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## RESPIRATORY PROTECTION AT NUCLEAR POWER PLANTS\*

by

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### I. BACKGROUND

The Industrial Hygiene Group at Los Alamos National Laboratory has been conducting respiratory protection research and development since 1969. This work has been supported by the Nuclear Regulatory Commission (NRC), Department of Energy (DOE), National Institute for Occupational Safety and Health (NIOSH), Bureau of Mines (BOM), Air Force, Army, Navy and Occupational Safety and Health Administration (OSHA). All participating agencies have benefited mutually because of their similar interests in protecting the health of workers. NRC and DOE are primarily responsible for the establishment of this program at Los Alamos and have been the largest supporters of the program. The NRC has supported some of the most important and beneficial respirator research conducted at the Laboratory. The major areas of research and development supported by NRC have included development of respirator fit testing methods and equipment, determination of protection factors for various classes of respirators, evaluation of the performance of respiratory protective equipment, technical assistance on special respiratory protection problems, and development of visual aids and guides for respirator training.

All NRC licensed nuclear power plants benefit from these activities because a comprehensive respiratory protection program is a vital part of any occupational radiation protection program. There are many operations,

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particularly maintenance, in a nuclear power plant where engineering controls are not feasible for controlling airborne radioactive materials that pose a respiratory hazard. In such cases only respiratory protection equipment is available to reduce occupational radiation exposure. Information available from the Los Alamos research efforts have kept the NRC and its licensees aware of the latest advances in respiratory protection, as well as being aware of the performance of various respiratory protective equipment. This allows the licensee to limit radiation exposure to their employees, and obtain the most benefit for their money in occupational radiation protection. A short review of the highlights of this program at Los Alamos, past and present, is presented here.

## II. FIT TESTING AND PROTECTION FACTORS

In the past, respirator facepiece fit was determined qualitatively by pressure checks, use of irritating aerosols, or by detection of the odor of a challenge vapor. Each of these qualitative tests relies on the wearer of the respirator to detect the challenge aerosol/vapor if it leaks past the respirator. Individual variation in response to these aerosols/vapors results in varying abilities to detect them. Because of the variability of response to these aerosols/vapors only low protection factors are allowed for this type of fit test. These low protection factors limit the use of air-purifying devices and would require the use of positive pressure atmosphere-supplying devices for the majority of work that would be done at power reactors.

Los Alamos has developed respirator fit test methods and equipment that allow respirator users to quantitatively determine what type of respirator facepiece best fits an individual. Whereas the qualitative fit test determines whether a respirator leaks, the quantitative fit test determines the degree of leakage. Quantitative fit testing involves measuring the concentration of a test atmosphere both outside and inside the respirator. A protection factor is calculated by the ratio of the test atmosphere concentration outside the respirator to the concentration inside the respirator. Assuring a good facepiece fit by quantitative means allows one to assume a higher level of protection than is acceptable

if other fitting methods are used. As part of this program, Los Alamos has developed quantitative fit test equipment that is now commercially available as well as the test method used to minimize variability of results while adequately simulating workplace conditions.

Los Alamos developed the use of protection factors for various classes of respiratory protective equipment. Protection factor is a number assigned to a class of respirator representing the minimum degree of protection that the respirator is thought to provide for the majority of users. These protection factors were developed to aid NRC licensees in selecting the best type of respirator for a particular degree of hazard. Subsequent consensus standards have adopted this concept as an aid to respiratory protective equipment selection.

### III. EVALUATION OF RESPIRATORY PROTECTIVE EQUIPMENT

Respiratory protective device evaluation has been ongoing at Los Alamos since 1969. Many categories of devices have been evaluated; however, NRC-sponsored research has been particularly significant in the area of atmosphere-supplying equipment. In fact, this research has provided the most comprehensive studies ever conducted on evaluating the performance of the various types of atmosphere-supplying devices. Testing of atmosphere-supplying respirators has included complete evaluations of airline respirators, self-contained breathing apparatus (SCBA), and emergency escape SCBA. These evaluations have covered weight of the device, size, in mask air pressures, ease of donning, airflow, wearing comfort, alarms, and evaluation of respiratory protection performance. This type of test protocol is significantly more comprehensive than that used by the regulatory agencies that approve respiratory protective equipment. In using such a comprehensive protocol, Los Alamos provides NRC and its licensees significantly more information than is available from the regulatory agencies that approve respiratory protective equipment. This additional information includes evaluation of not only the respiratory protection characteristics of the device but also wearing and use characteristics of the device that may be critical to the choice of the type of device for

use in nuclear reactors. Special emphasis is placed on the application of these types of protective devices to the hazards encountered at nuclear facilities during these evaluations.

#### IV. TECHNICAL ASSISTANCE AT THREE MILE ISLAND

Technical assistance to NRC has been a continuing object of this program. Special hazards associated with nuclear facilities have required unique solutions in the area of respiratory protective equipment. Los Alamos has provided a ready source of expertise to NRC on such problems at Three Mile Island. Los Alamos provided on-site assistance to NRC on assuring the proper respiratory protective equipment was used during recovery operation.

This assistance covered consulting on most aspects of the respirator program including respirator selection, fitting, training, and maintenance. Particular emphasis was placed on assistance in selecting the proper types of respiratory protection to get the job done while still providing adequate protection. Since radioiodine was a problem during the recovery phase Los Alamos was asked to recommend what types of canisters and/or cartridges could be used with air-purifying respirators. Atmosphere-supplying respirators were not always practical for this application because of the difficulty of supplying airhoses to all work areas and the limited work time available with SCBA. An evaluation was conducted at Los Alamos of using air-purifying respirators for protection against radioiodine. This evaluation and final recommendations were based on review of available devices and also laboratory work to establish the performance of commercially available sorbent canisters against elemental iodine, hydroiodous acid, and methyl iodine.

A selection of atmosphere-supplying devices to support other recovery operations was made. This included recommendation of a combination airline/air-purifying device and selection of a closed-circuit, self-contained breathing apparatus to provide longer stay times in hot areas. The selection of the closed-circuit SCBA involved laboratory testing at Los Alamos to assure adequate protection of the users.

Technical assistance at Three Mile Island provided valuable information to the NRC, its licensee, and Los Alamos on the unique aspects of respiratory protection during emergency situations. It has required a new look at the requirements for respiratory protection in these situations and also demonstrated the need for a significant amount of preplanning if recovery operations are to be conducted with a minimum of radiological exposure problems. A project to develop a manual for respiratory protection in radiological emergencies was developed as a result of the lessons learned at Three Mile Island.

## V. TRAINING

NRC has used the expertise available at Los Alamos to assist them in developing training programs for respiratory protection. Throughout the 13 years that Los Alamos has been providing respirator support to the NRC it has sponsored several symposiums and training courses on respiratory protection. These programs provided information to NRC and NRC licensee personnel on the details of establishing a respirator program, regulatory requirements, and in the case of the symposiums offered a forum to discuss mutual respiratory protection problems. Los Alamos has produced several video tapes that are available to licensees to help them in establishing and maintaining their respiratory protection programs. This has included the following training tapes.

1. Acceptable Practices for the Use of Air-Purifying Respirators
2. Acceptable Practices for the Use of Atmosphere-Supplying Respirators
3. Acceptable Practices for Fitting Respirator Users
4. Acceptable Practices for Cleaning, Inspection, Maintenance, and Storage of Respirators

We have also assisted NRC in the development of Regulatory Guide 8.15, Acceptable Programs for Respiratory Protection, and NUREG-0041, Manual of Respiratory Protection Against Airborne Radioactive Materials, which detail the requirements of a respiratory program for power reactors and other NRC facilities.

## VI. CURRENT ACTIVITIES

During FY 1982, the program at Los Alamos was directed to

- a) provide the NRC with information necessary to supplement NRC Regulatory Guides covering the use of respirators for protection against inhalation of airborne radioactive materials;
- b) develop an NRC manual of respiratory protection practices for radiological emergencies such as Three Mile Island. This manual will be published as a NUREG report detailing practical information to guide NRC and its licensees in implementing a respirator program during these vital work situations. The report will cover equipment requirements under postulated emergency conditions, contaminants of concern, personnel, skills necessary to implement and maintain the program and administrative requirements. The manual will be organized to provide specific information for the various type of licensee operations such as power reactors;
- c) advise NRC of new developments in respiratory protection so these developments can be promptly integrated into programs at NRC facilities. This is an ongoing program that provides NRC with information on new respiratory protective devices, new test methods, changes in test equipment, and impending consensus standards that may be of interest to NRC and its licensees;
- d) provide technical assistance and laboratory support in respiratory protection for guidance necessary for standards development, compliance cases, NRC licensee program reviews or other actions within the responsibility of the NRC. A report of a survey of licensee respiratory protection programs was completed during FY 1982. This survey was conducted at selected power reactors, uranium mills, and research reactors. An evaluation was made of the respiratory protection programs at each facility and NRC was given

recommendations for improvement of the overall respiratory protection programs for licensees based on what was seen at the facilities visited by Los Alamos. Also, under this assistance program, Los Alamos evaluated three powered air-purifying respirators (PAPR), provided information on measurement and control of airflows in supplied-air respirators, and evaluated special PAPR for use at Three Mile Island;

- e) provide criteria for test procedures and instrumentation for evaluating performance and defining protection factors of respiratory protective equipment. Many operations at NRC licensee facilities have respiratory protection requirements that cannot easily be met by currently available NIOSH approved respirators. In such cases, special unapproved devices may be all that is available. To assure that these types of devices are adequately evaluated, NRC has requested that Los Alamos establish a system to evaluate such special respiratory protective equipment. A charter is also being prepared to establish a committee of respirator experts who will review the Los Alamos test results, formulate conclusions, and make recommendations to NRC on whether the tested device should or should not be accepted for use by the licensee. Another project recently began under this program which involves comparing the use of monodisperse and polydisperse aerosols for quantitative respirator fitting and quality assurance testing of respirator filters. This project proposes to determine if a single type of aerosol can be used for both purposes. Use of a single aerosol would greatly reduce the cost of equipment needed to support a respiratory protection program; and
  
- f) develop criteria and test methods for certifying air-purifying respirators against elemental, organic vapor, and gaseous forms of radioiodine. Since radioiodine is a hazard of particular interest to power reactors, NRC requested that



Los Alamos develop some criteria and test methods for radioiodine cartridges so that NIOSH could certify commercial cartridges and canisters for use in atmospheres containing radioiodine. This required identification of environmental conditions of use, development of testing apparatus and procedures, experimental studies with commercial sorbents and cartridges to identify parameters affecting this performance, development of acceptable performance and approval criteria, and transfer of testing technology to NIOSH to establish a respirator sorbent approval schedule for iodine. Transfer of the testing technology to the NIOSH Testing and Certification Branch was completed during FY 1982.

Future work planned for NRC includes developing test procedures to determine the field performance of respiratory protective equipment. These test procedures will be designed to, as realistically as possible, determine how well a respirator works when challenged with hazardous materials in the workplace. The project will attempt to determine how the field performance of respirators compares with the performance as determined under controlled laboratory conditions. Future phases of this project will involve actual field testing and data evaluation.

Additionally, the work on setting up a system for evaluating the performance of special respiratory protective equipment will be continued. The test protocols and charter of the review committee will be reviewed with NRC. The review committee will be established and evaluation of special respiratory protective devices will be conducted.

#### PUBLICATIONS

1. "Evaluation and Performance of Open-Circuit Breathing Apparatus," NUREG/CR-1235 (January 1980).
2. "Evaluation and Performance of Escape-Type Self-Contained Breathing Apparatus," NUREG/CR-1586 (July 1980).
3. "Evaluation and Performance of Closed-Circuit Breathing Apparatus," NUREG-CR-2652 (April 1982).