UNIVERSITY OF CALIFORNIA
Radiation Laboratory, Livermore Site
Livermore, California

THE SAFETY PROGRAM OF THE
UNIVERSITY OF CALIFORNIA RADIATION LABORATORY
AT LIVERMORE, CALIFORNIA

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ABSTRACT

The Safety Program of the University of California Radiation Laboratory at Livermore, California, is discussed in terms of the functions of the six independent safety groups that comprise the laboratory's primary safety organization, namely, Industrial Safety, Medical Safety, Fire Prevention and First Aid, Health Chemistry, Health Physics, and High-Explosives Safety Groups. The conclusion reached is that the safety program of a large modern research laboratory is one of wide scope and complexity. It appears that the University of California Radiation Laboratory at Livermore is actively working towards the goal of maximum safety for its personnel and equipment.

FOREWORD

The information contained in this report represents material obtained by the author from various sources within the University of California Radiation Laboratory, Livermore. It is not intended, however, to attempt any official delineation of the group organizational relations that exist, nor to place any differential emphasis upon individual or group contributions to the over-all problem of safety at a large research laboratory. Rather, the purpose of this report is to indicate only the wide and complex scope of safety programs in this modern atomic age. The materials presented are the observations and opinions of the author alone and do not necessarily reflect the official viewpoints of the Navy Department or the University of California Radiation Laboratory.

It should be mentioned that this report includes only unclassified material. There possibly exist complicated safety problems dealing with classified subjects that cannot be discussed in this report. For brevity, usually only one typical procedure of a safety group is discussed in detail. A complete treatment would require a volume of a thousand pages.

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Medical Safety - M. W. Biggs, M. D.

FOREWORD (Cont.)

Fire Protection - R. E. Noble, Chief

Health Chemistry - O. L. Meadors, C. L. Lindeken

Health Physics - W. E. Nolan, Seymour Block, G. E. Wilcox

High Explosives Safety - J. O. Vineyard, Herbert Zenger

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I. INTRODUCTION

Today we live, work, play, and die in a machine age. We need only look about us to see the past high productivity of America's industrial system. Now atomic energy has raised the curtain on an unlimited vista of future industrial development! But as with any evolving organism, industry has had growing pains which have sometimes taken a high toll of human suffering in the form of industrial accidents and deaths. Soon after 1800 the effects of the Industrial Revolution that had begun in England about a century earlier began to be evidenced in America. For many years, working conditions were deplorable. Gradually state governments passed laws regarding safety for industrial workers, and created departments with at least partial responsibility for the safety of the wage earners in that state. Industrialists and humanitarians began to interest themselves in the field of accident prevention. The history of the Industrial Accident Prevention Movement is an inspiring story of industry's struggle against its environment. The interested reader is invited to pursue this story thoroughly by utilizing the references listed in the bibliography of this report.

The findings of numerous of these studies in the field of accident prevention indicates that accidents don't just happen;

they have causes. The elimination of the causes of accidents, therefore, becomes of great importance to every industrial management program.

Although some industrial accidents have similar causes and analogous circumstances, especially in the same or a similar industry, it is nevertheless true that each industrial organization must pattern its Safety Program to best serve the needs of its personnel in the particular environment in which its personnel functions. One new type of environment that has evolved concurrently with the Atomic Age is a large modern research laboratory, of which the University of California Radiation Laboratory is a typical example.

The University of California Radiation Laboratory was established at Berkeley, California, in 1936 with Professor Ernest O. Lawrence as Director. Early years of the laboratory were devoted to basic research utilizing the cyclotrons that were then in various stages of development. Two outstanding achievements during this period that made possible the military utilization of nuclear energy were the electromagnetic method for separation of uranium-235 and the discovery of the new element plutonium.

After World War II, discovery and investigation of new particles were made possible by higher-energy accelerators. Fundamental research continued as a large part of the work at this laboratory, but nuclear-weapon research became increasingly important.

In order to augment this research and to gain wider participation by University of California scientists, the U. S. Atomic Energy

Commission, in cooperation with the University of California, established a weapons-research laboratory at Livermore, California. This laboratory (hereafter abbreviated "UCRL-Livermore") was set up in July 1952, and was first directed by Dr. Herbert F. York; since February 1958, it has been directed by Dr. Edward Teller.

The laboratory at Livermore occupies a site that was formerly a U. S. Naval Air Facility. The laboratory site, approximately 3 miles east of Livermore, covers more than 600 acres, and its laboratories, shops, and offices incorporate the newest developments in research facilities.

All of the work at the Livermore site is administered under a contract between the U. S. Atomic Energy Commission and the Regents of the University of California. The scope of research at Livermore has been constantly expanded. Among the programs now under way at the laboratory are investigations concerning

- (1) Design and development of fission and thermonuclear devices.
- (2) Nuclear propulsion program.
- (3) Design and development of measurement techniques for nuclear detonations.
- (4) Critical assembly and reactor research.
- (5) Basic nuclear-particle research with various types of accelerators.
- (6) Peaceful uses of atomic explosives.

At the present time the personnel associated with these research programs in either design or support capacities is about three thousand people. UCRL-Livermore is truly a large modern research laboratory.

II. FUNCTIONS AND ORGANIZATION OF THE UCRL-LIVERMORE SAFETY PROGRAM

A. Industrial Safety Program

At UCRL-Livermore the over-all problem of safety for personnel and equipment ranks high as an important adjunct to the efficiency and high productivity of the laboratory. A life lost, a worker injured, or a valuable piece of equipment immobilized by an industrial accident is as serious a national loss as the loss of life or limb in battle, or the sabotage of defense equipment by an enemy. Scientists, laboratory executives, and workmen at UCRL-Livermore all agree that the practice of the fundamental rules of safety will reduce accidents, save lives, and represents economic and national gain of substantial proportion.

To bring this practice of safety into reality in every-day work conditions, UCRL-Livermore has established six primary safety groups whose purpose is to formulate and administer the laboratory's safety program in the three major fields of Industrial, Radiation, and High-Explosives Safety. The primary function of these six groups is to safeguard human life and limb and to preserve laboratory equipment by bringing about the application of informed, safety-minded common sense to the work procedures and environment which constitute the day-by-day operation of UCRL-Livermore. These six safety groups are: 1) Industrial Safety; 2) Medical Safety; 3) Fire Prevention and First Aid; 4) Health Chemistry; 5) Health Physics; and 6) High-Explosives Safety Groups.

A brief description of each group's functions, with discussion of perhaps one typical procedure per group, will serve to demonstrate

the point of this report, namely, that safety problems have a wide and complex scope in a large research laboratory in this Atomic Age.

1. Industrial Safety Group

At UCRL-Livermore the Industrial Safety Group is the Safety Engineering Department, which is staffed by three full-time safety engineers. These men are specialists in the field of safety engineering. They possess college backgrounds in the engineering sciences and have participated in numerous safety courses and seminars. The group performs the functions of the safety engineer at an industrial plant. The members of the group are representatives of and a part of the managerial and supervisory staff that directs the work of employees, and they therefore share the primary responsibility of management for accident prevention.

The Safety Engineering Department is responsible for the administration, coordination, and promotion of the Industrial Safety Program at Livermore and Site 300. Site 300, a section of UCRL-Livermore, is located in hilly country about 16 miles east of the main laboratory. All testing of high explosives required by UCRL-Livermore is done at this site. See Section II, C for further details. This responsibility includes safety training, control of many toxic substances (e.g., lead, mercury, zinc, and cadmium), preparation of industrial safety procedures, furnishing protective equipment by stores issuance, and dissemination of printed safety material.

Being specially qualified in safety work, the UCRL-Livermore Industrial Safety Group makes periodic inspections or surveys of the

plant and industrial operations, the machines, appliances, equipment, tools, procedures, and processes for the purpose of determining mechanical or physical hazards and unsafe practices of employees. The group makes recommendations and suggestions for improvement, takes part in the training and education of supervisors and employees, conducts or participates in safety meetings, and acts as a coordinator of safety work. In general, the group supervises and promotes the work of accident prevention as a specialized industrial task.

One example of safety education techniques used at UCRL-Livermore is the current program to make all workers conscious of eye protection procedures. New workers are acquainted with the various eye protection devices in their orientation lectures. On-the-job training in the correct use of eye protection procedures is given by the workers' immediate supervisors. Safety signs and posters are posted prominently in work spaces. The results of this program have been extremely beneficial, as attested by a recent case: In a metal-foundry accident, a worker saved his eyes because he was wearing protective glasses which were shattered but not pierced by flying molten-metal chips.

2. Medical Safety Group

The Medical Department serves as the Medical Safety Group. It is headed by a qualified physician who is available for official consultations during scheduled hours and is "on call" for emergencies at any hour. Four full-time registered nurses provide dispensary supervision at Livermore and Site 300 during the daytime and swing workshifts. A bioassay laboratory is operated as part of the Medical Department.

The Medical Department performs the functions of providing medical

treatment and planning medical safety. It counsels all Laboratory groups concerning the health hazards of any material or process, and advises safe working limits for these operations. It cooperates with the Industrial Safety, Health Chemistry, and Health Physics groups on problems of Industrial Hygiene.

Medical treatment of employees at the dispensary is concerned primarily with industrial health aspects. Industrial illnesses are cared for to the extent of the Medical Departments' capacity. Normally only first aid or emergency treatment is provided. Serious injuries or hospitalization cases requiring hospital beds are referred to outside sources. Applicable portions of the State Compensation Insurance Laws concerning industrial illnesses provide general guidance criteria. Non-industrial illnesses are, in general, not treated except for minor conditions which do not require the services of a physician.

Besides these medical treatments, the Medical Department plans and administers an extensive prophylactic program for all employees. Important in this program are the complete physical examinations given employees prior to placement, every eighteen months after employment, upon termination of employment, and at other special times. Laboratory work, including blood and urine analyses, is regularly performed at nine-month intervals. Chest X-ray photographs are taken at the time of physical examinations. Eyes and ears are also thoroughly examined during the physical examinations. The eyes are examined with the aid of a Keystone machine. This machine permits measurement of depth perception and indicates near or far vision defects. An audiometer

test is used to detect hearing deficiencies. This extensive examination program permits the proper "fitting" of employees to their jobs, especially if certain physical defects require work restrictions.

The Medical Department provides a complete immunization program for employees who do extensive official travel. The Department provides inoculations against tetanus, typhoid, and smallpox to all employees on a voluntary basis. Frequently, vaccinations are also given for special purposes, e.g., polio-immunization.

The Medical Department is concerned with general industrial health problems, such as the industrial-health aspects of radioactivity, possible hazards resulting from group inhalation of toxic and/or radioactive materials, etc. Because of the magnitude of the work done by the laboratory with radioactivity (both natural and induced), it has been found necessary to operate an extensive radiation safety program. This subject is treated more fully under the Radiation Safety Program. It is noteworthy that the head of the Medical Department holds a staff position with the Donner Laboratory,* and that there are always available the services of a salaried consultant who is a professor of medical physics in the College of Medicine of the University of California. Such close liaison amongst this and other leading institutions doing laboratory research insures the rapid exchange of latest techniques and knowledge of medical safety in dealing with radioactivity and other industrial health hazards.

* The medical laboratory of the University of California.

3. Fire Safety and First Aid Group

The UCRL-Livermore Fire Department acts as the Fire Safety and First Aid Group. The Fire Department consists of 17 full-time firemen and about 50 auxiliary firemen. The auxiliary firemen are laboratory employees who have undergone special fire-fighting training. The auxiliary firemen augment the permanent fire department in actual emergencies. They are chosen and trained on the basis of availability and suitability of their work occupations. The permanent fire department is staffed by experienced career firemen. In addition to knowing the latest standard fire-fighting techniques, the career firemen are taught how best to fight fires involving the special materials used at this laboratory. The UCRL-Livermore Fire Department probably represents the best qualified fire-fighting force within many miles of the laboratory site.

The primary duties of the UCRL-Livermore Fire Department include responsibility for:

a. Fire Prevention

- (1) Inspection of buildings and areas with the aim of reducing hazards by removing any item that may be a fire-danger to life or property.
- (2) Supervision of the destruction of flammable or hazardous materials.
- (3) Instruction of all new employees on prevention of fire hazards (electrical, flammable liquids, flammable metals, etc.).
- (4) Inspection of all welding and cutting operations. A permit is issued prior to the work, if the intended operation is in

accordance with existing regulations.

(5) Pre-fire planning all buildings for which the department is responsible.

b. Fire Protection

(1) Testing all fire alarm systems, telephone box alarms, telephone station number 333 (for fire or other emergencies), horns and bells at the fire station, sprinkler alarms, etc.

(2) Maintenance and testing of all automatic fire-extinguishing equipment, sprinkler systems, CO₂ flooding systems, etc.

(3) Maintenance and testing of all portable fire-fighting equipment, fire extinguishers, fire-hose reels, etc.

c. Fire Suppression

(1) Protection of life and property in the event of fire or any other emergency at the Livermore Site, Site 300, or the adjacent Sandia Corporation* Site.

(2) Instructions to auxiliary firemen, who are usually maintenance machinists, on Fire Department operations, drills, etc.

(3) Instructions to all new employees on operation of fire equipment, extinguishers, alarms, etc.

d. First Aid

(1) Ambulance service to personnel at UCRL-Livermore, Site 300, and Sandia Site.

(2) Conducting first aid classes at UCRL-Livermore and Site 300.

(3) Maintenance of First Aid Kits.

* Livermore site of the Sandia Corporation, also doing contract work in the weapons field for the U.S. Atomic Energy Commission.

e. Miscellaneous

Assisting in general emergencies such as acid spills, water spills, etc.

Frequent inspections of firemen and equipment by the Fire Chief and outside safety agencies have helped maintain a high state of readiness in the UCRL-Livermore Fire Department. These inspections plus a rigorous training program occupy a large portion of the effort of the Fire Department's routine day. But if a fire comes, nothing will be routine! There is no assurance of a second chance where fire is concerned. The UCRL-Livermore Fire Department is preparing to meet such emergencies at anytime so as to preserve the safety of personnel and equipment of the laboratory.

B. Radiation Safety Program

Radiation has been with the human race for a long time in the form of cosmic rays and natural radioactive-decay products. Radiation Safety, however, refers usually to control of, and protection against, impinging particles such as alpha, beta, or neutron particles, or impinging electromagnetic waves such as gamma-rays or x-rays. Radiation damage to living tissue and inorganic materials results from over-exposure to such radiation, either from natural or artificial radiation sources. Since the beginning of the twentieth century, scientists have been probing radiation phenomena more and more energetically, usually with larger and larger radiation sources. Hence, the scope and complexity of radiation hazards have increased greatly as more people come in closer working contact with a larger number of radiation sources.

UCRL-Livermore is very active in research problems that utilize radiation phenomena. This laboratory, therefore, has taken a keen interest in maintaining its radiation safety program at peak efficiency to ensure the safest possible working conditions for personnel and equipment exposed to radiation.

To accomplish this goal, two independent UCRL-Livermore safety groups share the primary responsibility for the radiation safety program. These groups are the Health Chemistry Group and the Health Physics Group. Although a certain amount of overlapping of functions does exist, a useful thumb-rule giving the demarcation of the two groups' interests is: Health Physics handles radiation problems arising from radiation from machine sources (accelerators, experiments, etc.), while Health Chemistry handles problems arising from radioactive

isotopes and other hazardous materials. The safeguarding of the assembly of fissionable materials to prevent the accidental assembly of a critical mass is under the separate supervision of a Critical Assembly Research Group whose operations will not be discussed here.

1. Health Chemistry Group

The UCRL-Livermore Health Chemistry Group consists of 48 members. Personnel of the group are well-grounded academically and by experience in chemistry and the life sciences. The primary functions of this group include the following:

- a. Monitoring of radioactive isotopes, both on and off the laboratory site.
- b. Evaluation and collection of data relative to radiological hazards.
- c. Design and assembly of radiologically-safe equipment.
- d. Filtration and ventilation systems.
- e. Transportation and storage of radioactive isotopes.
- f. Decontamination and disposal of radioactive waste materials.
- g. Evaluation and development of special detection instruments for hazardous materials.
- h. Maintenance of an accounting system for strategic and fissile materials.
- i. Consultation and research on radiological safety problems.
- j. Performance of special research to solve problems of a classified nature.

In carrying out these functions, the Health Chemistry Group

follows a system of "control by containment." This system requires that every effort be made to minimize personal contact with dangerous materials. Control of all hazardous materials is effected by means of a rigid accounting system. The supervision of this system is done by group personnel who handle receiving, storage, transportation, and disposal of hazardous materials. Containment of hazardous materials is sometimes effected by specially designed work equipment that prevents contamination of personnel and normal work spaces above tolerance limits. These limits are part of the rigorous standards concerning radiation dosage tolerances and allowable source strengths which are set forth in national recommendations¹ and government handbooks^{2,3}. The Health Chemistry Group takes every precaution to insure that these safety standards are observed for radioisotopes in the custody of the laboratory.

¹ Part 20, Chapter 1, Title 10, Number 19, Volume 22, of Federal Register of January 29, 1957.

² National Bureau of Standards Handbook 52, "Maximum Permissible Amounts of Radioisotopes in Human Body and Maximum Permissible Concentrations in Air and Water."

³ N.B.S. Handbook 9, "Permissible Dose from External Sources of Ionizing Radiation."

2. Health Physics Group

The Health Physics Group staff consists of 18 persons. Members of this group are well-grounded academically and by work experience in the physical sciences. The primary functions of the group include responsibility for:

- a. The Personnel Monitoring Program for all laboratory employees and other personnel associated with laboratory enterprises, on and off site.
- b. Radiation monitoring of certain equipment.
- c. Radiation monitoring of certain experiments.
- d. Accountability of certain radioactive sources used in experiments.
- e. Design of special radiation-detection instruments.
- f. Certain radio-biological research problems.
- g. Certain neutron radiation research problems.
- h. Special research problems of a classified nature.

Members of the Health Physics Group are consulted about safety aspects in many challenging research problems of the various scientific groups working at the laboratory. These problems vary from the use of gigantic particle accelerators to microscopic studies of radiation phenomena. Every effort is made to maintain and expand professional qualifications of group members by close liaison with national and international organizations doing similar work. Group members hold prominent offices in numerous societies. These contacts, as those of

the Health Chemistry Group, insure that the laboratory's radiation safety groups are aware of the latest techniques being developed anywhere in the world.

The Health Physics Group has recently inaugurated a new film badge procedure at UCRL-Livermore which combines a film badge with the identification pass. This system makes the wearing of a radiation dosimeter (a film badge) more convenient for laboratory personnel, since the film badge is now a part of the security identification pass which must be worn at all times. This insures a more accurate total indication of an individual's exposure than did the separate film badges which were not worn continually by all personnel.

Since the film badge program is fundamental for the radiation safety of all workers at the laboratory, the Health Physics Group gives this program its thorough attention. Over 3300 individual film badges are issued and read each month. The film badges are individually numbered and inserted in each person's identification pass which has radiation absorbers of cadmium, lead, aluminum, and an air window specially built into the identification pass holder. These absorbers permit differential filtering that can be correlated with the energy of radiation exposures; hence these absorbers give a more realistic measure of the radiation dosage received by the wearer of the film badge.

The sequence of processing an exposed film badge consists of the following steps:

- a. Segregating the undeveloped film strips by numbers.
- b. Perforating undeveloped films with an index number.

- c. Developing film strips on mass.
- d. Reading individual exposures by means of relative photo-densitometer measurements.
- e. Correlating differential filtering action with the energy of radiation exposure.
- f. Recording of any radiation dosage in the individual's radiation dosage records.

The film badge is one negative with respect to which both the expert and the amateur photographer agree that underexposure is the best policy.

C. High-Explosives Safety Program

Gunpowder and other high explosives have long carried the connotations of death and destruction because of man's use of them in warfare. However, a review of history shows that man has often used high explosives for his benefit. Without high explosives many mining excavations, highway clearances, canals, removals of large navigational hazards, and other projects of great benefit could not have been accomplished. Man has done wonders, including moving mountains, with the aid of high explosives.

Yet even in peaceful uses, high explosives are extremely dangerous. At UCRL-Livermore scientists doing basic research sometimes have need to study high pressures or other physical environments most easily achieved by using high explosives. To facilitate these experiments, the laboratory operates an isolated testing site away from population centers, called Site 300. Here experiments using a limited quantity of high explosives are conducted. The laboratory has undertaken a High-Explosives Safety Program to insure that personnel working at Site 300 and others who come in contact with explosives have knowledge of the safety procedures necessary for the safe handling of explosives.

1. High-Explosives Safety Group

The High-Explosives (H-E) Safety Group consists of two Safety Advisors. These men are specially qualified by academic training and experience in safe handling procedures for explosives. Their primary functions include responsibility for:

- a. Evaluating and establishing safe and workable standard operating procedures for laboratory personnel concerned with the storing,

handling, assembling, and transporting of all high-explosive materials used by laboratory personnel at the base laboratory in Livermore, Site 300, Nevada Test Site, and the Eniwetok Proving Grounds.

- b. Consultation on safety problems and procedures.
- c. Cooperation in certain classified research problems.

The high explosives facilities at Site 300 support various laboratory research programs. Since there may be several scientific groups working at the site at one time, it is necessary for the H-E Safety Group to function also as a coordination center to insure optimum safety conditions at all times. To accomplish this goal, specific and detailed safety procedures have been compiled and edited by the H-E Safety Group for personnel using Site 300. Normally, no high explosive is permitted at the main Livermore Site, with the exception of small experimental quantities used by chemists.

The compilation of safety procedures for high explosives is called the H-E Safety/Operational Manual. Its use has been made mandatory at Site 300. Because new experiments arise continually, proper means to revise and add to these safety procedures has been provided. A safety-evaluation advisory committee has been formed to give guidance in the establishment of new procedures. Committee members are provided by interested groups such as Chemistry, H-E Operations, Experimental Physics, and Weapons Engineering. The H-E Safety Group acts as a safety advisor on this committee and in all other activities where explosion safety is under consideration. At UCRL-Livermore, no effort is spared to insure that every explosion is a safe explosion!

III. SUMMARY

The Safety Program at UCRL-Livermore is one of wide scope and complexity. It is implemented by the constant efforts of six independent and cooperative safety groups whose primary purpose is the prevention of accidents. Accidents are being prevented, primarily by making safety the day-by-day working habit of every person. UCRL-Livermore is one large, modern research laboratory that is actively engaged in reaching the goal of maximum safety for its personnel and equipment.

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