.

The impact of worker age on the relation between occupational radiation exposure and health effects needs to be characterized and incorporated into study design and analysis. Analytic and design methods to account for exposure and demographic differences across sites need to be developed for and applied to multisite studies.

Studies of current workers need to include, when appropriate, biological markers of exposure and health effects to enhance records-based or self-reported information.

Table I: Research Issues Addressed by Research Projects
NIOSH Occupational Energy Research Program
December 2000

(See Notes at end of Table)

Major research issues	Ongoing projects				
	Cohort Mortality Study of Idaho Engineering and Environmental Laboratory Workers Study ID: INEL	Cohort Mortality Study of Portsmouth Naval Shipyard Study ID: PNSP	Leukemia Case-Control Study Study ID: LCCS	Multiple Myeloma Case-Control Study at the Oak Ridge Gaseous Diffusion Plant (K–25) Study ID: MMCC	Cohort Mortality Study of DOE Chemical Laboratory Workers Study ID: CLWS
Unstudied sites	INL				
New followup data				K–25	K–25, Y–12, ORN, SRP
Unstudied factors		PNS	HNF, LAN, PNS, SRP, X–10	K–25	K–25, Y–12, ORN, SRP
Non-cancer effects					
Primarily external radiation		PNS			
Internal emitters				K–25	K–25, Y–12, ORN, SRP
Chemical exposures		PNS	HNF, LAN, PNS, SRP, X–10		K–25, Y–12, ORN, SRP
Exposure methods					K–25, Y–12, ORN, SRP
Current workers					
Underserved groups	INL		HNF, LAN, PNS, SRP, X–10	K–25	K–25, Y–12, ORN, SRP
Multiple sites			HNF, LAN, PNS, SRP, X–10		K–25, Y–12, ORN, SRP
Stakeholder requests	INL			K–25	
Contribute to other studies	INL	PNS			
Support surveillance					
Support intervention					

Continued

(Continued)

	Exposure Assessment of Hazardous Waste, Decontamination, and Decommissioning, and Cleanup Workers (Phase I) Study ID: HAWW	Lung Cancer Case-Control Study Study ID: LUNG	Construction Workers Mortality Study Study ID: CONS	Feasibility Study for an Integrated Database for DOE Site Remedation Workers Study ID: DDWR	Cohort Mortality Study of Fernald Environmental Management Plant Study ID: FNUP
Unstudied sites					
New followup data		HNF, INL, SRP, X–10	X–10, HNF		FRN
Unstudied factors	FRN, HNF, MND, SRP, ORN, K–25, Y–12, INL, RFP				
Non-cancer effects					FRN
Primarily external radiation		HNF, INL, SRP, X–10			
Internal emitters					
Chemical exposures	FRN, HNF, MND, SRP, ORN, K–25, Y–12, INL, RFP				FRN
Exposure methods	FRN, HNF, MND, SRP, ORN, K–25, Y–12, INL, RFP		X–10, HNF		FRN
Current workers	FRN, HNF, MND, SRP, ORN, K–25, Y–12, INL, RFP		X–10, HNF	FRN	
Underserved groups	FRN, HNF, MND, SRP, ORN, K–25, Y–12, INL, RFP	HNF, INL, SRP, X–10			FRN
Multiple sites	FRN, HNF, MND, SRP, ORN, K–25, Y–12, INL, RFP	HNF, INL, SRP, X–10	X–10, HNF		
Stakeholder requests	FRN, HNF, MND, SRP, ORN, K–25, Y–12, INL, RFP	HNF, INL, SRP, X–10	X–10, HNF	FRN	FRN
Contribute to other studies					
Support surveillance	FRN, HNF, MND, SRP, ORN, K–25, Y–12, INL, RFP	HNF, INL, SRP, X–10		FRN	
Support intervention	FRN, HNF, MND, SRP, ORN, K–25, Y–12, INL, RFP	HNF, INL, SRP, X–10			

Continued

	Exposure Assessment of Radiologic Technologists for Epidemiology Studies Study ID: XRAY	Cancer Incidence Study of Rocky Flats Plant Study ID: RKFL	International Collaborative Study of Nuclear Industry Workers Study ID: IARC	Chronic Beryllium Disease Among Beryllium-Exposed Workers Study ID: BER1	Beryllium Disease Natural History and Exposure Response Study ID: BER2
Unstudied sites			INL		
New followup data		RFP	INL, PNS		
Unstudied factors					
Non-cancer effects				Non-DOE	Non-DOE
Primarily external radiation	XRAY		INL, PNS		
Internal emitters					
Chemical exposures		RFP		Non-DOE	Non-DOE
Exposure methods	XRAY		INL, PNS	Non-DOE	Non-DOE
Current workers				Non-DOE	Non-DOE
Underserved groups	XRAY	RFP			
Multiple sites	XRAY		INL, PNS	Non-DOE	Non-DOE
Stakeholder requests		RFP		Non-DOE	Non-DOE
Contribute to other studies			INL, PNS		
Support surveillance				Non-DOE	Non-DOE
Support intervention				Non-DOE	Non-DOE

Continued

	Measurement Error Methods for Underground Miner Studies Study ID: MEUM	Studies of Heat Stress and Performance in Carpenters at DOE Sites Study ID: HTST	Ionizing Radiation and Mortality Among Hanford Workers Study ID: HANF	Acute Radiation Syndrome in Russian Nuclear Workers Study ID: ARSR	Surveillance Methods for Solvent-Related Hepatotoxicity, a Cross-Sectional Study at Hanford Study ID: SEES
Unstudied sites					
New followup data			HNF		
Unstudied factors			HNF		
Non-cancer effects		HNF, ORN	HNF	Non-DOE	HNF
Primarily external radiation					
Internal emitters	U				
Chemical exposures					
Exposure methods	U	HNF, ORN	HNF		
Current workers		HNF, ORN			HNF
Underserved groups	U				
Multiple sites					
Stakeholder requests	U	HNF, ORN	HNF		
Contribute to other studies					
Support surveillance		HNF, ORN			HNF
Support intervention					

Continued

	Radon and Cigarette Smoking Exposure Assessment in Fernald Workers Study ID: PFRS	Correcting for Measurement Errors in Radiation Exposure Study ID: CMER	Epidemiologic Studies to Evaluate Health Effects of Uranium Milling Study ID: EPUM	Dose of Beryllium Causing Sensitization and Disease Study ID: DCDS	Analysis for Characterizing Plutonium Exposure to Improve Lung Cancer Risk Estimates Study ID: ACPE
Unstudied sites					
New followup data					
Unstudied factors				TBD	TBD
Non-cancer effects					
Primarily external radiation		TBD			
Internal emitters			TBD		TBD
Chemical exposures	FRN		TBD	TBD	
Exposure methods	FRN	TBD	TBD	TBD	TBD
Current workers	FRN				
Underserved groups				TBD	
Multiple sites					
Stakeholder requests	FRN				
Contribute to other studies	FRN	TBD	TBD		TBD
Support surveillance	FRN				
Support intervention					

Continued

	Cohort Mortality Study of Civilian Nuclear Power Workers Study ID: CNPW	Evaluating Time-Related Variables in Occupational Epidemiologic Studies Study ID: AEWP	Neutron Exposure Assessment in Epidemiology Studies of DOE Cohorts Study ID: NUTR	Documentation of Historical Dosimetry Practices at DOE Sites Study ID: HDP1	Exposure Assessment of Hazardous Waste, Decontamination, and Decommissioning, and Cleanup Workers (Phases II & III) Study ID: HAWW
Unstudied sites	TBD		TBD		
New followup data	TBD				
Unstudied factors	TBD	TBD	TBD		TBD
Non-cancer effects					
Primarily external radiation	TBD		TBD		
Internal emitters					
Chemical exposures					TBD
Exposure methods			TBD	TBD	TBD
Current workers	TBD				TBD
Underserved groups	TBD				TBD
Multiple sites	TBD		TBD	TBD	TBD
Stakeholder requests	TBD		TBD		TBD
Contribute to other studies	TBD				
Support surveillance					TBD
Support intervention					TBD

Continued

	Update of Cohort Mortality Study of Mound Workers Study ID: MCMS	Medical/Off-Site Radiation Exposures Study ID: MORE	Brain Cancer Case-Control Study Study ID: BRAN	Bone Cancer Case-Control Study Study ID: BONE	JEM Data Sensitivity Analysis Study ID: JEMS
Unstudied sites					
New followup data	MND		TBD	TBD	
Unstudied factors		K–25	TBD	TBD	
Non-cancer effects					
Primarily external radiation		K–25		TBD	
Internal emitters					
Chemical exposures					
Exposure methods		K–25			TBD
Current workers					
Underserved groups					
Multiple sites					
Stakeholder requests					
Contribute to other studies		K–25			
Support surveillance					
Support intervention					

Notes for Table I: Major research issues for proposed projects at various DOE sites

This table communicates the purpose, variety and content of the NIOSH/HERB Occupational Radiation Research Program. It identifies the major research issues within each project and also contains the name of the DOE sites or facilities where each study is being conducted. The following information is a key to the site and facility acronyms and a brief description for the titles of the research issues.

Abbreviation Key

FRN	Feed Materials Production Center (Fernald). *Ohio*
HNF	Hanford Site. *Washington*
INL	Idaho National Engineering and Environmental Laboratory. *Idaho*
K–25	K-25 Site. *Tennessee*
LAN	Los Alamos National Laboratory. *New Mexico*
MND	Mound Site. *Ohio*
ORN	Oak Ridge Site. (Includes K-25, X-10, Y-12) *Tennessee*
PNS	Portsmouth Naval Shipyard. *Maine*
RFP	Rocky Flats Plant. *Colorado*
SRP	Savannah River Plant. *South Carolina*
TBD	To be determined
U	Uranium Miners Cohort. *Colorado, Utah, New Mexico*
XRAY	Radiation Technologists Study (in collaboration with National Cancer Institute). *All States*
X–10	Oak Ridge National Laboratory. *Tennessee*
Y–12	Y-12 Plant. *Tennessee*

Research Issues Key (Brief Descriptions)

Unstudied sites: Conduct epidemiologic studies among workers at DOE sites that have not been studied to date.

New followup data: Improve study statistical power with new follow-up data (for example, adding additional worker years of experience to update a previous mortality study).

Unstudied factors: Improve study precision by analyzing previously unstudied factors

(for example, chemicals) in appropriate study designs.

Non-cancer effects: Study the relationship between worker exposures and the risk of noncancer health effects (for example, stress in workers in downsized facilities).

Primarily external radiation: Evaluate work exposure to primarily external radiation at sites where internal radiation exposure is minimal.

Internal emitters: Evaluate work exposure to separate the effects of internal emitter exposures from effects due to other exposures.

Chemical exposures: Evaluate the effects of contributions from chemical exposures.

Exposure methods: Develop methods of exposure assessment from sets of existing data.

Current workers: Conduct epidemiologic studies among current workers at DOE sites.

Underserved groups: Identify and study female and minority worker groups of sufficient size to offer meaningful health effects information to these groups.

Multiple sites: Conduct epidemiologic studies among workers at multiple DOE sites to strengthen study statistical power and broaden applicability of study findings.

Stakeholder requests: Respond to stakeholder requests to address study issues.

Contribute to other studies: Use study data to contribute to other significant multisite studies or to improve/enhance other research study efforts.

Support surveillance: Use study findings to support and enhance medical or exposure surveillance activities at sites.

Support intervention: Use study findings to suggest, support, or enhance intervention activities at DOE sites.

Worker Outreach and Communication

The Health-Related Energy Research Branch (HERB) has a responsibility to communicate with the workers, the community, Native American Tribes, DOE, and the scientific community about its research on the health risks associated with exposure to radiologic, chemical, and other stressors.

One of the goals of the HERB research program is to "conduct research in an open environment with meaningful communication among all interested parties." This is of critical importance. The historic perceptions of secrecy and the heightened awareness and concern regarding the impact of DOE sites on health necessitate the conduct of occupational health research in an open manner. We have set forth several objectives that we believe will help us to achieve this goal:

1. Interact and maintain a dialogue with all interested parties
2. Identify a variety of ways to conduct and enhance worker outreach
3. Communicate all study findings effectively and without bias
4. Provide individual worker notification of study results when appropriate
5. Evaluate effectiveness of all phases of worker outreach/community involvement

The efforts that we have undertaken (or are planning), to address these objectives are discussed below.

Objective 1: Interact and maintain a dialogue with all interested parties

The NIOSH/DOE partners and stakeholders meeting historically has been held annually at the NIOSH Hamilton Laboratory in Cincinnati, OH. The meeting is sponsored by NIOSH in coordination with DOE for the extramural research groups that have cooperative agreements, contracts, or grants with NIOSH in energy-related epidemiologic research. DOE medical surveillance cooperative agreement holders are also invited to attend and participate as a part the NIOSH role to provide for oversight review.

The goals of the meeting are as follows:

- Allow NIOSH and DOE to present an overview of their intramural and extramural occupational research programs in energy-related epidemiologic and medical surveillance areas associated with the DOE nuclear weapons complex.
- Provide a forum for the extramural research groups to present their current progress and anticipated future activities as they relate to the various Federal legislative mandates and the programmatic interests of DOE and NIOSH.
- Allow discussion of general and site-specific issues of interest that are unique to DOE contractor and subcontractor workers.
- Provide an opportunity for scientific exchange, collaboration, and cooperation among the extramural research groups and the DOE and NIOSH staffs.

The Centers for Disease Control and Prevention (CDC) and the Agency for Toxic Substances and Disease Registry (ATSDR) have initiated a community involvement program. In 1994, CDC and ATSDR chartered the Citizens Advisory Committee on Public Health Service Activities and Research at DOE sites after holding meetings with stakeholders. HERB has historically sought to include workers and workplace issues in this program. The Citizens Advisory Committee is composed of five health effects subcommittees (the Hanford site, the Savannah River plant, the Idaho National Engineering and Environmental Laboratory, the Oak Ridge facilities, and the Fernald plant). The purpose of the Citizens Advisory Committee is to provide CDC and ATSDR with consensus advice and recommendations regarding issues and concerns at DOE sites.

HERB staff communicates with site-specific health effects subcommittees on a variety of issues, as needed (e.g., study protocols, peer reviewers, progress reports, study results, and problems encountered). Currently, NIOSH devotes most of its efforts to enhancing communication with current and former workers of the DOE facilities. NIOSH holds meetings with labor representatives to discuss research activities and solicit any questions and concerns workers may have. Additionally, NIOSH provides labor groups with supplemental materials (NIOSH pamphlets, one-page study summaries, NIOSH-HERB Program Book, etc.).

Objective 2: Identify and use methods to conduct and enhance worker outreach

Multiple methods are used that enable NIOSH/HERB to communicate effectively with current and former workers about occupational research activities it conducts at DOE sites. These communications also give workers the opportunity to learn about the availability of NIOSH technical assistance such as Health Hazard Evaluations, the NIOSH toll free number for occupational health and safety information, and NIOSH technical documents and CD-ROMs that can be used to address safety and health concerns. Communication methods include the following:

- Conference calls and on-site meetings that allow workers to learn more about current and proposed NIOSH occupational health research and discuss their concerns about health problems and exposures.

- An extensive worker e-mail listing allows NIOSH to communicate quickly with many current and former workers at several different DOE sites simultaneously. NIOSH materials that provide site–specific information about current and proposed research projects and the availability of NIOSH occupational research information on an as-needed basis have been developed and distributed.

- The Internet gives NIOSH an opportunity to post all information about completed, current, and proposed occupational research at all DOE sites for anyone to view. The address is www.cdc.gov/niosh/oeindex.html.

- One-page study summaries have been developed that clearly communicate the purpose, activities, or findings of NIOSH studies that are proposed, ongoing, or completed at the DOE sites. These one-page summaries are converted to a conventional file format (portable document file or pdf) so that they can be easily placed in site newsletters, on bulletin boards, and on Web sites. They are also distributed directly to workers as an e-mail attachment.

- An extensive computerized list of labor representatives at all the DOE sites enables NIOSH to conduct frequent, fast, and efficiently targeted mailings to workers.

Objective 3: Communicate all study findings effectively without bias

Project researchers have an obligation to the site workforce, the community near the site, the DOE and its site contractors, and the media to report the results of their research. When a study is completed, the workers and management at the participating sites are always informed of the study results before informing the health effects subcommittee of the study site, the community or the general public. To do this, researchers coordinate a

sequence of communication activities for the release of study results with DOE headquarters, DOE site point of contacts, and labor representatives. These communication activities involve the release of our one-page study summaries, which include the following information:

- Name of the principal investigator
- Type of study conducted
- Description of the study population
- Description of the main study findings
- Limitations of the study
- Glossary of terms
- Date, time, and location for satellite presentation or site visit, if applicable
- A DOE site contact and DOE reading room information
- Instructions on how to obtain a copy of the study abstract, full report, and/or videotaped presentation.
- Phone numbers (NIOSH-HERB main number and the toll free NIOSH workplace hazards information number) to call for more information

Researchers also coordinate subsequent communication activities so that the principal investigator or study team can present findings through a site visit, satellite presentation, or other subsequent presentation of the study results. Lecture format presentations are videotaped, and copies are made available to all DOE study site reading rooms and/or libraries.

When doing presentations, researchers keep in mind three basic concerns:

1. The study findings must be presented in an understandable manner. A short, easy-to-read summary of study findings is developed.

2. The presentation must be as unbiased as possible.

3. The study results and the distribution of final reports occur regardless of whether the results are considered to be positive, negative, or indeterminate.

It is important to report study findings to as wide an audience as possible, since workers at other sites may have similar exposures or health concerns to those of the study group. HERB is examining ways to assure that all DOE sites, workers, and communities are informed of study findings in a timely manner.

Finally, the research is regularly presented at scientific meetings and published in scientific journals.

Objective 4: Provide individual worker notification of study results

In addition to reporting research results to the workers in a group, individual notification of the workers in the study cohort is sometimes warranted. NIOSH published policy and procedures for worker notification in the1988 *NIOSH Worker Notification Procedures Manual*. Individual notification occurs most frequently in studies in which direct interaction has occurred between researchers and all members of the study group. A number of study criteria and study result considerations are addressed to determine whether and when individual worker notification is appropriate. To date, researchers have not had a study finding that necessitated formal individual worker notification.

Objective 5: Evaluate effectiveness of all phases of worker outreach/community involvement

We continue to seek ways to evaluate the effectiveness of our efforts to communicate study findings, enhance worker input, and improve our community involvement. This includes tools such as one-page study summaries that are incorporated into the communication process. The development of these summaries was the result of outreach activities with numerous workers and DOE staff who provided input on the forms of communication best suited for communicating with current and former workers. During FY 2000, NIOSH/HERB used these one-page study summaries to help communicate the findings of three completed studies to more than 150,000 current and former DOE workers. DOE workers have commented that the summaries are clear, easy to read, and effective in communicating study results.

In summary, we think we have made progress in meeting these objectives. We continue to learn and expect challenges ahead as we strive to improve communication efforts, stakeholder involvement, and worker outreach. Additionally, we continue to seek different approaches and invite feedback to address the needs and characteristics of the various sites, worker populations, and studies.

Program Accomplishments

A total of 21 occupational studies transferred under the original memorandum of understanding have been completed or concluded. A complete listing of studies and accompanying final reports and manuscripts is provided in Tab 8.

A comprehensive occupational health research agenda has been developed and initiated.

Studies completed in the last 6 months have yielded important findings:

- Dose–response relationships were between ionizing radiation exposures and leukemia mortality among female nuclear weapons workers.
- Health studies of DOE cleanup workers will be more feasible in the future if work history, exposure, and medical data for this group are improved.
- Workers who continue employment after a downsizing event at a DOE site may exhibit stress-related health consequences similar to terminated workers.

Additional completed NIOSH-initiated research projects are listed in Tab 7.

An ongoing occupational radiation and energy-related grants program has provided extramural researchers opportunities to independently propose and conduct research supporting the NIOSH research agenda. A total of 5 cooperative agreements, 2 contracts, and 7 grants have been awarded to 14 different research partners. A listing is provided in Tab 13.

More historical DOE exposure record systems are available for occupational research.

A radiation agenda workshop was held to identify areas of research in exposure assessment and epidemiology that need to be addressed.

NIOSH responded to the Fernald Health Effects Subcommittee request for an exposure assessment and updated mortality study of Fernald workers.

Results of seven completed NIOSH studies have been presented to the workers at sites where the studies were conducted. Additionally, three technical reports on NIOSH methods were completed.

DOE-requested Health Hazard Evaluations (HHE) at the Idaho National Engineering and Environmental Laboratory and the Portsmouth Gaseous Diffusion Plant were completed.

The requested NIOSH Occupational Energy Research Program final reports were submitted to the Committee on the Biological Effects of Ionizing Radiations (BEIR VII).

Labor contact networks were established at all DOE study sites.

Greater emphasis was given to multiple exposures, chemical exposure contact, external neutron, and internal radiation.

Program book was developed that identifies program activities, research contracts, synopsis of completed reports, etc as initially recommended by the Advisory Committee on Energy-Related Epidemiologic Research.

Ongoing Research Activities

Intramural Research

1. Cohort Mortality Study of Idaho National Engineering and Environmental Laboratory Workers

Project Officer: Mary Schubauer-Berigan, Ph.D.

Study Period: 10/1/92–3/30/01

Summary: An all-cause cohort mortality study is underway at INEEL, a previously unstudied site. More than 70,000 workers employed at this site between 1952 and 1991 have been followed to ascertain causes of death in workers who died. Exposures of interest are external ionizing radiation and a variety of chemicals. The first phase of the study (Standard mortality ratio [SMR] analysis) is planned for completion by March 2001.

Significance: This study of a previously unstudied site was initiated at a governor's request and from congressional interest. Data from the study will be used in other studies, e.g., lung cancer case-control study.

2. Cohort Mortality Study of Portsmouth Naval Shipyard, Kittery, Maine

Project Officer: Tim Taulbee, M.S.

Study Period: 10/1/93–9/30/02

Summary: The mortality study of civilian employees at Portsmouth Naval Shipyard is being updated through 1996. The cohort has been expanded to include all workers employed through 1992. Naval Sea Systems Command has provided access to records and facilities. In addition to the cohort update, cases and controls have been chosen for leukemia and lung cancer nested case-control studies of this population. Detailed coding of radiation exposure has been determined for all cases and controls. Original records of workers' dosimetry have been located and

copied in preparation to study rate of exposure, a unique aspect of this study.

Significance: Exposure was to external ionizing radiation almost exclusively. The study was supported by US Navy. Data will be used in other studies, such as the, NIOSH leukemia case-control study and International Agency for Research Center study.

3. Leukemia Case-Control Study

Project Officer: Thurman Wenzl, Sc.D.

Study Period: 7/1/95–12/31/01

Summary: This multi-site case-control study will explore the relation between external radiation and leukemia risk. About 250 leukemia deaths have been identified at five DOE sites and Portsmouth Naval Shipyard when the vital status is updated through 1996. Confounding exposures to internal radiation, chemicals and electromagnetic fields will be evaluated for all cases and controls.

Significance: This is a followup to recent positive findings of leukemia and radiation in cohort studies. It is the largest study of its kind ever done. The study design allows control of confounders. It is a companion to a study of multiple myeloma (hematopoietic cancer, also) conducted at the same sites. The study includes update of vital status of Hanford and Savannah River cohorts.

4. Multiple Myeloma Case-Control Study at the Oak Ridge Gaseous Diffusion Plant (K-25)

Project Officer: Cynthia Robinson, Ph.D.

Study Period: 10/01/95–09/30/02

Summary: This case-control study of multiple myeloma deaths among workers at the Oak Ridge (K–25) gaseous diffusion plant complements the multisite, multiple myeloma study recently completed by the University of North Carolina. Exposures to multiple sources of

external and internal ionizing radiation and chemicals are fully characterized in this study. The vital status of the K-25 cohort is being updated through 1998.

Significance: This is the largest single-site study of multiple myeloma. The relatively large number of cases provides reasonable statistical power to evaluate a dose-response relationship in the presence of multiple exposures and potential confounders.

5. Exposure Assessment of Hazardous Waste, Decontamination and Decommissioning, and Cleanup Workers - Phase I

Project Officer: Greg Kinnes, M.S.

Study Period: 5/1/96–[Awaiting Manuscript]

Summary: Exposures encountered by hazardous waste, clean–up, and decontamination and decommissioning workers will be characterized. In Phase I, background information will be collected at seven DOE sites to assess working conditions, and to identify issues and research needs at the sites. This phase will be completed by late 2000.

Significance: This study addresses exposures to current workers assesses feasibility of tracking workforce for future studies evaluates mixed exposures and supports surveillance activities.

Recovery or placement of waste storage drums in shallow earth burial site. *Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho. 1979. Photo Courtesy of the U.S. Department of Energy*

6. Cohort Mortality Study of DOE Chemical Laboratory Workers

Project Officers: Cynthia Robinson, Ph.D.

Study Period: 10/1/96–9/30/01

Summary: In limited studies of chemical laboratory workers, an increased risk of cancer was reported. A cohort mortality study and exposure assessment of DOE chemical laboratory workers is being conducted. The sites selected include Savannah River and three facilities at Oak Ridge (X–10, Y–12, and K–25). To address sample size needs, a fifth site (Hanford) is under evaluation for inclusion. The exposures of interest include external ionizing radiation, internal radiation, and chemicals. SMR analysis and a dose response assessment will be conducted.

Significance: The study addresses hazards outside the DOE complex, including chemical and mixed exposures. The study will advance our knowledge about cancer risks in chemical laboratory workers.

7. Lung Cancer Case-Control Study

Project Officer: Sharon Silver, M.A.

Study Period: 9/30/97–9/29/03

Summary: Five recent epidemiologic studies have shown a dose-response relationship between lung cancer and external ionizing radiation. The occupational settings studied, however, have involved exposures to other potential lung carcinogens. The current project will investigate the relation between lung cancer mortality and exposure to external ionizing radiation among nuclear reactor operators. The sites identified include Hanford (Area 100), Savannah River (Area 100), Oak Ridge National Laboratory (X-10), and the Idaho National Engineering and Environmental Laboratory (Naval reactor facility and test reactor area).

Significance: Internal dose and confounder data available for this project were limitations of previous studies.

8. Cohort Mortality Study of DOE Construction Workers

Project Officer: Cynthia Robinson, Ph.D.

Study Period: 10/1/97–[Suspended pending re-evaluation and additional funding]

Summary: This all-cause retrospective cohort mortality study of DOE construction workers provides an opportunity to further define the risks for construction trades associated with radiation, asbestos fibers, silica-containing dusts, beryllium particulates, and other exposures regularly encountered by construction workers on DOE sites.

Significance: Only a few studies have been conducted among construction worker cohorts; most have been PMR studies of union or association populations. DOE work sites often maintain stable construction worker populations. The study is relavent to the present construction and site remediation workforces and is an opportunity to evaluate effects of combined radiation and chemical exposures.

9. Feasibility Study for an Integrated Database for DOE Site Remediation Workers

Project Officer: Cynthia Robinson, Ph.D.

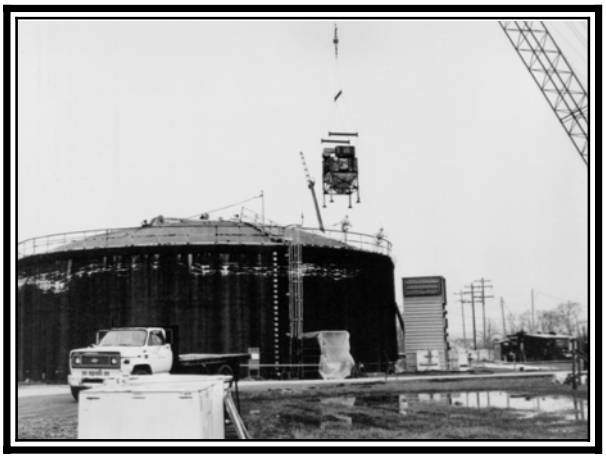
Study Period: 10/1/97–[Suspended pending re-evaluation and additional funding]

Summary: Workers involved in the site remediation (decontamination and decommissioning) process underway at the Fernald site encounter exposures different from those in the production phase. This project will gather historical, radiologic, industrial hygiene, work history, and medical data for each worker (including the subcontractors) for use in a pilot study. The pilot study will test whether existing site systems can be used to prepare an integrated database that might

be used to identify, track, and evaluate health risks for all site remediation workers. A report will be written that assesses the results of the pilot study and identifies key variables for the database.

Significance: This study was requested by The Advisory Committee on Energy-Related Epidemiologic Research (ACERER). No registries have been established that allow identification and tracking of current and future site remediation workers on DOE or any other sites. Only a few health studies of site remediation workers are available.

10. Cohort Mortality Study of Fernald Environmental Management



K-65 no. 3 dust collector removal at Fernald.
Fernald, Ohio. Date Unknown. Photo courtesy of the U.S. Department of Energy

Plant (FEMP)

Project Officer: John Cardarelli II, Ph.D.

Project Period: 09/01/98–09/31/02

Summary: This study is updating the mortality status of Fernald workers through 1996, and expanding the cohort to include females and all races. Additionally, NIOSH will conduct a retrospective exposure assessment for external and internal radiation, radon, asbestos, uranium dust, and acid mists. A previous cohort mortality study found a

statistically significant excess of lung cancer mortality among hourly workers (SMR=1.26), and a statistically significant excess of stomach cancer among salaried workers (SMR=2.61). Dose-response associations were seen between lung cancer and external radiation exposure, and between nonmalignant respiratory disease and internal exposure.

Significance: This study is an update of a previous cohort study (increased latency). It includes an underrepresented populations (women and nonwhite men) and additional assessments of chemical and physical hazards (radon, uranium dusts, asbestos, and acid mists).

11. Exposure Assessment of Radiologic Technologists for Epidemiology Studies

Project Officer: James Neton, Ph.D.

Study Period: 1/1/99–9/30/01

Summary: Radiation exposure estimates will be developed for epidemiology studies of radiologic technicians being conducted by the National Cancer Institute (NCI). This large cohort of radiation exposed workers (>145,000) began in 1982 and includes case-control incidence studies for breast, thyroid and lung cancer as well as leukemia. Survey data have been collected for diet, smoking status, family history of breast cancer, and other pertinent information. Radiation exposure records are incomplete and widely scattered. Use of common surrogates for exposure, such as duration of employment or years certified as a radiologic technician, have not proved fruitful.

Significance: Collaboration with external partner; mostly female population; cancer incidence data has been collected.

EXTRAMURAL RESEARCH (COOPERATIVE AGREEMENTS)

1. Cancer Incidence/Mortality Study of Rocky Flats Plant

Awardee: Colorado Department of Public Health and Environment (Normie Morin, Ph.D)

Award Period: 9/30/93–[Awaiting final report]

Summary: Based on the findings of a previous study, a cancer incidence study and an update of the mortality study at the Rocky Flats Plant were intiated. The dosimetry data for neutrons and plutonium are being improved. Job exposure matrices have been completed for chemical exposures and are being assessed through a field study and expert panel review. The study roster is complete, followup has been completed, and deaths have been coded. A nested case control study of lung cancer at Rocky Flats is being conducted as well.

Significance: This is a cancer incidence study. Re-evaluation and upgrade of dosimetry data benefits DOE and the contractor and will be used in a grant to study lung fibrosis.

2. International Collaborative Study of Nuclear Industry Workers

Awardee: International Agency for Research on Cancer (IARC) (Elisabeth Cardis, Ph.D.)

Award Period: 4/1/95–6/30/01

Summary: IARC has undertaken a cancer mortality study of nuclear workers in 17 countries. Two U.S. cohorts are included in the study. Vital status and dose data from these countries will be combined to increase the power to quantify small increases in cancer risk in workers exposed to low doses of ionizing radiation.

Significance: This is the largest study of nuclear workers ever done. It involves collaboration among 17 countries and with The World Health Organization (WHO)/IARC.

3. Chronic Beryllium Disease Among Beryllium-Exposed Workers

Awardee: Michigan State University (Kenneth Rosenman, M.D.)

Award Period: 9/30/95–[Awaiting final report]

Summary: This cross-sectional study of 1000 workers at 2 plants will examine the natural history of chronic beryllium disease and evaluate the utility of the lymphocyte transformation test in detecting beryllium sensitization and predicting chronic beryllium disease development. The effectiveness of medical treatment of sensitized workers and of control measures in preventing overt chronic beryllium disease will also be evaluated.

Significance: This study characterizes disease process and a health outcome other than cancer. It is a morbidity study that is pertinent to current workers and applicable to surveillance.

4. Beryllium Disease Natural History and Exposure Response

Awardee: National Jewish Center (Lee Newman, M.D.)

Award Period: 9/30/95–[Awaiting final report]

Summary: This investigation will determine the natural history of beryllium sensitization and subclinical chronic beryllium disease and identify beryllium compounds and processes associated with chronic beryllium disease. Exposure-response relationships for both sensitization and chronic beryllium disease will also be determined. Exposure assessment is underway at an Alabama plant where take-home toxicants are being assessed for 60 employees.

Significance: This study characterizes the disease process and evaluates intervention methods. It describes a health outcome other than cancer. It is a morbidity study that is pertinent to current workers and applicable to surveillance.

EXTRAMURAL RESEARCH (GRANTS)

1. Measurement Error Methods for Underground Miner Studies

Grantee: University of Southern California (Dan Stram, Ph.D.)

Award Period: 9/30/95 –5/31/02

Summary: This study will develop methods to deal with radiation exposure measurement errors when exposures are extended over time and apply them in a reanalysis of exposure-time-response (including dose– rate effects) in lung cancer mortality for uranium miner cohorts in the Colorado Plateau and New Mexico.

Significance: The study addresses developing statistical methods for addressing measurement uncertainty. It may be useful to the Department of Justice in the disposition of uranium miner compensation issues.

2. Study of Heat Stress and Performance in Carpenters at DOE Sites

Grantee: United Brotherhood of Carpenters Health and Safety Fund (Kenneth Rosenman, M.D.)

Award Period: 9/30/95 – [Awaiting final report]

Summary: This study will determine if heat stress from the use of protective clothing affects performance of carpenters and other construction workers in remediation and hazardous waste work at Hanford and Oak Ridge. Physiologic measures of heat stress and neurobehavioral performance will be assessed under actual working conditions.

Significance: This is a nonradiation and nonmortality study. It is applicable to current workers to a preponderance of work at DOE sites and applicable to surveillance.

3. Ionizing Radiation and Mortality Among Hanford Workers

Grantee: University of North Carolina (Steven Wing, Ph.D.)

Award Period: 9/30/96–9/30/01

Summary: This study will re-analyze cancer and noncancer mortality among Hanford workers with chronic, low-level external radiation exposure. New methods will be used to estimate doses previously assumed to be zero and to consider internal dose in analyses of health risks. New analytic methods will be used to consider time-related exposure effects, such as age at exposure.

Significance: Update of important previous cohort study (increased time of observation). Application of new methodologies for epidemiologic analyses.

Storage tanks for high-level liquid radioactive waste at Hanford. *Hanford Site, Richland, Washington. October 31, 1984. Photo courtesy of the U.S. Department of Energy*

4. Acute Radiation Syndrome in Russian Nuclear Workers

Grantee: University of Pittsburgh (Neil Wald, M.D.)

Award Period: 12/1/96–[Awaiting final report]

Summary: The long-term objective of this study is to facilitate the acquisition of diagnostic and prognostic information. This information will help nonexpert medical and paramedical personnel with the early recognition of acute radiation syndrome in hospital and field conditions. The study will use data from 59 acute radiation syndrome cases that occurred from 1948 to the present among workers at the Mayak nuclear facilities in Russia.

Significance: This is a noncancer study that involves international collaboration.

5. Surveillance Methods for Solvent-Related Hepatotoxicity, a cross-sectional study at Hanford

Grantee: University of Washington (Carl A. Brodkin, M.D.)

Award Period: 10/1/98–9/29/01

Summary: To establish a scientific basis for surveillance of hepatic effects in solvent exposed workers, a cross-sectional study is being conducted at the Hanford Nuclear Reservation. One hundred industrial painters exposed subacutely and chronically to a variety of solvent mixtures over their working careers will be compared with a referent group of 100 nonexposed carpenters matched by age, gender and race. The proposed study will examine the hypothesis that solvent–related hepatic injury is characterized by parenchymal changes of steatosis and fibrosis without associated necrotic changes, which are detected by elevated hepatic transaminases in blood.

Significance: The non–invasive surveillance methods address a priority research area of the National Occupational Research Agenda.

6. Radon and Cigarette Smoking Exposure Assessment in Fernald Workers

Grantee: University of Cincinnati (Susan Pinney, Ph.D.)

Award Period: 7/1/99– 6/30/01

Summary: This study proposes to develop yearly and cumulative individual radon exposure estimates for Fernald workers using a variety of data resources. Exact work location for about 2,500 workers can be assigned using data from occupational history interviews collected previously. Site information will be used to determine work location for others. Smoking history information from an ongoing medical surveillance program will be extended to living workers not enrolled. Surrogate data will be collected from family members of the deceased. Risk estimates for lung cancer will then be calculated for the Fernald workers.

Significance: A previous mortality study of this cohort reported a significant excess risk of lung cancer deaths among hourly workers. Detailed assessment of occupational radon exposure in this cohort, along with the collection of smoking history, will improve future risk assessments.

7. Correcting for Measurement Errors in Radiation Exposure

Grantee: New York University (Xiaonan Xue, Ph.D.)

Award Period: 7/1/99–6/30/02

Summary: This research will develop methods for correcting radiation exposure measurement errors, including both systematic and random errors. In this research, a joint model for measurement error and dose– response relationship will be developed, and may be used for more precise and accurate risk assessment.

Significance: The methods for modeling and correcting measurement errors developed from this research will apply to

ongoing and future worker radiation studies and analysis of other environmental exposure-response data.

8. Epidemiologic Studies to Evaluate Health Effects of Uranium Milling

Grantee: University of New Mexico
(William E. Lambert, Ph.D.)

Award Period: 9/30/97–[Awaiting final report]

Summary: This study will investigate the long-term health effects of exposures in uranium mills in Non-Hispanic white, Hispanic, and American Indian former uranium millers in New Mexico and Colorado. Although the high risk of uranium miners for lung cancer is well known, the risks associated with uranium milling have not been as extensively studied. The limited available data suggest that former millers may have increased risk for non-malignant respiratory diseases and renal disease.

Significance: Gains are anticipated in understanding the long-term health effects of uranium milling that may allow identification of exposed workers at risk for lung and renal diseases.

9. Dose of Beryllium Causing Sensitization and Disease

Grantee: National Jewish Center (Lee S. Newman, M.D.)

Award Period: 7/1/99–6/30/02

Summary: This research aims to determine the personal beryllium dose that produces beryllium sensitization and chronic beryllium disease in beryllium machinists, and to characterize the beryllium aerosol and lung deposition that produce beryllium sensitization and chronic beryllium disease in these individuals.

Significance: This research will influence prevention by providing data on which to base a new beryllium exposure standard and help direct engineering and industrial hygiene practices to reduce exposure.

10. Analysis for Characterizing Plutonium Exposure to Improve Lung Cancer Risk Estimates

Grantee: University of Colorado (James Ruttenbur, Ph.D.)

Award Period: 8/1/99–7/31/02

Summary: This research will explore important issues of measurement errors in quantifying exposures and their effects on risk estimates in epidemiologic studies.

Significance: This research will benefit future epidemiologic studies by: (1) developing and exploring methods to assess the measurement of radiation doses, (2) developing methods for analyzing exposure data from different sources, and (3) evaluating current methods and developing new ones for incorporating of measurement error estimates for radiation doses into risk estimates.

Completed NIOSH-Initiated Research

1. Multi-Site Multiple Myeloma Case-Control Study

Contractor: University of North Carolina (Steven Wing, Ph.D.)

Award Period: 1993–1997

Summary: This multisite case-control study focused on external radiation and chemical exposures at five DOE sites: Savannah River, Los Alamos National Laboratory, Los Alamos National Laboratory-Zia, Oak Ridge National Laboratory, and Hanford. Ninety-eight workers who died from multiple myeloma and 391 age-matched controls were selected from the combined roster of 115,143 workers hired before 1979. These workers were followed for vital status through 1990 (1986 for Hanford). Cases were disproportionately African–American, male, and hired before1948. Although an association between multiple myeloma and cumulative whole body ionizing radiation dose was not observed, external penetrating radiation doses received at age 45 and above were associated with multiple myeloma.

Manuscript: Wing S, Richardson D, Wolf S, Mihlan G, Crawford-Brown D, Wood J [2000]. A case control study of multiple myeloma at four nuclear facilities. Ann Epidemiol 10: 144-153.

Significance: This study complements the HERB intramural leukemia case-control study being done at the same sites and the myeloma case-control study with internal radiation exposure at the Oak Ridge Gaseous Diffusion Plant (K–25). The role of age at exposure in ionizing radiation studies was examined.

2. Mercury Workers Health Study

Contractor: Oak Ridge Associated Universities (Donna Cragle, Ph.D.)

Award Period: 1993–1996

Summary: This is a followup study of neurologic health outcomes in workers exposed to elemental mercury at the Y–12 Plant (Oak Ridge) between 1953–1966. Neurologic effects of relatively heavy exposure to mercury were still detectable more than 30 years after exposure ceased. The adverse effects were observed primarily for the peripheral nervous system (by both clinical examination and electrodiagnostic evaluation). Postural tremor was also associated with past mercury exposure. Study participants were notified of their individual results, overall study results were presented to a labor-management group in April 1997, and a technical report was prepared for NIOSH at the end of the study.

Manuscript: Departments of Behavioral Sciences and Health Education and of Environmental and Occupational Health; Rollins School of Public Health of Emory University, and The Center for Epidemiologic Research Environmental and Health Sciences Division; Oak Ridge Associated Universities, [Undated]. A study of the health effects of exposure to elemental mercury: a followup of mercury exposed workers at the Y–12 plant in Oak Ridge, Tennessee. (DHHS Contract 200–93–2629, Final Technical Report.) Available from the National Institute for Occupational Safety and Health/Health-related Energy Research Branch, Cincinnati, OH,134 pg.

Significance: This morbidity study of noncancer neurologic outcomes associated with chemical exposure is applicable to surveillance efforts.

3. Historical Plutonium Bioassay Measurements

Contractor: New York University (Norman Cohen, Ph.D.)

Award Period: 1993–1995

Summary: This research evaluated the bias, uncertainty, and selectivity of plutonium bioassay procedures used by DOE over time, since they may affect the retrospective dosimetry of plutonium workers.

Significance: This study includes an analysis and is needed for internal exposure assessment of plutonium.

4. Accounting for Errors in Radiation Dose Estimates

Grantee: Battelle Pacific Northwest Laboratories
(Ethel Gilbert, Ph.D.)

Award Period: 1994–1996

Summary: This study developed an approach to accounting for random uncertainties in estimates of cumulative external dose and applied the model to Hanford data. The analysis included evaluation of photon energy, angle of photon incidence, and different dosimeter designs. The effect of these factors on estimates of organ dose and on dose-response analysis in epidemiology studies was also evaluated.

Manuscript: Gilbert E, Fix JJ, Baumgartner WV [1996]. An approach to evaluating bias and uncertainty in estimates of external dose obtained from personal dosimeters. Health Physics *70 (3):336–345.*

Significance: Uncertainty analysis; accounting for bias in external dose estimates.

5. Cohort Mortality Study of Portsmouth Gaseous Diffusion Plant, Piketon, Ohio

Investigator: NIOSH intramural study
(Project officer: Robert Rinsky, Ph.D.)

Study Period: 1992–2001

Summary: The mortality of workers at Portmouth Gaseous Diffusion Plant was updated through 1992. Radiation exposure assessments were performed for internal and external ionizing radiation, certain chemicals, and electromagnetic fields. No significantly elevated standardized mortality ratios (SMRs) were observed for overall or specific causes of death. Case-control analyses of lung, lymphoma, hematopoietic, and stomach cancers and exposures to internal soluble alpha dose, flourines, nickel, and uranium were done. The results of the analysis have been incorporated into a draft final report, which is in branch review. A presentation of the findings is being prepared for labor and management.

Manuscript: Pending

Significance: This study, initiated by a response to a congressional request, assessed lung cancer in this previously studied cohort and extensive exposure assessment for chemicals and radiation were completed.

6. Feasibility Study of Assessing Adverse Reproductive Outcomes Among Females Employed at DOE Facilities

Investigator: NIOSH intramural study
(Project officer: Barbara Massoudi, Ph.D.)

Study Period: 1995–1996

Summary: The feasibility of conducting a retrospective cohort study of adverse reproductive outcomes among women employed at DOE sites depends on four factors: (1) availability of an appropriate study population; (2) a valid case definition and means of ascertainment; (3) exposure to the agent(s) in question and sufficient information to characterize such exposure; (4) and adequate sample size to demonstrate an

effect. To address these issues, several sources of data were collected and evaluated by NIOSH investigators. Data obtained on women who worked at 20 previously studied DOE sites included demographic characteristics, radiation monitoring data, and vital status. Information was collected on birth defects registries in states near DOE facilities. Assembly of a cohort of female DOE workers to examine clinically recognized outcomes such as miscarriage and birth defects would be difficult. However, other study designs to assess reproductive health in the DOE workforce may be feasible.

Manuscript: Massoudi BL [1996]. Adverse reproductive outcomes among females employed at Department of Energy facilities: The feasibility of epidemiologic studies. Available from the National Institute for Occupational Safety and Health/Health-related Energy Research Branch, Cincinnati, OH. [Final Report] Unpublished. 18 pg.

Significance: This feasibility assessment addresses issues relevant to current women workers and noncancer outcomes.

Cafeteria. *Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho. 1957. Photo courtesy of the U.S. Department of Energy.*

7. Childhood Leukemia Case-Control Study

Awardee: Batelle Laboratories (Lowell Sever, Ph.D.)

Award Period: 1992–1997

Summary: This case-control study assessed the potential association between paternal exposure to ionizing radiation and risk of leukemia in offspring, a finding observed in Sellafield, England by Gardner et al. (1990). The study follows up on previous findings of birth defects (Central nervous system [CNS] tumors) at Hanford. The study, initiated at the Hanford Site, was expanded to Oak Ridge and Idaho National Engineering and Environmental Laboratory, and included non-Hodgkin's lymphoma and central nervous system CNS tumors as outcomes. The study found no evidence of a link between childhood cancer risk and father's radiation work at the DOE sites included in the study. This finding did not change if each site was looked at alone or all together. A much weaker finding that relates only to Hanford children was noted. Children whose fathers worked at Hanford were more likely to get CNS cancer than children whose fathers worked at the other sites. However, this finding was not statistically significant and was based on a small number of cases. The study was completed in November 1997; communication of results to workers and management at the sites studied occurred in October 1998.

Installing reactor vessel. *Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho. Date unknown. Photo courtesy of the U.S. Department of Energy.*

Manuscript: Sever LE, Gilbert ES, Tucker K, Greaves J, Greaves C, Buchanan J [1997]. Epidemiologic evaluation of childhood leukemia and paternal exposure to ionizing radiation. Seattle, WA: Battelle Memorial Institute; (CDC Cooperative Agreement U50/CCU012545–01, Final Report.) Available from the National Institute for Occupational Safety and Health/Health-Related Energy Research Branch, Cincinnati, OH, 51 pg.

Significance: Three other studies since the report of the results for Sellafield have not shown an increase in childhood cancers among children whose fathers were exposed to radiation before their child's conception. This NIOSH–sponsored study agrees with and supports those study findings.

8. Time-Related Factors in Radiation-Cancer Dose Response

Grantee: University of North Carolina (Steven Wing, Ph.D.; David Richardson, Ph.D.)

Award Period: 1996–1997

Summary: This study expanded, updated and re-analyzed a cohort of workers at the Oak Ridge National Laboratory, that was originally analyzed by Checkoway. The cohort included persons employed at Oak Ridge National Laboratory between 1943 and 1972. Special emphasis was given to the associations between radiation, cancer, and time-related factors including age-at-exposure, latency, and time since exposure. Evidence was found of a stronger dose response association between exposure and cumulative dose received at older ages.

Manuscript: Richardson DB, Wing S [1998]. Methods for investigating age differences in the effects of prolonged exposures. Am J Ind Med 33:123-130.

Significance: Dose received after age 45 is strongly predictive of all-cancer-combined mortality as well as lung cancer, which has implications for future occupational epidemiologic research and exposure standards.

9. Dose Estimation from Daily and Weekly Dosimetry Data

Grantee: Oak Ridge National Laboratory (George Ostrouchov, Ph.D.)

Award Period: 1997–1998

Summary: Statistical methods were used to estimate distributions of external radiation exposures for workers included in epidemiology studies at the Oak Ridge National facilities. The method took into account measurement errors from film badge and pocket meter systems, from recording left-censored doses as zeros, and from other practices and policies. The amount of bias in previously used estimates of exposure was substantial, although incorporation of the daily pocket chamber readings reduced uncertainty in some estimates but increased it in others.

Manuscript: Ostrouchov G, Frome EL, Kerr GD [1998]. Dose estimation from daily and weekly dosimetry data. Oak Ridge, TN: Oak Ridge National Laboratory; (CDC-NIOSH Grant RO1 OH12956, Final Draft.) 38 pg.

Significance: This study involved exposure assessment methods development and uncertainty analysis for external radiation exposure estimates used in previous and current studies of workers at Oak Ridge facilities.

10. Cohort Mortality Study of Workers at Fernald Feed Materials Production Center

Contractor: Oak Ridge Associated Universities (Donna Cragle, Ph.D.)

Award Period: 1992–1997

Summary: Mortality patterns were examined for 4,014 white males hired at the Fernald Feed Materials Production Center between 1951 and 1981. Vital status ascertainment through 1989 found 1,064 deaths among this population. Exposure estimates were developed for internal radiation, because of the potential for exposure to uranium dust and for external ionizing radiation. Although salaried workers showed a healthy worker effect, a significant increase for stomach cancer deaths was found in this subcohort. Hourly workers

did not demonstrate a healthy worker effect and had excess mortality from all cancers, lung cancer, and motor vehicle injuries. For all workers, chronic non-malignant respiratory disease showed a positive dose-response relationship with internal exposure. These findings were produced without controlling for other lung carcinogens that were likely present in the work environment, such as radon and other chemicals.

Manuscript: Cragle DL, Watkins JP, Ingle JN, Robertson-Demers K, Tankersley WG, West CM [1995]. Mortality among a cohort of white male workers at a uranium processing plant: Fernald feed materials production center, 1951–1989. Oak Ridge, TN: Center for Epidemiologic Research, Oak Ridge Institute for Science and Education. Unpublished. 29 pg.

Significance: This assessment of a previously unstudied cohort complements Mallinckrodt studies and includes exposure assessment for both internal and external radiation.

Feed materials Productions Center (FMPC). *Fernald, 20 miles outside Cincinnati, Ohio. January 1, 1987. Photo courtesy of the U.S. Department of Energy.*

11. Cohort Mortality Study of Workers at Savannah River Plant

Contractor: Oak Ridge Associated Universities (Donna Cragle, Ph.D.)

Award Period: 1992–1997

Summary: A cohort mortality study of 9,757 white male workers at the Savannah River site employed between 1952 and 1974 reported 1,722 deaths, with followup complete through 1986. A strong healthy worker effect was noted in the SMR analysis, with no significant excesses noted. However, when trend tests were performed by external dose category, a significant positive dose-response relation was observed for external radiation and leukemia mortality when doses were lagged 2 years. The estimated for excess relative risk per Sievert for leukemia mortality was 13.61, which is consistent with the estimates derived for the Canadian (19.0 per Sievert) and Sellafield (13.92 per Sievert) populations. A draft final report was prepared for NIOSH in 1996.

Manuscript: Cragle D [1998]. Mortality among workers at the Savannah River nuclear fuels production facility. In: ASA 1998 proceedings of the section on statistics in epidemiology. Alexandria, VA: American Statistical Association, pp. 83–87.

L-Reactor Facility. *L Area, Savannah River Site, South Carolina. September 16, 1982. Photo courtesy of the U.S. Department of Energy.*

Significance: This cohort, included in the leukemia case-control study, demonstrated a significant dose-response for leukemia. Both internal and external radiation exposures were evaluated.

12. Mine Specific Exposure Information for Uranium Miners Study

Investigator: NIOSH intramural study
(Project officer: Mark Methner, Ph.D.)

Study Period: 1998–1999

Summary: Additional mine-specific assignment of exposure levels identified in historic records were entered into a database and delivered to the principal investigator on the Measurement Error Methods for Underground Miner Studies. The data will be used to examine exposure measurement errors over time and apply them in a reanalysis of exposure-time-response (including dose rate effects) in lung cancer mortality for uranium miner cohorts in the Colorado Plateau and New Mexico.

Significance: Lung cancer risks identified for underground uranium miners exposure to radon have been used extensively for setting residential and occupational exposure limits.

13. Assessment of Electric and Magnetic Field Exposures of Transportation Workers

Project Officer: NIOSH intramural study (Project officer: Thurman Wenzl, Sc.D.)

Study Period: 1996–2000

Summary: Personal exposures to power-frequency magnetic fields were measured among airline employees and employees of a municipal electric bus system. Among the bus workers, only electricians and those assigned to work downtown (including police and supervisors) had elevated average exposures; the downtown exposures appeared to be due to various sources not necessarily related to the electric bus. Among airline maintenance and ground personnel system, only maintenance supervisors had slightly elevated exposures. Agents working on reservations and at ticket counters had exposures equivalent to typical magnetic fields.

Manuscripts: Kaune WT [1999]. Study of occupational magnetic-field personal exposures of non-flying airline employees. Richland, WA: EM Factors; (CDC NIOSH Contract 200–94–2837, Contractor report.) Available from the National Institute for Occupational Safety and Health/Health-Related Energy Research Branch, Cincinnati, OH, 52 pg.

Factors EM [1999]. Study of occupational magnetic-field personal exposures associated with Seattle metro transit's electric trolley system. Richland, WA: EM Factors; (CDC NIOSH Contract 200–94–2837, Contractor report.) Available from the National Institute for Occupational Safety and Health/Health-Related Energy Research Branch, Cincinnati, OH, 67 pg.

Significance: Since little is known of workers' magnetic field exposures outside of electric utilities, these measurement surveys have clarified that few of these transport workers have elevated exposures.

14. <u>Cohort Mortality Study of Pantex Plant, Amarillo, Texas</u>

Project Officer: NIOSH intramural study
(Project officer: Barbara Grajewski, Ph.D.)

Study Period: 1996–1999

Summary: A study of Pantex workers published in 1985 was limited by the small number of deaths and short follow-up, although the risk of several cancers was elevated. Vital status was updated through 1995. An SMR analysis with examination of dose-response was conducted; however, it was not possible to update exposure information for the cohort (duration of employment was used as a surrogate for dose). No statistically significant elevations in SMRs were found. A decision to return to the facility to conduct an updated analysis is pending.

Manuscript: Pending

Significance: Pantex is an operating facility that had not been downsized. Similar exposures will be encountered by current and future workers.

15. Cancer Incidence and Sentinel Event Registries

Project Officer: NIOSH intramural study
(Project officer: Sara Foster, M.P.H.)

Study Period: 1998–2000

Summary: Because a standardized national registry system does not exist in the United States, incidence-based studies often depend on State disease registries. This project examined population-based State cancer and sentinel event registries to determine the feasibility and suitability of these registry systems for occupational studies. Information was collected from statewide cancer registries in 16 States of sixteen states containing DOE sites and those in the immediately adjacent States. Despite limitations in state-wide cancer registry systems, it is feasible to use many statewide registries for occupational health studies.

Manuscript: Foster S, Espinoza R [2000]. Cancer incidence and sentinel event registries. Cincinnati, OH: National Institute for Occupational Safety and Health/Health-Related Energy Research Program. [Final draft report] Unpublished. 107 pg.

Significance: This study will help researchers design incidence and morbidity studies near DOE sites.

16. Prevention of Stress and Health Consequences of Downsizing and Reorganization

Awardee: Boston University (Lew Pepper, M.D.)

Award Period: 1995–2000

Summary: Job stressors (i.e., work-related conditions implicated in disease development) include job dissatisfaction, lack of job control, and under-utilization of abilities. Sudden job change through strike, retirement, layoff, relocation, or job loss may trigger these stressors. In this multisite project, five DOE

sites (Idaho National Engineering and Environmental Laboratory, Los Alamos National Laboratory, Nevada Test Site, Oak Ridge Y–12 Plant, and Pantex) were selected to study the effects of downsizing on organizational climate, worker health, and performance. Data gathering included interviews, workplace observations, employee discussion groups, an employee survey distributed to more than10,500 employees, and a historical record review. Fore each downsizing organization, researcher identified opportunities to reduce job stress that could lead to improved employee health and organizational well-being. Suggested intervention strategies were proposed for further research.

Manuscript:

Pepper L [2000]. The Health effects of downsizing in the nuclear industry: findings at the Idaho National Engineering and Environmental Laboratory. Boston, MA: Department of Environmental Health, Boston University School of Public Health; (CDC Cooperative Agreement U60 CCU 112215, Final Report.) Available from the National Institute for Occupational Safety and Health/Health-Related Energy Research Branch, Cincinnati, OH, 129 pg.

Pepper L [2000]. The Health effects of downsizing in the nuclear industry: findings at the Los Alamos National Laboratory. Boston, MA: Department of Environmental Health, Boston University School of Public Health; (CDC Cooperative Agreement U60 CCU 112215, Final Report.) Available from the National Institute for Occupational Safety and Health/Health-Related Energy Research Branch, Cincinnati, OH, 135 pg.

Pepper L [2000]. The Health effects of downsizing in the nuclear industry: findings at the Nevada Test Site. Boston, MA: Department of Environmental Health, Boston University School of Public Health; (CDC Cooperative Agreement U60 CCU 112215, Final Report.) Available from the National Institute for Occupational Safety and Health/Health-Related Energy Research Branch, Cincinnati, OH, 125 pg.

Pepper L [2000]. The Health effects of downsizing in the nuclear industry: Pantex. Boston, MA: Department of Environmental Health, Boston University School of Public

Health; (CDC Cooperative Agreement U60 CCU 112215, Final Report.) Available from the National Institute for Occupational Safety and Health/Health-related Energy Research Branch, Cincinnati, OH, 133 pg.

Pepper L [2000]. The Health effects of downsizing in the nuclear industry: findings at the Y–12 Plant, Oak Ridge Reservation. Boston, MA: Department of Environmental Health, Boston University School of Public Health; (CDC Cooperative Agreement U60 CCU 112215, Final Report.) Available from the National Institute for Occupational Safety and Health/Health-Related Energy Research Branch, Cincinnati, OH, 129 pg.

Significance: This psychosocial morbidity study is relevant to current and future workers, and could be used as the basis of future intervention or surveillance efforts.

17. Mortality Among Female Nuclear Weapons Workers

Grantee: State University of New York (Gregg Wilkinson, Ph.D.)

Award Period: 1994–2000

Summary: Although 80,000 female workers have been employed at DOE facilities over the years, the small numbers of female workers at any one facility has limited their inclusion in previous health studies. Female workers from 12 DOE plants were combined in this cohort mortality study. Risk estimates were developed for exposure to ionizing radiation or to chemical hazards. A strong healthy worker effect was demonstrated for all causes of death among these workers. For the entire pooled cohort, mortality from mental disorders, diseases of the genitourinary system, and from ill-defined conditions was higher than expected. External ionizing radiation exposure in these workers appeared to be associated with increased relative risk for leukemia and suggestively associated with increased relative risks for all cancers combined and for breast cancer.

Manuscript: Wilkinson GS, Trieff, N, Graham, R [2000]. Study of mortality among female nuclear weapons workers. Buffalo, NY: Department of Social and Preventative Medicine,

School of Medicine and Biomedical Sciences, University of Buffalo, State University of New York; (DHHS Grant Numbers: 1R01 OHO3274, R01/CCR214546, R01/CCR61 2934–01, Final Report.) Available from the National Institute for Occupational Safety and Health/Health-Related Energy Research Branch, Cincinnati, OH, 447 pg.

Significance: The first multisite mortality study of women workers at DOE facilities.

18. Glycophorin A Biodosimetry in I-131 Treated Patients

Grantee: University of Pittsburgh (William Bigbee, Ph.D.)

Award Period: 1994–1999

Summary: This research evaluated the in vivo glycophorin A-based somatic cell mutation assay as a retrospective biodosimeter for use in epidemiologic studies. The response of the assay as a biodosimeter of radiation exposure was validated in a longitudinal study of patients receiving I-131 therapy for thyroid disease. Assessment of the glycophorin A assay in this project demonstrated that assay results are substantially reduced for low dose/low dose rate radiation exposures.

Manuscript: Bigbee WL, Brown ML, Burmeister LA, Carty SE, Swanson D, Watson CG [1998]. Glycophorin A (GPA) biodosimetry in I-131 treated patients. Center for Environmental and Occupational Health and Toxicology; Department of Environmental and Occupational Health; Graduate School of Public Health; University of Pittsburgh, Pittsburgh, PA. (DHHS Grant 5 RO1 OH03276, Final performance report.) Available from the National Institute for Occupational Safety and Health/Health-Related Energy Research Branch, Cincinnati, OH, 36 pg.

Significance: This research evaluated a biomarker of radiation exposure.

19. Specificity of the National Death Index and the Social Security Administration Death Master File When Information on Social Security Number is Lacking

Project Officer: NIOSH intramural study
(Project officer: Mary Schubauer-Berigan, Ph.D.)

Study Period: 1999–2000

Summary: Epidemiologic researchers rely on the National Death Index and the Social Security Administration (SSA) Death Master File for ascertainment of vital status. This study evaluated the specificity of name and date of birth in ascertaining deaths through the National Death Index and the SSA Death Master File, and the sensitivity of this information for the latter. The sensitivity and specificity of the SSA Death Master File were 86.92% and 98.62%, respectively. The comparable specificity for the National Death Index was 99.51%. Specificity increased when more complete identifying information was used, and was higher for persons with uncommon names. When name and date of birth are used to ascertain vital status from national databases, specificity and sensitivity vary with the accuracy and completeness of these identifiers.

Manuscript: Foster SO, Schubauer-Berigan MK, Waters KM [2000]. The specificity of the National Death Index and Social Security Administration Death Master File when information on Social Security Number is lacking. (In press).

Significance: This methods study outlines ways for researchers to achieve accurate vital status ascertainment with incomplete information.

20. Lung Fibrosis in Plutonium Workers

Grantee: National Jewish Hospital (Lee Newman, M.D.)

Award Period: 1995–1999

Summary: This project studied whether workers were at increased risk for developing radiographic abnormalities consistent with fibrosis. The relationship between ^{239}Pu and other

exposures and lung fibrosis was examined in chest x-rays of 327 plutonium-exposed Rocky Flats Plant workers and 194 workers without plutonium exposure. A significantly higher proportion of abnormal chest radiographs was found among plutonium workers (17.4%) compared with nonplutonium workers (7.2%). Inhaled plutonium may cause lung fibrosis in humans at absorbed lung doses above 5 Sv.

Manuscript: Newman LS, Ruttenber JA, Mroz MM [1999]. Lung fibrosis in plutonium workers. Division of Environmental and Occupational Health Sciences; National Jewish Medical and Research Center, Denver, CO. (DHHS Grant RO1 811855, Final performance report.) Available from the National Institute for Occupational Safety and Health/Health-Related Energy Research Branch, Cincinnati, OH, 19 pg.

Significance: Plutonium-induced lung fibrosis was observed in a plutonium exposed worker population consistent with results in animal testing using multiple species.

Previous DOE Studies

Under the original 1990 memorandum of understanding NIOSH assumed responsibility for the management of a number of ongoing studies, then being conducted by four DOE contractors: Oak Ridge Associated Universities, which became the Oak Ridge Institute for Science and Education (ORISE); Los Alamos National Laboratory, Battelle Pacific Northwest Laboratory, and Hanford Environmental Health Foundation. Approximately 40 research efforts were itemized in the memorandum of understanding. Ten projects were performed by ORISE, five by Los Alamos National Laboratory, and five by Hanford Environmental Health Foundation and Battelle Pacific Northwest Laboratory were transferred for management by NIOSH. In most of these cases, the research efforts were well under way by the time of the implementation of the memorandum of understanding; therefore, NIOSH had minimal opportunity to provide scientific or technical input. NIOSH worked with these contractors to complete the studies summarized below:

I. OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION (ORISE)

The following studies were performed by investigators from the Center for Epidemiologic Research of ORISE, under the leadership of Donna Cragle, Ph.D. The analysis of the studies of two sites, X–10 and Y–12, were conducted by investigators from the University of North Carolina, as a subcontract to Oak Ridge Associated Universities.

Oak Ridge National Laboratory (X–10)

1. Manuscript: Wing S, Shy CM, Wood JL, Wolf S, Cragle DL, Frome EL [1991]. Mortality among workers at Oak Ridge National Laboratory. JAMA 265(11): 1397-1402.

Summary: White males hired at the Oak Ridge National Laboratory between 1943 and 1972 were followed up for vital status through 1984 (N=8,318). Relatively low mortality compared with that in U.S. white males was observed for most causes of death. However, leukemia mortality was elevated in the total cohort (63% higher, 28 deaths) and in workers who had at some time been monitored for internal radionuclide contamination (123% higher, 16 deaths). External radiation with a 20-year exposure lag was related to all causes of death (2.68%, increase per 10 mSv), primarily due to an association with cancer mortality (4.94%, increase per 10 mSv).

2. **Manuscript:** Shy C, Wing S [1994]. A report on mortality among workers at Oak Ridge National Laboratory: followup through 1990. (PO 3C–70837, Final Report). Oak Ridge, TN: Oak Ridge Associated Universities, 21 pg.

Summary: This study is a followup of the mortality experience of the cohort of white males employed at the Oak Ridge National Laboratory, originally described in 1991 (see preceding manuscript citation). An additional 586 deaths were identified (compared with 1,524 deaths in the original followup). The all-cause SMR, the all-cancer SMR, and lung cancer SMR were unchanged from the previous update; however, the leukemia SMR was 1.35, compared with 1.63. The SMR for leukemia declined to 0.71 for the recent followup years (1985–1990). This decline may reflect a leukemia-radiation association due to relatively high doses in the 1940s and 1950s.

Y–12 Plant, Oak Ridge

Manuscript: Loomis D, Wolf S [1996]. Mortality of workers at a nuclear materials production plant in Oak Ridge, Tennessee, 1947-1990. Am J Ind Med, 29:131-141.

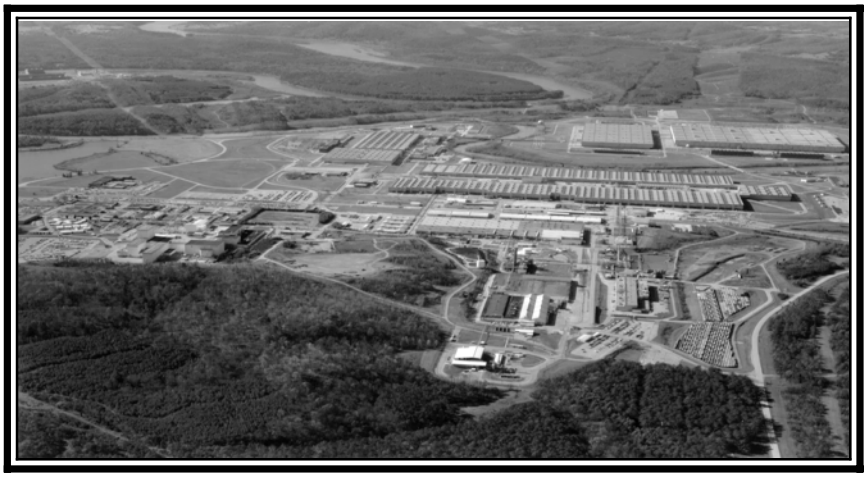
Summary: The mortality experience of a cohort of 10,597 males and females who worked at Y–12 between 1947 and 1974 was somewhat lower than that of the United States population, and cancer mortality was equal to that of the general population. Deaths from lung cancer were significantly elevated (SMR=1.17, 95% CI=1.01, 1.34). Small excesses of brain and miscellaneous lymphatic cancers were also found (SMRs=1.13 and 1.32, respectively). A small increase in pancreatic cancer deaths was also noted (SMR=1.36).

Oak Ridge Gaseous Diffusion Plant (K–25)

Manuscript: Dupree EA, Wells SM, Watkins JP, Wallace PW, Davis NC [1994]. Mortality among workers employed between 1945 and 1984 at a uranium gaseous diffusion facility. Oak Ridge, TN: Center for Epidemiologic Research Medical Sciences Division; Oak Ridge Institute for Science and Education; (DOE Contract DE-AC05-760R00033, Final report.) Available from the National Institute for

Occupational Safety and Health/Health-Related Energy Research Branch, Cincinnati, OH, 24 pg.

Summary: Mortality patterns among 35,712 workers ever employed for 30 days or more at K–25 between 1945 and 1984 were investigated. For white males, the SMR for all causes of death was significantly elevated (SMR=1.03, CI=1.01, 1.05). Other statistically significant increases among the white male population included cancers of the respiratory system including lung cancer, cancer of the bone, mental disorders, and respiratory diseases, and all injuries. Among nonwhite males, no cause of death showed a statistically significant increase.



Oak Ridge K-25 Site. *Oak Ridge, Tennessee. Date unknown. Photo Courtesy of the U.S. Department of Energy.*

Combined Oak Ridge Facilities (Tennessee Eastman Corporation [TEC], Y–12, X–10, K–25)

1. Manuscript: Watkins JP, Cragle DL, Frome EL, Reagan JL, West CM, Crawford-Brown D, Tankersley WG [1997]. Collection, validation, and treatment of data for mortality study of nuclear industry workers. Appl Occup Environ Hyg 12(3):195-205.

Summary: This paper describes methodologic issues related to combining facilities at Oak Ridge Operations in Tennessee. It includes evaluation of 118,588 workers employed at TEC, Y–12, K–25, or X–10. Validation and treatment of data for study members, and characteristics of their radiation exposure are discussed. Findings

suggest under-ascertainment of external dose during the early years at two of the facilities.

2. Manuscript: Frome EL, Cragle DL, Watkins JP, Wing S, Shy CM, Tankersley WG, West CM [1997]. A mortality study of employees of the nuclear industry in Oak Ridge, Tennessee. Radiation Res 148:64–80.

Summary: An analysis was conducted of 27,982 deaths occurring among 106,020 persons employed for at least thirty days at four nuclear facilities in Oak Ridge, Tennessee [TEC, Y–12 (after 1947), X–10, and K–25] between 1943 and 1983. Overall mortality and overall cancer mortality estimates were in close agreement with national rates. The only notable excesses occurred for lung cancer (SMR=1.18) and nonmalignant respiratory disease (SMR=1.12) among white males. Analysis showed that workers employed at TEC, K–25, and multiple facilities had higher death rates than similar workers employed only at X–10 and Y–12. These elevations were due to differences among the facilities for lung cancer, leukemia, and other lymphatic cancers.

Welders at Oak Ridge Facilities

3. Manuscript: Wells SM, Cragle DL, Tankersley WG [Undated]. An update of mortality among welders, including a group exposed to metal oxides. Oak Ridge, TN: Oak Ridge Associated Universities, Oak Ridge Institute for Science and Education, Center for Epidemiologic Research; (DOE Contract DE-AC05-76OR00033) Unpublished. 22 pg.

Summary: Overall mortality and all causes of death were examined among 1,211 white male welders employed at three DOE facilities in Oak Ridge, from 1943 through 1989. A slight excess in emphysema deaths was noted in the overall cohort, and a slight excess of deaths from diseases of the respiratory system among workers exposed to nickel oxides. The SMR for lung cancer in the total cohort also reached statistical significance (SMR=1.38, CI=1.03–1.82). Elevations in deaths due to ulcers and prostate cancer were also noted among workers exposed to nickel oxides.

Lung Cancer Case-Control Study of Uranium Workers (TEC, Y–12, Fernald, Mallinckrodt)

Manuscript: Dupree EA, Watkins JP, Ingle JN, Wallace PW, West CM, Tankersly WG [1995]. Uranium dust exposure and lung cancer risk in four uranium processing operations. Epidemiology 6(4): 370–375.

Summary: This study sought to examine the relationship between uranium dust exposure and lung cancer mortality among workers employed in four uranium processing or fabrication operations located in Missouri, Ohio, and Tennessee. A total of 787 cases were identified. Odds ratios for lung cancer mortality for seven cumulative internal dose groups did not demonstrate increasing risk with increasing dose. However, an exposure effect was suggested for workers hired at age 45 years or older. Categorizing workers by facility, and further analyses for cumulative external dose and exposures to thorium, radium, and radon did not reveal any statistically significant association between exposure and increased risk.

Mallinckrodt Chemical Works

Manuscript: Dupree-Ellis E, Watkins JP, Ingle JN, Phillips JA [2000]. External radiation exposure and mortality in a cohort of uranium processing workers. Am Epidemiol 152:91-95.

Summary: This study investigated 2,514 white males employed in a uranium processing plant between 1942 and 1966. Through 1993, a total of 1,013 deaths were ascertained. The SMR for all causes was 0.90 (95% CI, 0.85–0.96) and 1.05 (95% CI, 0.9 – 1.17) for all cancers. Respiratory diseases, chronic nephritis, and lymphatic cancers were significantly elevated. Trend test revealed a statistically significant increase of kidney cancers with external radiation based on 10 cases with an excess relative risk of 10.5 per Sv of whole body exposure. The results must be considered provisional, since external radiation exposure may be a surrogate for internal radiation dose or chemical exposures that were not considered in this study.

5 Rem Study (multiple facilities)

Manuscript: Fry SA, Dupree EA, Sipe AH, Seiler DL, Wallace PW [1996]. A study of mortality and morbidity among persons occupationally exposed to >50mSv in a year: phase I, mortality through 1984. Appl Occup Environ Hyg 11(4):334-343.

Summary: This study investigated the mortality experience of 3,145 individuals who reportedly received ≥50 mSv of penetrating ionizing radiation in any calendar year of employment (1943 through 1978) at all facilities operated for DOE. A total of 588 deaths (19%) occurred. The overall mortality experience of the total white male cohort was consistent with a healthy worker effect. SMRs for all causes of death, as well as diseases of the circulatory and digestive systems, were significantly decreased. SMRs were elevated for cancers of the esophagus and rectum, for lymphosarcoma, and for benign neoplasms. However, no statistically significant differences were found in mortality that were due to these causes or due to cancers of any of the major organ systems.

The "gadget" in the Trinity Test Site tower awaiting detonation. Built in 1945 at the Los Alamos National Laboratory. *Los Alamos, New Mexico. Photo courtesy of the U.S. Department of Energy.*

II. LOS ALAMOS NATIONAL LABORATORY

The following five studies were performed by investigators at Los Alamos National Laboratory (principal epidemiologist: Laurie Wiggs, Ph.D.).

Mound Plant, Miamisburg, Ohio

1. **Manuscript:** Reyes M, Wilkinson GS, Tietjen GL, Wiggs LD, Galke WA [1991]. Mortality among workers at the Mound facility: a preliminary report. (DOE Contract DE91 010482) Los Alamos National Laboratory, Los Alamos, NM, 20 pg.

   Summary: This technical report details an investigation of 4,697 white males employed at least 30 days between 1943 and 1979. No statistically significant elevations were found for the overall cohort. However, SMRs for thyroid, pharyngeal, lung, and prostate cancers were greater than 1.0. Significant elevations in lung cancer deaths were found among polonium workers employed between 1943 and 1959. Among workers employed for less than two years between 1943 and 1959, significant elevations were found for all causes, lung cancer, and for all injuries.

2. **Manuscript:** Wiggs LD, Cox-DeVore CA, Wilkinson GS, Reyes M [1991]. Mortality among workers exposed to external ionizing radiation at a nuclear facility in Ohio. J Occup Med 33(5): 632-637.

   Summary: This study investigated 4,182 white males employed at the Mound facility between 1947 and 1979. No statistically significant elevations for overall mortality or site-specific cancers were noted. A subcohort of 3,229 workers were monitored for external radiation. This subcohort was assessed for possible dose-response relationships between mortality from various causes and external exposure to ionizing radiation. No statistical differences in mortality were observed between workers exposed to ionizing radiation and unexposed workers. However, among workers exposed to external radiation, a statistically significant dose-response relationship was seen for lymphopoietic/hemotopoietic cancers and for all leukemias.

3. Manuscript: Wiggs LD, Cox-DeVore CA, Voelz GL [1991]. Mortality among a cohort of workers monitored for ^{210}Po Exposure: 1944-1972. Health Phy 61(1):71-76.

Summary: This study investigated mortality patterns among 2,181 white males employed at the Mound facility between 1944 and 1972, years in which polonium-210 was processed and urine monitoring was in place. The SMR for all causes was less than 1.0. SMRs for cancers of the thyroid, rectum, esophagus, lymphatic system, oral cavity, and lung were elevated, though not significantly. Elevated SMRs were seen for lung cancer among workers employed during WWII, but not for the post-WWII group. No dose-response relationship was noted between mortality and exposure to internal radiation.

Los Alamos National Laboratory (LANL)

Manuscript: Wiggs LD, Johnson ER, Cox-DeVore CA, Voelz GL [1991]. Mortality through 1990 among white male workers at Los Alamos National Laboratory: Considering exposures to plutonium and external ionizing radiation. Health Phy 67(6): 577–588.

Summary: A cohort mortality study was conducted of 15,727 white males employed at LANL from 1943 to 1977. No cause of death was elevated among this cohort. Mortality from all causes of death and all cancers was significantly low, as was mortality from many other cause-specific categories. SMR analyses were also conducted for a subcohort of workers first employed during WWII. The SMRs for the WWII subcohort indicated that mortality in this subcohort was also low compared with the general population. No cause of death was significantly elevated. Analyses of mortality comparing plutonium-exposed with unexposed workers considering a 10-year induction period also showed that no cause of death was significantly elevated. However, dose-response relationships were observed for cumulative dose of external ionizing radiation and cancers of the brain/central nervous system, esophagus, and Hodgkin's disease.

Rocky Flats Nuclear Weapons Plant, Golden, Colorado

Manuscript: Wilkinson GS, Tietjen GL, Wiggs LD, Galke WA, Acquavella JF, Reyes M, Voelz GL, Maxweiler RJ [1987]. Mortality among plutonium and other radiation workers at a plutonium weapons facility. Am J Epidemiol 125(2): 231-250.

Summary: Mortality patterns were examined for 5,413 white males employed for at least two years at the Rocky Flats Plant from 1952 through 1979. Fewer than expected deaths were observed for all causes, all cancers, and lung cancer. An excess of brain cancer was found for the overall cohort. Elevated rate ratios (RRs) for all causes of death and all lymphopoietic cancers were found, when comparing workers with plutonium burdens of ≥2 nCi with those with body burdens < 2 nCi. Increased RRs were also observed for esophageal, stomach, colon, and prostate cancers, as well as lymphosarcomas and reticulum cell sarcomas. When workers with ≥1 rem were compared with those with < 1 rem cumulative exposure, several elevated RRs were observed (myeloid leukemia, lymphosarcomas and reticulum cell sarcomas, liver neoplasm, and unspecified brain tumors). No overall dose-response relationships were found for either plutonium or external radiation exposure.

Zia Company, Los Alamos, New Mexico

1. **Manuscript:** Galke GA, Johnson ER, Tietjen GL [1992]. Mortality in an ethnically diverse radiation exposed occupational cohort. Los Alamos, NM: Los Alamos National Laboratory; Unpublished. 70 pg.

Summary: A total of 5,424 workers employed at Zia between 1946 and 1978 who were monitored for exposure to either plutonium or external ionizing radiation were included in this retrospective cohort mortality study. Among male workers, significantly elevated SMRs were seen for stomach cancer, senility and ill-defined conditions, all injuries, all incidents, and motor vehicle incidents. SMRs for female workers were consistent with mortality rates in the general population. Hispanic male workers, however, had significantly higher mortality from stomach cancer, all injuries, all incidents, and motor vehicle incidents. Non-Hispanic males had significantly higher mortality from all causes, all cancers, lung cancer, all

circulatory diseases, and all respiratory diseases. Stratified rate ratio (RR) analyses were conducted to test the association between radiation exposure and mortality. No significantly high RRs were seen in either Hispanic or non-Hispanic males in the plutonium or external ionizing radiation analyses.

Plutonium Workers (Los Alamos National Laboratory, Zia)

2. Manuscript: Voelz GL, Johnson ER, Lawrence JNP [1993]. Mortality of 244 male workers exposed to plutonium. Los Alamos, NM: Los Alamos National Laboratory; Unpublished. 16 pg.

Summary: This paper describes an updated mortality study of 224 male workers exposed to plutonium at the Los Alamos National Laboratory and Zia. Study subjects were selected by searching the Los Alamos plutonium dosimetry records for all workers who were estimated to have plutonium depositions over 370 Bq. Two types of mortality analyses were performed: (1) SMRs (calculated as of 1990) based on mortality rates of white males in the U.S. general population, and (2) mortality RRs to compare deaths occurring in the exposed group with those in an unexposed comparison group. The SMRs for all malignant neoplasms were below 1.0. Only the SMR for bone cancer was elevated (SMR=10.6, CI=0.15, 59), though this is based on only one case. All mortality rate ratios (RRs) were calculated with a 10-year cancer induction time. The ratios for all causes of death and all malignant neoplasms were not significantly elevated. Only the standardized rate ratio (SRR) for digestive system cancer was above 1.0 (SRR=1.13, CI=0.42, 3.08).

III. HANFORD ENVIRONMENTAL HEALTH FOUNDATION BATTELLE PACIFIC NORTHWEST LABORATORIES

Several research projects were performed jointly by investigators at the Hanford Environmental Health Foundation(principal epidemiologist: Ellen Omohundro, Ph.D.) and Pacific Northwest Laboratory (principal investigator: Ethel Gilbert, Ph.D.). Hanford Environmental Health Foundation was responsible for the collection and verification of mortality, occupational history, and medical and personal health history data. Pacific Northwest Laboratory gathered radiation dosimetry data and was responsible for data integration and analysis. With the exception of the combined studies, all the research efforts by these contractors pertained to the Hanford Site.

Hanford Site, Richland, Washington

1. **Manuscript:** Gilbert ES, Omohundro E, Buchanan JA, Holter NA [1993]. Mortality of workers at the Hanford Site: 1945–1986. Health Phy 64(6):577-590.

   Summary: This study investigated mortality among contractor employees initially employed at the Hanford site from 1944–1978. Both the SMR for overall mortality and mortality from malignant neoplasms for all workers were below 1.0. SMRs for diseases of the musculoskeletal system among all workers, for cancer of the pancreas in males not monitored for external radiation, and for all other solid tumors in males not monitored for external radiation were elevated, but not significantly. Comparisons of death rates by radiation dose within the cohort showed no evidence of a correlation for all causes of death, all cancers, or leukemia with radiation dose. Cancer of the pancreas ($p=0.07$) and Hodgkin's disease ($p=0.04$) showed positive correlations with radiation dose. Rates for multiple myeloma death in this cohort continue to be elevated, consistent with a previous report.

2. **Manuscript:** Omohundro E, Gilbert E [1993]. An evaluation of the adequacy of vital status follow-up in the Hanford Worker Mortality Study. Richland, WA: Hanford Environmental Health Foundation; (DOE Contract DE-AC06-76RLO 1830, report prepared for the National Institute for Occupational Safety and Health/Health-Related Energy Research Branch, Cincinnati, OH). Available from NTIS, Springfield, VA; DE94005179, 40 pg.

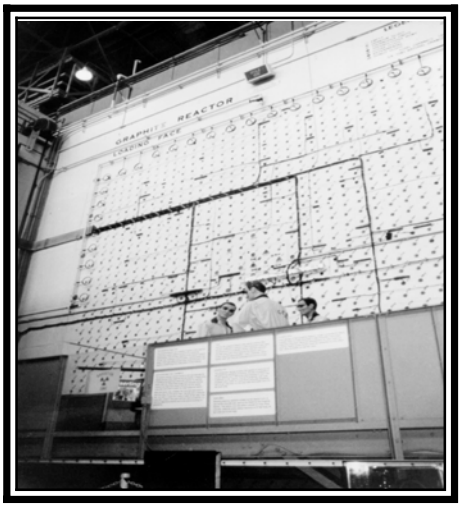
   Summary: This report was designed to evaluate the completeness of vital status ascertainment in the Hanford worker cohort. Identifying information about 17,708 Hanford workers was submitted to Equifax Government and Special Systems. For the period 1945–86, Equifax ascertained only 12 new deaths. To evaluate the adequacy of the methods used by Equifax, information about 2,254 Hanford workers who had been previously identified as dead were also submitted. Equifax missed less than 2% of known Hanford deaths during 1965–86, but missed about 18% of deaths occurring before 1965. For the period 1987–89, Equifax identified 49 new deaths. A stratified random sample of 1,600 of the 17,708 workers with unknown vital status was submitted to Equifax for a more extensive

investigation of followup status. Information about these workers was compared with consumer credit databases to determine the last date these workers were known to be alive. The results of this part of the study indicate that if these procedures had been applied to all workers with unknown vital status, about 90% of these workers would have been confirmed to be alive. About 5% of the total study population would have remained lost to followup.

Combined U.S. Cohorts (Hanford, Oak Ridge National Laboratory, Rocky Flats)

Manuscript: Gilbert ES, Cragle DL, Wiggs LD [1993]. Update analyses of combined mortality data on workers at the Hanford Site, Oak Ridge National Laboratory, and Rocky Flats Nuclear Weapons Plant. Radiation Res 136:408–421.

Summary: Combined analyses of mortality data for 44,943 workers from Hanford, Oak Ridge National Laboratory, (X–10), and Rocky Flats were undertaken to assess cancer risks associated with protracted low-dose exposure to ionizing radiation. Of 24 cancer sites evaluated, 12 showed positive correlations with radiation dose, and 12 showed negative correlations. Cancer of the esophagus, cancer of the larynx, and Hodgkin's disease showed statistically significant correlations with radiation dose, but these correlations were likely to have resulted from bias or chance fluctuations. Evidence of an increase in the excess relative risk with increasing age at risk was found for all cancer in both Hanford and Oak Ridge National Laboratory. Both populations showed significant correlations of all cancer with radiation dose among those 75 years and older. Although this age effect may have resulted from bias in the data, its presence suggests that summary risk estimates for nuclear workers be interpreted cautiously.



Oak Ridge Graphite Reactor, code-named "X-10," produced the world's first quantities of plutonium. *Oak Ridge Graphite Reactor Landmark, Oak Ridge National Laboratory, Tennessee. Date not provided. Photo courtesy of the U.S. Department of Energy.*

Combined International Studies (U.S., Canada, U.K.)

Manuscript: Cardis E, Gilbert E, Carpenter L, Howe G, Kato I, Armstrong BK, Beral V, Cowper G, Douglas A, Fix J, Fry SA, Kaldor J, Lave C, Salmon L, Smith PG, Voelz GL, Wiggs LD [1995]. Effects of a low dose and low rates of external ionizing radiation: Cancer mortality among nuclear industry workers in three countries. Radiation Res 142:117–132.

Summary: This paper presents the results of combined analyses of mortality data for 95,673 workers monitored for external exposure to ionizing radiation and employed for 6 months or longer in the nuclear industry in the United States, the United Kingdom, and Canada. No evidence was found of an association between radiation dose and mortality from all causes or from all cancers. Mortality from leukemia, excluding chronic lymphocytic leukemia, showed a statistically significant association with cumulative external radiation dose. Among 31 other cancer sites evaluated, a statistically significant association with external dose was observed only for multiple myeloma. This was attributable primarily to the associations reported previously in the Hanford and Sellafield cohorts. The relative risk of all cancers excluding leukemia was 0.99, and 1.22 for leukemia excluding chronic lymphopoietic leukemia for a cumulative protracted dose of 100 mSv compared to 0 mSv.

Proposed Research

Each of the proposed activities outlined below addresses one or more of the NIOSH Energy-Related Health Research Agenda objectives and has been approved by the DHHS Advisory Committee on Energy Related Epidemiologic Research (ACERER). These research objectives are not a comprehensive list of research opportunities or knowledge gaps for occupational hazards at DOE sites. A new Advisory Committee to replace ACERER is being considered, and NIOSH will work with the new committee to refine and prioritize the research objectives that will guide future energy-related research.

1. Civilian Nuclear Power Workers

Summary: Establish a cohort from the more than 500,000 civilian nuclear power workers who have been primarily exposed to external radiation with estimated cumulative dose averages between 2.2 and 4.2 rem. This cohort would also present opportunities to contrast neutron exposures. Records have been collected on this cohort in support of the cooperative agreement with IARC on the International Collaborative Study of Nuclear Industry Workers.

2. Evaluating Time-Related Variables in Occupational Epidemiolgic Studies

Summary: Several epidemiologic studies have suggested that time-related variables, including age at time of radiation exposure may have a significant effect on risk of cancer. Methods for statistically modeling this biological effect are not well defined. Following a literature review, a statement of work was prepared to create age–based analysis files and propose analytic approaches to these issues.

3. Neutron Exposure Assessment

Summary: Work environments with substantial neutron exposure records are being evaluated to develop methods for neutron exposure estimation and the appropriate incorporation of these estimates in epidemiologic studies. Additionally, numerous reports indicate that substantial uncertainties in estimating neutron exposure may have caused bias in the neutron dose estimates. Currently, risk estimates for neutron exposures are derived from animal studies.

4. Historical Dosimetry Practices

Summary: Documents that describe historical dosimetry practices at DOE facilities will be identified, collected, and summarized to better describe uncertainties in exposure estimates in epidemiology studies at those facilities. A list of key contacts with knowledge of historical dosimetry practices at each site is being developed.

5. Exposure Assessment of Hazardous Waste, Decontamination and Decommission, and Cleanup Workers (Phases II and III)

Summary: Phase I of this research project is described in *Ongoing Research*. If the analysis of Phase I information indicates a need for further evaluation, Phase II would include visits to collect additional site information and develop hypotheses for further study based on priorities of hazards and exposures. Phase III would include studies to test the hypotheses.

Decontamination and monitoring of a truck. *Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho. 1975. Photo courtesy of the U.S. Department of Energy.*

6. Update of Cohort Mortality Study of Mound Workers, Miamisburg, Ohio

Summary: This facility engaged in operations with potential exposures to polonium-210, plutonium-238, and tritium. A mortality study through 1979 showed elevated lung cancer mortality in workers employed from 1943–1959 and a significant dose-response relationship between plutonium-238 exposure and lymphopoietic/hematopoietic cancers and leukemia. Because of these suggestive results, the health effects of tritium, polonium, and external radiation along with potential chemical exposures at the Mound plant should be further investigated. An update would allow an additional 20 years of followup and use of validated bioassay.

7. Medical/Off-Site Radiation Exposures

Summary: The precision of occupational epidemiology studies will be improved by characterizing multiple exposure conditions. The potential effect of medical and off-site exposures to ionizing radiation in occupational epidemiologic studies has never been evaluated. Risk estimates from studies without characterization of these exposures could be biased. At K–25, an investigation has found that routine fluoroscopic chest x-ray examinations in the 1940s and 1950s may have resulted in substantial whole–body equivalent radiation exposures. This study will determine the feasibility of using medical and off-site records for workers and, if feasible, whole-body doses would be estimated using information from these additional sources of radiation.

8. Case-Control Study of Brain Cancer

Summary: Mortality studies at Los Alamos, Oak Ridge, Y–12, and Rocky Flats have found nonsignificant excesses in brain cancer. Individually, these studies lacked sufficient power to evaluate exposure response associations because of the rarity of brain cancer and the relatively small size of the cohorts. Preliminary feasibility analysis indicates that sufficient brain cancer cases exist across the DOE complex to support a multisite case-control study that would evaluate any association of the disease with chemical and ionizing radiation exposures.

9. Case-Control Study of Bone Cancer

Summary: Uranium and plutonium have well known tumorigenic potential. Worker cohort studies at sites with potential uranium or plutonium exposures have not demonstrated significant elevated risk for bone cancer primarily because of low statistical power to detect an excess. Bone cancer deaths from combined DOE cohorts should be reviewed to determine whether a multisite study is warranted where uranium or plutonium was present in the work environment. This study would provide the most sensitive evaluation of excess bone cancer in nuclear workers possible.

10. JEM Data Sensitivity Analysis

Summary: When actual monitoring data on individual workers are absent, exposures may be estimated from facility, building, or job information through exposure matrices. Because of the extensive individual external radiation monitoring information at DOE sites, the reliability of grouped estimates for chemicals or internal sources may be evaluated when they are derived under various conditions from exposure matrices. A sensitivity analysis will be performed to determine "how much data is enough" to construct a reasonably accurate job exposure matrix. This study will: (1) identify a set of health physics monitoring data with known work histories and tasks; (2) use programming to remove various portions of the data (e.g., collapse job titles and reduce sample sizes within jobs) according to preset criteria; (3) determine indicators of instability or unreliability using various modeling techniques; and (4) determine the level of uncertainty of the estimates at each level of data completeness.

Medical Surveillance Grants Activities Program Overview

NIOSH medical surveillance of former DOE workers is divided into two separate areas under different enabling authorizations. Under a Memorandum of Understanding between DOE and the Department of Health and Human Services (DHHS), NIOSH administered five DOE-funded research grants. One of these grants was completed in 1998, and a final report and evaluation were released. The remaining four grant activities were completed in 1999, and final reports are being submitted to the NIOSH Grants Office. These grants are summarized under Research Grants Administration.

Under the requirements of the Defense Authorization Act of 1993, DOE must work with DHHS, the Centers for Disease Control and Prevention (CDC), and the National Institute for Occupational Safety and Health (NIOSH) "regarding determinations of significant health risk resulting from DOE work-related exposures." Under a Memorandum of Understanding, DOE has asked that NIOSH independently conduct peer reviews of DOE former worker medical surveillance projects and make recommendations regarding the conduct of these projects. These DOE efforts are summarized under Department of Energy Medical Surveillance Activity.

Research Grants Administration

1. Improved Systems for Worker Exposure Surveillance (Grant 1 R01 CCR412029-01)

Grantee: Oak Ridge Associated Universities
William G. Tankersley, M.S.

Summary: This project will (1) evaluate current exposure–monitoring programs and data bases at the DOE Y–12 plant, (2) develop a new system for classification of workers based on substances with which they commonly work, and (3) develop and test in a working environment, a system based on readily available bar code technology for continual tracking of workers and recording the primary substances with which they work.

Manuscript: West CM, Rutherford BF, Tankersley WG [1997]. Current programs for estimating dose and chemical exposure: Volume I. Oak Ridge, TN: Oak Ridge Associated Universities; (CDC Grant R01/CCR412029) Available from the National Institute for

Occupational Safety and Health/Health-Related Energy Research Branch, Cincinnati, OH, 140 pg.

West CM, Rutherford BF, Tankersley WG [1997]. Current programs for estimating dose and chemical exposure: Volume II. Oak Ridge, TN: Oak Ridge Associated Universities; (CDC Grant R01/CCR412029) Available from the National Institute for Occupational Safety and Health/Health-Related Energy Research Branch, Cincinnati, OH, 122 pg.

Significance: The evaluation will be useful for future researchers conducting epidemiologic studies at this facility. Additionally, the development and testing of these practical and cost-effective informational systems will complement the existing worker exposure assessment programs and provide surveillance for a greater percentage of the worker population.

2. Work Histories Evaluating New Participatory Methods (Grant R01 CC512026–01)

Grantee: University of Cincinnati
Eula Bingham, Ph.D.

Grants Office Advisor: David Pedersen, Ph.D

Award Period: 9/30/95–9/29/99

Summary: Workers in the construction trades are exposed to a wide variety of chemical and radiological agents at DOE sites. Creation of an exposure history for these workers is difficult because complex exposure patterns across a large number of short-term workplace assignments must be recalled. To provide an improved basis for the characterization of worker occupational exposures over time, this project is aimed at developing and testing several innovative techniques for improving occupational history recall. The technique found to be the most efficient and effective in identifying workers at higher risk will be tested at a different DOE site with a new cohort, to validate guidelines and formats for maintaining personal work histories.

Manuscript: Awaiting final report.

Significance: Validated improvements in assembling retrospective occupational exposure histories have general application in increasing the validity of studies of the associations between exposure histories and health risk(s). Benefits from this improvement include increased capability to allocate medical surveillance resources more effectively, thus reducing unnecessary and duplicative effort.

3. Comprehensive Occupational Health Surveillance (Grant 1R01 CC12031)

Grantee: University of Washington
Scott Barnhart, Ph.D.

Grants Office Advisor: David Pedersen, Ph.D.

Award Period: 9/30/95–9/29/99

Summary: This project is concerned with the design and implementation of a model occupational safety and health surveillance system. The goal of this system is to gather appropriate occupational medicine and industrial hygiene data to provide information for the systematic identification of hazardous exposures and adverse health outcomes.

Manuscript: Ertell K, Takaro T, Shorter C, Stover B, Beaudet N, Barnhart S, Rabito F, White LE [2000]. Results of Employee Job Task Analysis (EJTA) quality assessment: Combined analysis for fourteen Hanford contractors. Seattle, WA: University of Washington; (NIOSH Grant 1R01 CC12031, Final Report.) Available from the National Institute for Occupational Safety and Health/Health-Related Energy Research Branch, Cincinnati, OH, 34 pg.

Significance: Readily available computerized information about workplace exposures and health status organized by tasks through an employee job task analysis provides information for accurate risk assessments leading to reduction of hazardous exposures. This level of documentation also supports objective evaluation of occupational health program intervention effectiveness and contributes to worker (stakeholder) involvement in prevention efforts.

Worker. *Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho. 1957. Photo courtesy of the U.S. Department of Energy.*

4. Hazard Surveillance in the Defense Nuclear Industry (Grant 1 R01 CC912034)

Grantee: University of California at Los Angeles
John Froines, Ph.D.

Grants Office Advisor: David Pedersen, Ph.D.

Award Period: 9/30/95–9/29/99

Summary: This project is intended to develop an integrated approach to statistical models for exposure assessment, especially characterization of occupational exposure to complex, mixed exposures to chemicals and biomechanical problems. Based on measured task-specific exposure data, the project is dedicated to identifying appropriate statistical tools to model single- and mixed-agent exposures and resulting internal doses.

Manuscript: Awaiting final report.

Significance: This research has application in complex exposure situations by providing an additional avenue for evaluating the relationships between exposure concentration and worker dose. The modeling capabilities of the developed system will provide a risk-based estimation of adverse health effect incidence on the basis of assessed environmental exposures to guide health interventions, including medical surveillance.

5. Sentinel Exposure Event Surveillance/Evaluation at DOE Sites (Grant 1 R01 CCR8120441)

Grantee: University of Colorado
James Ruttenber, M.D.

Grants Office Advisor: David Pedersen, Ph.D.

Award Period: 9/30/95–9/29/99

Summary: This project is intended to develop a generic hazard surveillance and evaluation system for exposures to chemical and radiation exposures. According to a job/task evaluation and analysis, the sentinel exposure event system will include exposure level measurements, worker-specific task definitions, and observation data (controls, exposure conditions, and defined health and safety policies). This input will be incorporated into a system for evaluating exposures, enhancing worker communications, and identifying necessary interventions through internally generated reports.

Manuscript: Awaiting final report.

Significance: The practice of using job/task definition as the fundamental unit of observation in a comprehensive exposure evaluation and reporting system provides generic capabilities identifying and directing occupational health interventions and enhanced worker communications. The potential for indicating and guiding improvements in occupational health program initiatives may have direct impact on the conduct of medical surveillance programs.

Department of Energy Medical Surveillance Activity

1. Medical Monitoring Program for Former Workers at Rocky Flats Environmental Technology Site

Grantee: University of Colorado
James Ruttenber, M.D., Ph.D.

Exposure Concerns: Internal/external radiation, asbestos, lead, heavy metals, solvents, formaldehyde

Target Population: Former Rocky Flats production workers (excluding cleanup workers) who were involved with weapons production between 1951 and 1989. The phase I effort estimated the target population at 14,430 former production workers.

Current Status: This project is in the second year of phase II activity. A roster of more than 15,000 former workers has been developed, and interviews with former workers regarding their occupational exposures are being conducted. The project anticipates the notification of more than 7,500 former workers in the current project year, accompanied by approximately 700 selective medical screening examinations based on exposure assessments and physician input.

2. Surveillance of Former Construction Workers at the Oak Ridge Reservation

Grantee: University of Cincinnati
Eula Bingham, Ph.D.

Exposure Concerns: Asbestos, silica, beryllium, heavy metals, solvents, welding fumes.

Target Population: Former construction workers who worked on selected buildings at the Oak Ridge site, including the Gaseous Diffusion Plant (K–25), the Y–12 Plant and the Oak Ridge National Laboratory (X–10). The needs assessment phase estimated that at least 7,000 former workers were eligible for medical screening in the second phase, based on selection from construction workers employed since 1943 (the start of construction at Oak Ridge).

Current Status: This project is in the second year of phase II activity. The project has completed an initial contact mailing to more than 1,200 former construction workers, and has conducted more than 200 worker interviews. Medical screening examinations, based on assessment of occupational exposures and medical considerations, are scheduled to begin in the current project year.

3. Medical Surveillance of Former Hanford Workers (Nonconstruction Trade Workers)

Grantees: University of Washington
Drew Brodkin, M.D., Tim Takaro, M.D.

Exposure Concerns: Asbestos, noise, beryllium

Target Population: Following the phase I needs assessment, the investigators limited this notification/medical screening program to former (1943–1997) nonconstruction trade workers who were potentially exposed to asbestos (~10,000 workers), noise (~14,000 workers), or beryllium (~6,000 workers). The investigators also intend to evaluate available site records to determine whether data on other hazardous exposures would identify more candidates for medical screening.

Current Status: This project is currently in the second year of phase II activity, and has sent out more than 12,000 letters announcing the project to identified workers, intending to continue the outreach process in the current year. The project has collected more than 700 occupational exposure histories and has assessed the hazardous exposures for these workers. At the end of the first year of phase II, the project had performed more than 100 medical screening examinations, and is continuing them in the current project year.

4. Medical Surveillance for Former Department of Energy Workers at the Nevada Test Site

Grantee: Boston University
Lewis Pepper, Ph.D., M.D.

Exposure Concerns: External/internal radiation, various chemical exposures, diesel exhaust, beryllium

Target Population: Former Nevada test site construction trade workers (underground and excavation construction workers and re-entry crews) who were employed between 1956 and 1991. Approximately 16,400 workers were represented by six construction trade unions for this period. The phase I investigation estimated that approximately 15,000 of these workers might be eligible for the program. The investigators were particularly concerned with exposures to internal and external radiation and were evaluating other hazardous exposures.

Current Status: This project is currently in the third year of phase II activity. Continuing research has indicated that more than 10,000 workers are potential candidates for the screening process, and more than 2,500 of these were individually notified in the second year of phase II. The project has provided medical screening for more than 700 workers, and intends to continue occupational history interview and medical screening efforts at similar levels in the current project year.

5. Former Worker Medical Surveillance Program at Department of Energy Gaseous Diffusion Plants

Grantees: Queens College, NY
Steven Markowitz, M.D.
Paper, Allied Industrial, Chemical and Energy Workers Union (PACE)
Robert Wages

Exposure Concerns: Beryllium, plutonium, radiation

Target Population: Former DOE production workers at the gaseous diffusion plants in Portsmouth, Ohio; Paducah, Kentucky; and the Oak Ridge, Tennessee K–25 complex. The investigators limited the notification and medical screening programs to (1) those workers with potential risk for bladder cancer at K–25 (estimated to be 500–600 workers who might be located and be eligible) and (2) those workers at the Paducah and Portsmouth sites at risk for a variety of lung diseases, including chronic obstructive lung disease, pneumoconioses and lung cancer. The phase I investigation estimated a first priority group of workers at risk of lung disease to be 2,300–3,500 workers at K–25, 300–400 workers at Portsmouth and 200–300 workers at Paducah; a second priority group was estimated to include 5,000–7,000 workers at K–25, 3,000–5,000 workers at Portsmouth and about 2,000 workers at Paducah.

Current Status: The project is currently in the second year of phase II activity. The project developed extensive worker contacts and outreach mechanisms and engaged in risk-mapping and exposure data investigations in the first year of phase II. Plans for the second year of phase II activity include the continued administration of occupational exposure history questionnaires, and the provision of more than 1,000 medical screening examinations.

6. Medical Surveillance of Former Construction Workers at Hanford

Grantee: Center to Protect Workers' Rights
Knut Ringen, Dr.P.H.

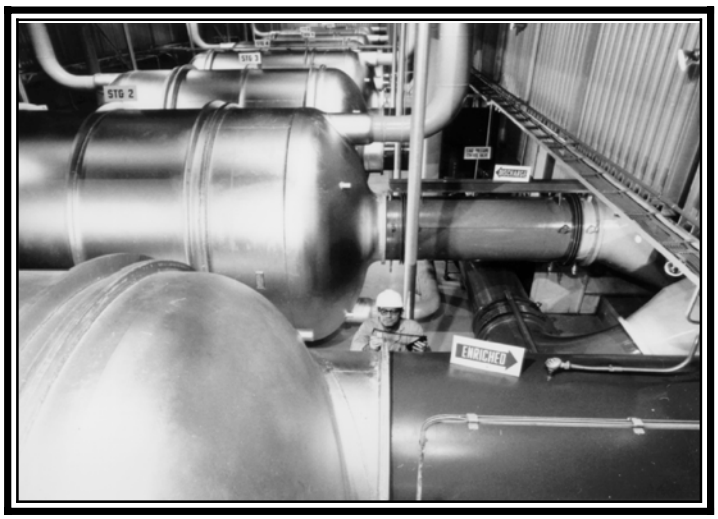
Exposure Concerns: Asbestos, beryllium, silica, heavy metals, solvents

Target Population: Former construction workers at Hanford who were involved in building construction from 1950 to 1963, excluding workers from before 1950 because of their age and a lack of records. The initial target population was estimated at 59,000, and narrowed down to 29,100 after determination of vital status and excluding those lost to followup.

Current Status: This project has just begun the third year of phase II activity. In years 1 and 2, this project contacted more than 2,500

workers, conducted more than 950 worker interviews, and provided more than 500 medical screening examinations.

7. Medical Surveillance for Former Workers at the Idaho National Engineering and Environmental Laboratory



Worker at Oak Ridge Gaseous Diffusion Plant uses special leak-detection device to examine large piping of process equipment at the plant. *K-25 Site, Oak Ridge, Tennessee. Date unknown. Photo courtesy of the U.S. Department of Energy.*

Grantees: Queens College, NY
Steven Markowitz, M.D.
Paper, Allied Industrial, Chemical and Energy Workers Union (PACE)
Robert Wages

Exposure Concerns: External/internal radiation, beryllium, solvents, noise

Target Population: The target population includes all former workers at the Idaho National Engineering and Environmental Laboratory site. During phase I, the investigators estimated that the number of workers eligible for the medical screening program might be as high as 17,500. The investigators also identified a number of exposures (including asbestos, beryllium, solvents, chromium, and radiation) that may further identify the study cohort for the site.

Current Status: This project is in the first year of phase II activity. Efforts are ongoing to add to the existing former worker roster, particularly from site contractor lists. Current exposure assessment efforts rely on both construction of a job exposure matrix and on the development of building/job classification categories for the Idaho National Engineering and Environmental Laboratory site. Medical screening protocols have been developed.

8. Medical Surveillance Program for Former Los Alamos National Laboratory Workers

Laundry worker. *Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho. 1957. Photo courtesy of the U.S. Department of Energy.*

Grantees: The Johns Hopkins University
Brian Schwartz, M.D., M.S. and Patrick Breysse, Ph. D.

Exposure Concerns: Ionizing radiation, chlorinated solvents, asbestos, beryllium, lead

Target Population: The target population includes all former Los Alamos National Laboratory workers employed since operations began in 1943. The number of workers eligible for the medical screening program was estimated at about 36,000 during phase I. Hazardous exposures that may further define the target populations were identified during phase I, and

include asbestos, beryllium, chlorinated solvents, ionizing radiation, lead and noise.

Current Status: This project is in the first year of phase II activity. Existing employee records have been analyzed for the refinement of the study cohort, and a two-stage questionnaire process for selecting workers for screening has been developed. Extensive procedures for communicating study results to both affected workers and the community have been developed. The investigators anticipate approximately 600 medical screening examinations and medical records examinations in the first year of phase II.

9. Savannah River Medical Surveillance Program for Building Trades Workers

Grantee: Center to Protect Workers Rights
Knut Ringen, Dr.P.H.

Exposure Concerns: Asbestos, cadmium, heavy metals, lead

Target Population: The estimated target population includes about 62,000 former and current building trades workers at the Savannah River site who worked from 1950 to the present. During Phase I, the investigators concluded that approximately 38,000 of these workers are alive. Phase I investigations estimated that medical screening tests might be administered to approximately 8,000 of these workers.

Current Status: This project is in the second year of phase II activity. In year 1, the project located nearly 6,000 workers, conducted nearly 500 worker interviews, and provided more than100 medical screening examinations. In phase II, year 2, the investigators anticipate locating an additional 2,500 workers, interviewing 1,500, and conducting a total of more than 1,000 medical screening examinations.

10. Savannah River Medical Surveillance for Former Production Workers

Grantees: Medical University of South Carolina
David Hoel, Ph.D.
and
University of South Carolina
David Adcock, M.D

Exposure Concerns: Asbestos, hydrazine, solvents, beryllium, internal/external radiation, dioxane, noise

Target Population: Former production workers at the Savannah River site from 1962 to the present. In phase I, the investigators estimated this to be approximately 23,000 living workers. Hazardous exposures defining this population include asbestos, beryllium, hydrazine, solvents, and internal and external radiation.

Current Status: This project is in the second year of phase II activity. Efforts to date have included developing screening questionnaires and risk assessment and medical screening protocols. Worker outreach efforts are ongoing, and the investigators have developed a Web site to assist in communications. Using existing hazard exposure and medical records, the project recently began providing medical screening examinations.

11. Medical Monitoring of Former Atomic Weapons Workers at the Iowa Army Ammunition Plant in Burlington, Iowa

Grantees: University of Iowa
Laurence Fuortes, M.D.
Stephen Reynolds, Ph.D.

Exposure Concerns: Radioactive materials, explosives, solvents, epoxies, heavy metals, and fibrogenic dusts

Target Population: Former production workers in the Line 1 facility of the Iowa Army Ammunition Plant, which served as an atomic weapons production and testing area operated by the Atomic Energy Commission from 1945 to 1975. The primary focus is on machinists employed in the area. An estimated 4,000

workers were employed in the Line 1 area, with approximately 1,000 employed at any one time.

Current Status: This project is regarded by DOE as effectively operating in phase II status at the time of project initiation. This is because DOE concluded that the proposal adequately demonstrated an understanding of the site and the exposures of the target population, adequately documenting the need for medical surveillance.

12. Amchitka Workers Medical Surveillance Program (Agreement in Principal with the State of Alaska)

Grantee: Alaska Council of Labor
Knut Ringen, Dr.P.H.

Exposure Concerns: The purpose of the program is to locate and provide medical screening to former workers at the Amchitka site. This screening is targeted to the occupational exposures of former workers at the site, especially radiation.

Target Population: Former workers employed at Amchitka from 1963 to the middle 1990s, when the U.S. government maintained a nuclear testing facility on the island. Approximately 3,000 workers may have been employed at the site, and it is estimated that about 1,500 will be located and screened.

Current Status: This project was initiated in 1999, and approximately 750 workers have been identified to date despite a wide geographical distribution. About 100 of these were deceased. Efforts to locate more former workers continue, with the help of union and Alaska Native organizations.

NIOSH (Ongoing and *Completed*) Studies by State

COLORADO

Rocky Flats Plant

- Exposure Assessment of Hazardous Waste, Decontamination, and Decommissioning and Cleanup Workers (Phase I)
- Cancer Incidence Study of Rocky Flats Plant
- Lung Fibrosis in Plutonium Workers
- *Study of the Mortality Among Female Nuclear Weapons Workers*
- *Mine Specific Exposure Information for Uranium Miners Study*

IDAHO

Idaho National Engineering and Environmental Laboratory

- Cohort Mortality Study of Idaho National Engineering and Environmental Laboratory Workers
- Exposure Assessment of Hazardous Waste, Decontamination and Decommissioning, and Cleanup Workers (Phase I)
- Lung Cancer Case-Control Study
- International Collaborative Study of Nuclear Industry Workers
- *Prevention of Stress and Health Consequences of Downsizing and Reorganization*
- *Childhood Leukemia Case-Control Study*

MAINE

Portsmouth Naval Shipyard

- Cohort Mortality Study of Portsmouth Naval Shipyard
- Lung Cancer Case-Control Study
- Leukemia Case-Control Study
- International Collaborative Study of Nuclear Industry Workers

MISSOURI

Mallinckrodt Uranium Works

- Cohort Mortality Study of Mallinckrodt Workers

NEVADA

Nevada Test Site

- Prevention of Stress and Health Consequences of Downsizing and Reorganization

NEW MEXICO

Los Alamos National Laboratory

- Leukemia Case-Control Study
- Prevention of Stress and Health Consequences of Downsizing and Reorganization
- *Study of the Mortality Among Female Nuclear Weapons Workers*
- *Multisite Multiple Myeloma Case-Control Study*
- *Mine– Specific Exposure Information for Uranium Miners Study*

NEW YORK

Linde Air Products

- *Study of the Mortality Among Female Nuclear Weapons Workers*

OHIO

Feed Materials Production Center (Fernald)

- Exposure Assessment of Hazardous Waste, Decontamination, and Decommissioning, and Cleanup Workers (Phase I)
- Feasibility Study for an Integrated Data Base for DOE Site Remediation Workers
- Cohort Mortality Study of Fernald Environmental Management Plant (Vital Status Followup through 1998)
- *Study of the Mortality Among Female Nuclear Weapons Workers*
- *Radon and Cigarette Smoking Exposure Assessment in Fernald Workers*
- *Cohort Mortality Study of Workers at Fernald Feed Materials Production Center (Vitus Status Followup Through 1989)*

Mound Site

- Exposure Assessment of Hazardous Waste, Decontamination, and Decommissioning, and Cleanup Workers (Phase I)
- Update of Cohort Mortality Study of Mound Workers
- Study of the Mortality Among Female Nuclear Weapons Workers*

Portsmouth Gaseous Diffusion Plant

- *Cohort Mortality Study of Portsmouth Gaseous Diffusion Plant*

SOUTH CAROLINA

Savannah River Plant

- Leukemia Case-Control Study
- Exposure Assessment of Hazardous Waste, Decontamination, and Decommissioning, and Clean-up Workers (Phase I)
- Cohort Mortality Study of DOE Chemical Laboratory Workers
- Lung Cancer Case-Control Study
- *Study of the Mortality Among Female Nuclear Weapons Workers*
- *Multi-Site Multiple Myeloma Case-Control Study*
- *Cohort Mortality Study of Workers at the Savannah River Plant*

TENNESSEE

Oak Ridge K–25 Plant

- Multiple Myeloma Case-Control Study at the Oak Ridge Gaseous Diffusion Plant (K–25)

Oak Ridge National Laboratory (X–10 Site)

- Leukemia Case-Control Study
- Lung Cancer Case-Control Study
- Construction Workers Mortality Study
- *Multisite Multiple Myeloma Case-Control Study*

Oak Ridge Y-12 Plant

- *Prevention of Stress and Health Consequences of Downsizing and Reorganization*
- *Mercury Workers Health Study*

Combined Oak Ridge National Laboratory Sites: X–10, K–25, Y–12

- Exposure Assessment of Hazardous Waste, Decontamination, and Decommissioning, and Cleanup Workers (Phase I)
- Cohort Mortality Study of DOE Chemical Laboratory Workers
- Studies of Heat Stress and Performance in Carpenters at DOE Sites
- *Study of the Mortality Among Female Nuclear Weapons Workers*
- *Childhood Leukemia Case-Control Study*
- *Time-Related Factors in Radiation-Cancer Dose Response*
- *Dose Estimation from Daily and Weekly Dosimetry Data*

TEXAS

Pantex Plant

- Cohort Mortality Study of Pantex Plant, Amarillo, TX
- *Study of the Mortality Among Female Nuclear Weapons Workers*
- *Prevention of Stress and Health Consequences of Downsizing and Reorganization*

WASHINGTON

Hanford Site

- Leukemia Case-Control Study
- Exposure Assessment of Hazardous Waste, Decontamination, and Decommissioning, and Cleanup Workers (Phase I)
- Lung Cancer Case-Control Study
- Construction Workers Mortality Study
- Studies of Heat Stress and Performance in Carpenters at DOE Sites
- Ionizing Radiation and Mortality Among Hanford Workers
- Study of the Mortality Among Female Nuclear Weapons Workers
- Surveillance Methods for Solvent-Related Hepatoxicity, a cross-sectional study at Hanford
- *Multisite Multiple Myeloma Case-Control Study*
- *Accounting for Errors in Radiation in Dose Estimates*
- *Childhood Leukemia Case-Control Study*

Listing of NIOSH Studies by DOE Site

Feed Materials Production Center (Fernald), OH

- Exposure Assessment of Hazardous Waste, Decontamination and Decommissioning, and Cleanup Workers (Phase I)
- Feasibility Study for an Integrated Data Base for DOE Site Remediation Workers
- Cohort Mortality Study of Fernald Environmental Management Plant (Vital Status Followup Through 1998)

- Study of the Mortality Among Female Nuclear Weapons Workers
- Radon and Cigarette Smoking Exposure Assessment in Fernald Workers
- *Cohort Mortality Study of Workers at Fernald Feed Materials Production Center (Vitus Status Followup Through 1989)*

Hanford Site, WA

- Leukemia Case-Control Study
- Exposure Assessment of Hazardous Waste, Decontamination, and Decommissioning, and Cleanup Workers (Phase I)
- Lung Cancer Case-Control Study
- Construction Workers Mortality Study
- Studies of Heat Stress and Performance in Carpenters at DOE Sites
- Ionizing Radiation and Mortality Among Hanford Workers
- *Study of the Mortality Among Female Nuclear Weapons Workers*
- Surveillance Methods for Solvent-Related Hepatoxicity, a cross-sectional study at Hanford
- *Multisite Multiple Myeloma Case-Control Study*
- *Accounting for Errors in Radiation in Dose Estimates*
- *Childhood Leukemia Case-Control Study*

Idaho National Engineering and Environmental Laboratory, ID

- Cohort Mortality Study of Idaho National Engineering and Environmental Laboratory Workers

- Exposure Assessment of Hazardous Waste, Decontamination, and Decommissioning, and Cleanup Workers (Phase I)
- Lung Cancer Case-Control Study
- International Collaborative Study of Nuclear Industry Workers
- *Prevention of Stress and Health Consequences of Downsizing and Reorganization*
- *Childhood Leukemia Case-Control Study*

Linde Air Products, NY

- *Study of the Mortality Among Female Nuclear Weapons Workers*

Los Alamos National Laboratory, NM

- Leukemia Case-Control Study
- *Study of the Mortality Among Female Nuclear Weapons Workers*
- *Prevention of Stress and Health Consequences of Downsizing and Reorganization*
- *Multisite Multiple Myeloma Case-Control Study*

Mallinckrodt Uranium Works, MO

- *Cohort Mortality Study of Mallinckrodt Workers*

Mound Site, OH

- Exposure Assessment of Hazardous Waste, Decontamination, and Decommissioning, and Cleanup Workers (Phase I)
- Update of Cohort Mortality Study of Mound Workers
- *Study of the Mortality Among Female Nuclear Weapons Workers*

Nevada Test Site, NV

- *Prevention of Stress and Health Consequences of Downsizing and Reorganization*

Oak Ridge, TN: All Oak Ridge Facilities Combined (X–10, K–25, Y–12)

- Exposure Assessment of Hazardous Waste, Decontamination, and Decommissioning, and Cleanup Workers (Phase I)
- Cohort Mortality Study of DOE Chemical Laboratory Workers
- Studies of Heat Stress and Performance in Carpenters at DOE Sites
- *Study of the Mortality Among Female Nuclear Weapons Workers*
- *Childhood Leukemia Case-Control Study*
- *Time-Related Factors in Radiation-Cancer Dose Response*
- *Dose Estimation from Daily and Weekly Dosimetry Data*

Oak Ridge, TN: K–25 Site

- Multiple Myeloma Case-Control Study at the Oak Ridge Gaseous Diffusion Plant (K–25)

Oak Ridge Laboratory, TN: X–10 Site

- Leukemia Case-Control Study
- Lung Cancer Case-Control Study
- Construction Workers Mortality Study

Oak Ridge, TN: Y–12 Plant

- *Prevention of Stress and Health Consequences of Downsizing and Reorganization*
- *Mercury Workers Health Study*

Pantex Plant, TX

- Cohort Mortality Study of Pantex Plant, Amarillo, TX
- *Study of the Mortality Among Female Nuclear Weapons Workers*
- *Prevention of Stress and Health Consequences of Downsizing and Reorganization*

Portsmouth Gaseous Diffusion Plant, OH

- *Cohort Mortality Study of Portsmouth Gaseous Diffusion Plant*

Rocky Flats Plant, Colorado

- Exposure Assessment of Hazardous Waste, Decontamination, and Decommissioning, and Cleanup Workers (Phase I)
- Cancer Incidence Study of Rocky Flats Plant
- Lung Fibrosis in Plutonium Workers
- *Study of the Mortality Among Female Nuclear Weapons Workers*

Savannah River Plant, SC

- Leukemia Case-Control Study
- Exposure Assessment of Hazardous Waste, Decontamination, and Decommissioning, and Cleanup Workers (Phase I)
- Cohort Mortality Study of DOE Chemical Laboratory Workers

- Lung Cancer Case-Control Study
- *Study of the Mortality Among Female Nuclear Weapons Workers*
- *Multisite Multiple Myeloma Case-Control Study*
- *Cohort Mortality Study of Workers at the Savannah River Plant*

Other NIOSH Studies Related to DOE Workers

- Correcting for Measurement Errors in Radiation Exposure
- Epidemiologic Studies to Evaluate Health Effects of Uranium Milling
- Dose of Beryllium Causing Sensitization and Disease
- Analysis for Characterizing Plutonium Exposure to Improve Lung Cancer Risk Estimates
- Acute Radiation Syndrome in Russian Nuclear Workers
- *Feasibility Study of Assessing Adverse Reproductive Outcomes Among Females Employed at DOE Facilities*
- *Assessment of Electric and Magnetic Field Exposures of Transportation Workers*
- *Cancer Incidence and Sentinel Event Registries*
- Glycophorin *A Biodosimetry in I–131 Treated Patients*
- *Specificity of the National Death Index and the Social Security Administration Death Master File when Information on Social Security Number is Lacking*

Research Partners

The Health-Related Energy Research Branch has established numerous partnerships that have proven productive in the conduct of intramural and extramural research program. These partnerships are with labor, academia, contractors, international organizations, and State and other governmental agencies. The research may be conducted within NIOSH and CDC (intramurally) or extramurally through grants, contracts, and cooperative agreements with the partners listed.

Academia, Contractors, and Unions

Battelle Pacific Northwest Labs
Battelle Memorial Institute
Boston University School of Public Health
Computer Science Corporation
HGO Technology
International Agency for Research on Cancer
Michigan State University
National Jewish Center for Immunology
and Respiratory Medicine
New York University Medical Center
Oak Ridge Associated Universities
Oak Ridge Institute of Science and Energy
Survey Research Associates, Inc.
Tri-S Incorporated
United Brotherhood of Carpenters
University of California at Los Angeles
University of Cincinnati
University of Colorado
University of North Carolina
University of Pittsburgh
University of Southern California
University of Texas Medical Branch
University of Washington
University of Buffalo
Westat Corporation

Centers for Disease Control and Prevention (CDC)

National Center for Environmental Health (NCEH)
National Center for Health Statistics (NCHS)

Department of Health and Human Services (DHHS)

Agency for Toxic Substances and Disease Registry (ATSDR)
Office for the Protection from Research Risks (OPRR)
National Cancer Institute (NCI)
National Institute of Environmental Health Sciences (NIEHS)

Other Government

Department of Energy
Office of Health Studies
Environmental Protection Agency
State Health Departments (Colorado, Idaho, Oregon, Tennessee, Washington)

National Institute for Occupational Safety and Health (NIOSH)
Health-Related Energy Research Branch (HERB)

Study	NIOSH Project officer	phone/fax/email	External principal investigator	External principal investigator phone/fax/email
INTRAMURAL STUDIES:				
Cohort Mortality Study of Portsmouth Gaseous Diffusion Plant	Steven Ahrenholz, M.S., Ph.D., C.I.H.	513-841-4471 513-841-4470 (fax) sha1@cdc.gov	N/A	N/A
Cohort Mortality Study of Idaho Natl Engineering Laboratory	Mary Schubauer-Berigan, Ph.D.	513-841-4251 513-841-4470 (fax) zcg3@cdc.gov	N/A	N/A
Cohort Mortality Study of Portsmouth Naval Shipyard	Timothy Taulbee, M.S.	513-841-4468 513-841-4470 (fax) tgt4@cdc.gov	N/A	N/A
Chemical Lab Workers Mortality	Cynthia Robinson, Ph.D.	513-841-4217 513-841-4470(fax) cfr2@cdc.gov	N/A	N/A

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National Institute for Occupational Safety and Health (NIOSH)
Health-Related Energy Research Branch (HERB)

Study	NIOSH Project officer	phone/fax/email	External principal investigator	External principal investigator phone/fax/email
Construction Workers Mortality	Cynthia Robinson, Ph.D.	513-841-4217 513-841-4470(fax) cfr2@cdc.gov	N/A	N/A
DOE Feasibility Study for Site Remediation Workers	Cynthia Robinson, Ph.D.	513-841-4217 513-841-4470(fax) cfr2@cdc.gov	N/A	N/A
Leukemia Case-Control Study	Thurman Wenzl, Sc.D.	513-841-4490 513-841-4470 (fax) tyw1@cdc.gov	N/A	N/A
Lung Cancer Case Control	Sharon Silver, M.A.	513-841-4313 513-841-4470(fax) zre4@cdc.gov	N/A	N/A
Multiple Myeloma Case-Control Study at K-25 Plant	Cynthia Robinson, Ph.D.	513-841-4217 513-841-4470(fax) cfr2@cdc.gov	N/A	N/A
Exposure Assessment of Hazardous Waste/Cleanup Workers (Phase I)	Gregory Kinnes, M.S.	513-841-4409 513-841-4470 (fax) gmk1@cdc.gov	N/A	N/A
Pantex Plant Mortality Study	Barbara Grajewski, Ph.D.	513-841-4429 513-841-4470 (fax) bag2@cdc.gov	N/A	N/A

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National Institute for Occupational Safety and Health (NIOSH)
Health-Related Energy Research Branch (HERB)

Study	NIOSH Project officer	phone/fax/email	External principal investigator	External principal investigator phone/fax/email
Fernald Cohort Mortality Study	John Cardarelli, Ph.D.	513-841-4439 513-841-4470 (fax) jjc0@cdc.gov		
Exposure Assessment of Radiologic Technologists	Jim Neton, Ph.D.	513-841-4552 513-841-4470 (fax) jfn2@cdc.gov	N/A	N/A

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National Institute for Occupational Safety and Health (NIOSH)
Health-Related Energy Research Branch (HERB)

Study	NIOSH Project officer	phone/fax/email	External principal investigator	External principal investigator phone/fax/email
EXTRAMURAL STUDIES (Cooperative Agreements):				
Cancer Incidence/Mortality Study of Rocky Flats Plant	Dennis Zaebst, M.S.	513-841-4459 513-841-4470 (fax) ddz1@cdc.gov	Norma Morin, Ph.D. Colorado DPH	303-692-2636 303-782-0188 (fax) normie.morin@state.co.us
International Collaborative Study of Nuclear Industry Workers	David Utterback, Ph.D.	513-841-4492 513-841-4470 (fax) dfu0@cdc.gov	Elisabeth Cardis, Ph.D. IARC	011-334-7273-8508 011-334-7273-8575 (fax) cardis@iarc.fr
Chronic Beryllium Disease Among Beryllium-Exposed Workers	Paul Henneberger, Sc.D.	304-285-5756 304-285-5861 (fax) pkh0@cdc.gov	Ken Rosenman, M.D. Michigan State Univ.	517-353-1846 517-432-3606 (fax) 21770kdr@msu.edu
Beryllium Disease Natural History and Exposure Response	Paul Henneberger, Sc.D.	304-285-5756 304-285-5861 (fax) pkh0@cdc.gov	Lee Newman, M.D. Natl. Jewish Center for Immun. & Resp. Med.	303-398-1725 303-398-1851 (fax) newman1@njc.org
Prevention of Stress and Health Consequences of Downsizing and Reorganization	Larry Murphy, Ph.D.	513-533-8171 513-533-8596 (fax) lrm2@cdc.gov	Lewis Pepper, M.D. Boston University	617-638-4620 617-638-4857 (fax) lpepper@bu.edu
EXTRAMURAL STUDIES (Contracts):				
Historical Plutonium Bioassay Measurements	HERB Office	513-841-4400 513-841-4470 (fax)	Norman Cohen, Ph.D. New York University	914-351-4368 914-351-3489 (fax) norman@charlotte.med.nyu.edu

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National Institute for Occupational Safety and Health (NIOSH)
Health-Related Energy Research Branch (HERB)

Study	NIOSH Project officer	phone/fax/email	External principal investigator	External principal investigator phone/fax/email
EXTRAMURAL STUDIES (Grants):				
Measurement Error Methods for Underground Miner Studies	Roy Fleming	404-639-2810 404-639-2196 (fax) rmf2@cdc.gov	Dan Stram, Ph.D. Univ. Southern Calif.	213-342-1817 213-342-2349 (fax) stram@rcf.usc.edu
Study of Heat Stress and Performance in Carpenters at DOE Sites	Roy Fleming	404-639-2810 404-639-2196 (fax) rmf2@cdc.gov	Ken Rosenman, M.D. Unit. Brthd. Carpenters	517-353-1846 517-432-3606 (fax) 21770kdr@msu.edu
Acute Radiation Syndrome in Russian Nuclear Workers	Roy Fleming	404-639-2810 404-639-2196 (fax) rmf2@cdc.gov	Neil Wald, M.D. University of Pittsburgh	412-624-2735 412-624-7534 wasld@vms.cis.pitt.edu
Surveillance Methods for Solvent-related Hepatotoxicity	Cynthia Robinson, Ph.D.	513-841-4217 513-841-4470 (fax) cfr2@cdc.gov	Carl Brodkin, Ph.D. University of Washington	206-731-2527 werd@u.wahington.edu
Radon and Cigarette Smoking Exposure Assessment at Fernald	Jim Neton, Ph.D.	513-841-4552 513-841-4470 (fax) jfn2@cdc.gov	Susan Pinney, Ph.D. University of Cincinnati	513-558-0684 513-558-4240 (fax) susan.pinney@uc.edu
Correcting for Measurement Errors in Radiation Exposure	Tim Taulbee, M.S.	513-841-4468 513-841-4470 tgt4@cdc.gov	Xiaonam Xue, Ph.D. New York University	212-263-6114 212-263-8570 (fax) xiaonan.xue@med.nyu.edu
Ionizing Radiation and Mortality Among Hanford Workers	Sharon Silver, M.A.	513-841-4313 513-841-4470 (fax) zre4@cdc.gov	Steve Wing, Ph.D. Univ. North Carolina	919-966-7416 919-542-4403 (fax) swing@sphvax.sph.unc.edu

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National Institute for Occupational Safety and Health (NIOSH)
Health-Related Energy Research Branch (HERB)

Study	NIOSH Project officer	phone/fax/email	External principal investigator	External principal investigator phone/fax/email
DOE SURVEILLANCE GRANTS:				
Hazard Surveillance in Defense Nuclear Industry	David Pedersen, Ph.D.	513-841-4223 513-841-4483 (fax) dhp1@cdc.gov	John Froines, Ph.D. UCLA	310-206-6141 310-206-9903 (fax) jfroines@ucla.edu
Improved Systems for Worker Exposure Surveillance	David Pedersen, Ph.D.	513-841-4223 513-841-4483 (fax) dhp1@cdc.gov	Wm. Tankersley, M.S. ORAU	423-576-3141 423-576-9557 (fax) tankersb@orau.gov
Work Histories—Evaluating New Participatory Methods	David Pedersen, Ph.D.	513-841-4223 513-841-4483 (fax) dhp1@cdc.gov	Eula Bingham, Ph.D. Univ. Cincinnati	513-558-5728 513-558-5062 (fax)
Sentinel Exposure Events Surveillance/Evaluation at DOE Sites	David Pedersen, Ph.D.	513-841-4223 513-841-4483 (fax) dhp1@cdc.gov	James Ruttenber, M.D. Univ. Colorado	303-315-5627 303-315-3183 (fax) jim.ruttenber@uchsc.edu
Comprehensive Occupational Health Surveillance	David Pedersen, Ph.D.	513-841-4223 513-841-4483 (fax) dhp1@cdc.gov	Scott Barnhart, Ph.D. Univ. Washington	206-731-3388 206-731-8247 (fax) sbht@u.washington.edu

NIOSH Health-Related Energy Research Branch

The NIOSH Health-Related Energy Research Branch (HERB) staff consists of a variety of professionals that work together on a research agenda supporting the NIOSH mission. Branch staff members include epidemiologists, health physicists, industrial hygienists, computer programmers, biostatisticians, a public policy analyst, information specialists, and administrative personnel. Various support contractor personnel, fellows, and student interns supplement the human resource needs of the Branch depending on program activities and expertise required. The organizational structure of the Branch is presented on the following pages. The Branch structure consists of program management, two sections (the Epidemiology and Exposure Assessment Sections), and program activities (computer programming, biostatistics, health communication, and administrative support) that report to program management.

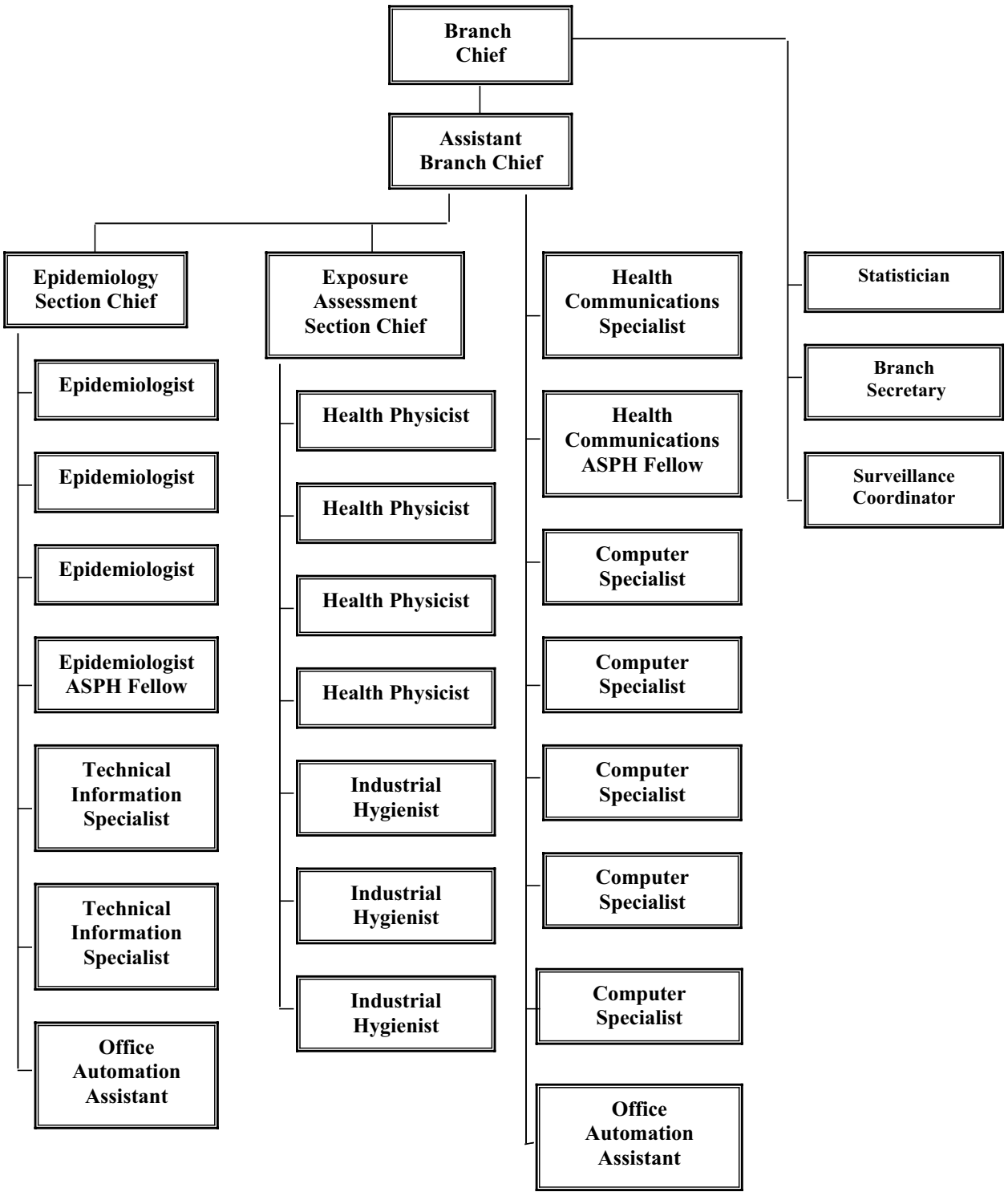
The HERB staff members possess a variety of credentials and backgrounds, contributing to the diversity and strength of the research program. Professional credentials held by staff members include: masters and doctoral degrees, Certified Health Physicist (CHP), and Certified Industrial Hygienist (CIH). The tenure among staff members in their respective disciplines ranges from a few years to over 20.

Primary points of contact regarding the Branch, the Sections, and the program activities are the following persons:

Branch Chief:	Vacant
Assistant Branch Chief:	Steven Ahrenholz
Epidemiology Section:	Barbara Grajewski
Exposure Assessment Section:	David Utterback
Surveillance Coordinator:	David Pedersen
Branch Secretary:	April Jenkins

All of these staff members may be reached at 513–841–4400, fax 513–841–4470.

National Institute for Occupational Safety and Health
Health-Related Energy Research Branch
Organizational Chart
December 2000



Glossary

Bequerel (Bq): The unit of activity equal to one disintegration per second. [37 billion bequerels = 1 curie (Ci)]

Bioassay: A determination of the concentration of a substance in the body by the analysis of urine, blood, feces, bone, or tissue. The use of the living organism to measure the amount of a substance that has been absorbed.

Biomarkers: A cellular or molecular indicator of exposure, disease, or susceptibility to disease.

Cancer incidence: The number of new cancer cases in a population within a period of time.

Carcinogen: A substance or agent that can cause cancer.

Carcinogenic: Capable of causing cancer.

Case control study: A scientific study that compares a group of people with disease (such as leukemia) to a similar group of people without that disease. This type of study compares the levels of exposure (radiation or chemical) each group had before appearance of the disease.

Cohort: A group of persons identified by common characteristics who are studied over a period of time.

Cohort study: An epidemiology study that observes a large group of people over a period of time. Within the cohort, morbidity or mortality rates can be calculated for group members with different exposures.

Confidence Interval (CI): A range of numbers around a mean, proportion, or rate that serves as a rough guide or minimum estimate of the inherent uncertainty in a epidemiologic result.

Confounder: Factors that distort or mask the true effect of exposure in an epidemiologic study.

Curie: A measure of the amount of radioactivity in a material. One Curie is 37 billion atoms undergoing radioactive decay each second.

Cross-sectional study: A study that examines the relationship between exposure and health outcome in a population at a certain point in time.

Dose: Amount of a substance that remains at a biological target during a time interval. With radiation, the amount of energy deposited in biological tissue during a specified time.

Dose response: A relationship in which a change in the amount, intensity, or duration of an exposure is associated with either an increase or decrease in risk of a specified health outcome.

Epidemiology: The study of factors that affect health and disease in groups of persons.

Exposure assessment: The process to estimate radiation and chemical exposures.

External radiation: Radiation capable of damaging human tissue that is given off by a nuclear or x-ray source outside the body.

Gamma radiation: High energy electomagnetic radiation that is emitted from an atom's nucleus has no mass or electrical charge has high penetrating power, and can pass though the human body.

Health physics: The science of radiation protection to reduce or prevent radiation exposure. The study of effects of ionizing radiation on humans and their environment.

Healthy worker effect: A study finding of fewer deaths for workers in an industry compared with the U.S. population, usually because severely ill and chronically disabled are excluded from employment. The general population may not be the best comparison group for workers.

Incidence or incidence rate: The number of persons becoming ill in a defined population within a period of time.

Induction period: Time period between exposure to an agent and disease detection.

Industrial hygiene: A science devoted to the protection and improvement of the health and well-being of workers exposed to chemical and physical agents in their work environment.

Institutional review board: A group of scientists and nonscientists who review proposed studies to ensure that the rights of study participants are protected.

Internal radiation: Radiation given off by nuclear materials that have been inhaled, swallowed, or absorbed into the body through a cut, puncture, or abrasion of the skin.

Latency: Time period between disease occurrence and detection, sometimes used interchangeably with induction.

MilliSievert (mSv): equal to one-thousandth of a sievert. **See Sievert.**

Mortality: Death.

Morbidity: Sickness or illness: departure from a state of physical or mental well-being.

Mortality rate: The proportion of a population that dies during a specified time period. Also referred to as the death rate.

Neutron: A particle that may be emitted from the nucleus of atoms and carries no electrical charge.

Nanocurie (nCi): Unit amount of radioactivity measurement equal to one-billionth of a curie. **See Curie.**

NIOSH Human Subjects Review Board: The NIOSH Institutional review board must approve all proposed studies conducted in-house from the Health-Related Energy Research Branch.

Odds ratio: Ratio of the odds of disease among the exposed compared with the odds of disease among the unexposed. For rare diseases, including some cancers, the odds ratio is an estimate of the relative risk.

Radiation (ionizing): Energy in the form of electromagnetic waves or particles capable of damaging cells by removing electrons from atoms or molecules. This damage can lead to cancer or other defects.

Relative risk: Ratio of the risk of disease or death among the exposed segment of the population to the risk among the unexposed.

Rem: A unit for measuring absorbed doses of radiation received by the body that includes an adjustment for the intensity of the damage to one or more cells. Rem is the abbreviation of roentgen equivalent man.

Sentinel event registry: An ongoing data collection for illness or health conditions that may be used to provide early notice of adverse health effects from one or more exposures.

Sievert: Unit of equivalent absorbed dose equal to 100 rems.

Standard mortality ratio (SMR): Ratio of the number of deaths observed in the study group to the number of deaths expected based on rates in a comparison population, multiplied by 100.

Standard rate ratio (SRR): A ratio of the rates of death or morbidity that has been adjusted (standardized) to the same population.

Statistical significance: The likelihood that an association between exposure and disease risk could have occurred by chance alone.

Stratified random sample: Process of separating a sample into several groups and randomly assigning subjects to those groups.

Vital status: The determination of alive or deceased status for members of an epidemiology study cohort.

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