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LEAD INDUSTRIES ASSOCIATION

420 LEXINGTON AVENUE

NEW YORK 17, N. Y.

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SUBJECT: LABORATORY DESIGN FOR HANDLING RADIOACTIVE MATERIALS

To Members of the Lead Industries Association:

The Atomic Energy Commission and the American Institute of Architects co-sponsored a meeting for the purpose of reviewing laboratory design for handling radioactive materials in light of the increased commercial use of radioisotopes. The meeting, conducted by the Building Research Advisory Board, was held at the National Academy of Sciences, Washington, D.C., on November 27 and 28, 1951.

The following are abstracts of the papers presented with emphasis on points brought out involving the use of lead, and therefore, may be of interest to members of the Lead Industries Association.

Very truly yours,

Secretary

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ARCHITECTURAL INTRODUCTION TO RADIOCHEMICAL LABORATORY LAY-OUT - A. D. Mackintosh, Oak Ridge National Laboratory

The design of processing buildings and laboratories and the planning of large plants for handling radioactive materials is one of the newest fields in architectural endeavor. Facilities for handling such materials fall into two main categories: (1) High level chemical process plants requiring plant scale equipment and heavy bulk shielding; (2) Laboratory facilities in which smaller quantities of radioactivity are handled for purposes of analytical control; development work in the use of isotopes in general industrial, agricultural and medical applications; or development work at Atomic Energy Commission sites. The design and construction of radiochemical laboratories is not vastly different nor more costly than that for a standard chemical laboratory. Precise handling of a few new factors and greater attention to detail are the major requirements. Pure alpha and beta emitters can be easily shielded against but offer a serious hazard if they enter the body because of their greater ionization potential. Gamma emitters require shielding to protect the operator from radiation but are less hazardous than alpha emitters if lodged in the body. In addition to providing biological protection, laboratories must be designed to minimize background radiation to which sensitive experimental radiation instruments are exposed.

Five general levels of activity may be encountered in commercial installations: (1) less than normal background (special radiation instrumentation), (2) normal background, (3) low activity ("tracer" work dealing with microcurie amounts of beta and gamma activity), (4) alpha activity of varying intensities, and (5) middle level activity where research work of a "warm" nature is carried on (millicurie amounts of beta and gamma radiations).

Millicurie amounts when handled in small quantities need not increase materially the complexity of laboratory lay-out. All that is required is close attention to details which are commonly used in handling chemical toxic materials. Potential spread of activity must be reduced by avoiding the placement of "hot" facilities directly adjacent to "cold" facilities. If this cannot be avoided, sufficient shielding will be needed between the areas. For biological protection, shielding should be calculated to give a total irradiation at the surface of the shield of 6.5 mrep/hr.

Flexibility is of utmost importance in building lay-out and location of laboratory equipment; far more essential than in normal industrial practice. For handling low activity levels such as in "tracer" work it is found that very little provision must be made for these laboratories beyond that normally used in any chemical facility. For middle activity levels, the areas where radioactivity is handled must be isolated mainly to provide for centralized waste gas and liquid handling facilities. Local shielding in the form of lead brick enclosures (usually 2" x 4" x 8" bricks) serve this purpose well. High level activity requires shielding of bulk or general material in addition to the local shielding. This general shielding may take the form of a one or two foot thickness of solid concrete blocks, usually 4" x 8" x 16". In areas for alpha operations, glove boxes should be used to prevent inhaling or ingesting particles having this type of radiation. Most shields are built to provide a radiation level of about 6.5 mr. per hour at the surface of the shield. Alpha radiation requires essentially no shielding. Beta radiation requires only thin plastic shielding less than 1 inch thick in all cases. Gamma radiation requires more massive shielding thus necessitating excessive floor

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loading in laboratory design to allow for the weight of shielding. Laboratory furniture must also be designed to carry unit shield loads. Somewhere between 1,500 and 2,500 pounds of lead may be stacked in an average hood.

Standard bench tops of material similar to Chemstone are normally quite acceptable. Some operators prefer tops of stainless steel. Hoods can be built of a variety of materials which should be protected with a coating of a strippable nature. Laboratory sinks may be of "Alberene" or stainless steel. Ducts from hoods for low activity levels can be brick, iron or galvanized and coated with a suitably corrosion resistant organic coating such as the numerous compound vinyl coatings available on the market. Stainless steel ducts are not necessary.

Process wastes are collected from all "cold" drain lines which have been chiefly of lead or Duriron but acceptance is becoming more general now that they may be of cast iron or even galvanised so long as Duriron traps are provided. Liquid waste in the "hot" drain line should always be of stainless steel without traps because of the build-up of activity which would take place at this point.

In summary, the factor of flexibility is of utmost importance. The technique of using radioisotopes is new and concepts of applications of radioactivity are rapidly changing. Site lay-out and laboratory design, therefore, must be sufficiently adaptable to changing ideas.

AIR SUPPLY AND EXHAUST IN LABORATORIES HANDLING RADIOACTIVE MATERIALS - Carlton P. Roberts, Voorhees, Walker, Foley and Smith.

Installations which do not anticipate handling radioactive materials above "tracer" level can operate satisfactorily with conventional hood systems with provision for ultimate local filtration when, or if, required.

Standardization of design is paramount and the modular system of laboratory design lends itself most readily to standardization of all facilities including ventilation. Modular design provides completely repetitive construction on a small unit basis. Each module or unit has the same structure, same electrical system, plumbing system and air handling system. The service mains and supply and exhaust duct systems must be designed to serve a combination of modules. Many laboratories are currently being designed so that the air flows from all clean areas of the laboratory space and thence out through the hoods. Filtering of this final exhaust may be accomplished with Chemical Warfare Service type filters or other dry filters. Occasionally, the exhaust duct work may be washed down to remove entrained radioactive particles.

The supply air systems are usually constructed of conventional materials, principally galvanized iron. Stainless steel has been utilized to a great extent for exahust systems in laboratories of this type although its use is difficult to justify. Galbestos, Lucoflex, Uscolite, Careyduct, aluminum and other materials offering resistance to corrosion of various vapors have been used occasionally. In some instances where dilution was extensive galvanized iron has been utilized. Where underground masonry ducts have been utilised, concrete with and without Amercoating, vitrified tile, and acid brick lined concrete ducts have been considered adequate.

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CONTROL AND SHIELDING OF ISOTOPES IN RADIOACTIVE LABORATORIES - Nelson B. Garden, University of California Radiation Laboratory.

The shielding and control of radioactivity apparently has been shifting from the "Dilute, Disperse and Decontaminate" (DDD) philosophy or the passing of contamination from one area or group to another, to the "Concentrate and Contain" (CC) philosophy whereby the material is entrapped once and for all at the outset. Adherents of the CC philosophy prefer the ultimate reduction of radioactive contamination areas to the glove or manipulator box. Such boxes are usually lead lined to protect the operators, the thickness of the lead depending upon the activity level. They are equipped with glove parts (low level activity) or remote control devices (high level). Observation of the operations is through specially compounded leaded glass. In certain cases, leaded glass windows up to 36 inches thick are used consisting of 1-in. plates of glass separated by a liquid medium having proper optical characteristics. Ventilation, air filtering and waste disposal problems are special control factors of the CC philosophy.

At gamma radiation energies up to five million electron volts (mev), ½ in. of lead shielding will reduce the radiation intensity by one-half. Shipping containers, as a rule, provide about 2½ in. of lead shielding. The density of special leaded glass windows with liquid interlayers ranges from 4/10 to 7/10 that of lead.

COMPARATIVE SHIELDING REQUIREMENTS

	Alpha	Beta	Gamma
Air	35 cm	37 cm	Infinite
Water	0.004 cm	0.05 cm	10 cm (1 mev) 17 cm (2.5 mev)
Aluminum or Concrete	No Penetration	No Penetration	4 cm (1 mev) 6.5 cm (2.5 mev)
Lead	" "	" "	0.85 cm (1 mev) 1.5 cm (2.5 mev)

SURFACES AND FINISHES FOR RADIOACTIVE LABORATORIES - James G. Terrill, Public Health Service.

Two main schools of thought influence the selection of materials for surfaces and finishes of radioactive laboratories. One prefers to use cheap materials which may be frequently discarded and cheaply replaced such as strippable coatings. The other favors the use of impervious surfaces which can be cleaned, readily decontaminated and re-used many times.

In above-grade installations, high quality vinyl or rubber sheeting and asphalt tile with regular tile cement provide satisfactory flooring. Linoleum installed with water-proof cement is also satisfactory where relatively dilute corrosives will be used. For on-grade installations the only satisfactory flooring seems to be grease-proof asphalt tile installed with a heavy coating of regular tile cement. Cleaning or moving plaster or tile walls or partitions generates dust which is particularly undesirable where radioactivity is present. This has resulted in limiting recommendations to the application of special air-dried coatings to concrete, wood and metal surfaces and to pre-finished partitioning.

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A suitable wall consists of concrete block bases covered by two coats of Pruf Coat, Amercoat, or their equal, covered by a special coating of stripper base over which a peelable surface may be sprayed in areas of potential contamination. Ordinary paint finishes are generally too porous where contamination is possible. Masonite, plywood and metal sheeting can all be treated with decontaminable paints, stripper base and strippable coatings. Strippable coatings in solvent carriers are generally applied with spray guns. They have vinyl polymer bases and comparable chemical resistance with vinyl paints.

Many of the older laboratories designed to handle radioactive isotopes installed stainless steel bench tops. Now both tests and experience have shown that other and more easily obtainable materials may be even better. Some stainless steel bench tops have become stained and rough and difficult to decontaminate. Newer materials include Alberene protected with a non-porous surface material, teflon, porcelainized metal and polyethylene sheets. Stainless steel does have the advantage of being more resilient and less rigid and can be fabricated without sharp corners, thus facilitating cleaning.

DISPOSAL OF RADIOACTIVE WASTES - E. C. Pitzer, General Electric Co., Schenectady, N.Y.

Two broad policies have been advocated for the disposal of radioactive wastes: (1) determination of the radioactivity of the waste solution below an arbitrary level and dispersion into a large volume of water (DID philosophy, see above) and (2) concentration and confinement of the activity, ultimately disposing of it by burial in waste lands and in the ocean (CC philosophy, see above).

Nature-made radioactivity has always been present in normal ground waters and other natural materials. An abundant source of beta activity is potassium due to the presence of a radioactive isotope K^{40}. Therefore, vegetable and animal tissue furnish a surprising amount of radioactivity because of the K content. Carbon 14, a radioactive isotope of carbon, is even more common. "It is evident, then, that we live in a sea of low level activity over which we have no control."

Any type of radioisotope can be buried in the earth if it is diluted with a non-radioisotope of the same element, in the same chemical form. The burial is made in suitably selected areas and at a minimum depth of 5 feet. Radioiodine may be discharged into the main sewer provided that it be discharged concurrently with potassium iodide so that the radioiodine will be diluted to 10 microcuries per liter. Radiophosphorus may be discharged into the sewer provided that it is diluted to 1/10 microcurie per liter with stable phosphorus as phosphate. In each case, appropriate radiation surveys must be carried out before repairs are made to the plumbing and disposal outlets to the main sewer. Of course, the sewage must not enter directly into the fresh water systems.

Radiocarbon may be exhausted into the air provided that no person shall be exposed to the inhalation of air containing greater than .01 microcuries per liter and that particulate matter be filtered from the exhaust air. Beta and gamma activities may be disposed of in alkaline flushes not to exceed 5 microcuries per flush and 50 microcuries per week. Many radioactive elements can be precipitated either alone or along with closely related elements and coagulated by the ferric hydroxide.

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Ion exchange is another approach that has been used. In general, three types of ion exchange media are available: zeolites (natural and synthetic); acid treated coals; and synthetic resins. Preliminary experiments show that individual radioactive elements and various mixtures flowing through combination of cation and anion exchange resins could be completely removed from solution.

A third method, that of evaporation, has proven to be the most effective system of separating radioactive material from laboratory wastes. The evaporation system now in use at the Knolls Laboratory consists of a flash pan, circulating pumps, heat exchangers, separating tower and condensor. The cost of evaporation, including overhead and amortization, is about 31 cents per gallon. Laboratory combustible material such as waste paper towels, strippable coating, clothing, etc., is charged into an incinerator and burned in an oxygen enriched atmosphere. Combustible gases are passed through a wet scrubber, glass wool filter and Chemical Warfare Service filter.

Proceedings of this meeting will be published along with illustrations and discussions at some future date by the Building Research Advisory Board, National Academy of Sciences, National Research Council, 2101 Constitution Avenue, N.W., Washington, D. C.