LEAD INDUSTRIES ASSOCIATION, INC.
292 MADISON AVENUE
NEW YORK 17, N. Y.

February 28, 1963

SUBJECT: REPRINT ON RADIATION PROTECTION

To Members of the Lead Industries Association, Inc.:

Enclosed is a reprint of an article which appeared in the Reference Data Section of "Air Conditioning, Heating and Ventilating," February, 1963, issue, entitled "Radiation Protection at Wall Openings for Duct or Pipe."

We plan on using this reprint to handle inquiries on this subject.

Additional copies are available free of charge in quantities up to 25. Over 25 copies may be obtained from us at our cost of 7¢ each.

Sincerely yours,

David H. Borcira
Secretary

DHB:HMH

Look Ahead with Lead

RADIATION PROTECTION AT WALL OPENINGS FOR DUCT OR PIPE

Harrison D. Goodman* and George Hollands**

The purpose of these data sheets is to acquaint the air conditioning engineer with the means for shielding ductwork and other openings that penetrate protective barriers around radiation facilities, particularly X-ray rooms.

Protection against radiation from X-ray tube, cyclotron, radium or other radioactive material is primarily a question of shielding to reduce the level of radiation to a safe or specified amount, of maintaining safe distances from the rays, and/or of limiting the time of exposure.

The prime consideration in preventing penetration of rays is density of the shielding material. Lead is the densest of any commonly available. Where space is at a premium, particularly in modern buildings, and where utmost radiation protection is demanded, lead is invariably used. Lead is useful, especially where neutrons and gamma rays are concerned, in that it does not itself become contaminated and emit harmful rays.

Lead, usually in sheet form, is used to line the walls, floor and often the ceiling of rooms containing radiation facilities. Openings through the barrier for air ductwork, piping, service boxes, conduit, etc., require shielding, usually obtained by a lead barrier around or behind these building utilities of sufficient coverage and thickness to prevent penetration of these rays.

Determining Shielding Dimensions

Shielding of duct and other openings in the protective barrier of radiation facilities depends on energy of radiation, orientation of the beam, dimensions and location of opening in the protective barrier, geometrical relationship between the radiation source and opening, and geometrical relationship between opening and persons, materials or instruments to be protected. The complexity of these factors requires the services of a radiological physicist, who determines extent of shielding, materials for shielding (usually lead or concrete) and the thickness of the shielding material. After the radiological physicist has done the basic design for this shielding, the protective barrier contractor provides the required shielding for the openings.

Role of Engineer

Design of ductwork, piping, etc., should *anticipate* some of the problems encountered both in the design and installation of shielding. Also, coordination between air conditioning contractor and shielding fabricator can best be achieved by understanding and forethought on the part of the air conditioning designer.

Figures 1-4 give some idea of the *area of shielding* required around ductwork. They show various duct installations which penetrate the protective barrier for walls or partitions of X-ray rooms. Lead shielding is used to cover these openings, the *approximate* extent of which is indicated in terms of simple equations involving the opening dimensions and wall thickness. These are *conservative estimates*, which will aid the air conditioning designer to understand what to expect as to the area of shielded ductwork. The radiological physicist actually determines for *each* case the *lead thickness* and the *exact amount of shielding* required.

Note in Fig. 4 that the protective shielding deals with *primary* radiation, while Figures 1-3 show protection against *scattered* or *secondary* radiation. Primary radiation comes directly from the source; scattered radiation has been deviated in direction; and secondary radiation is emitted by an irradiated material. Primary radiation requires more protection because its energy level is higher.

Fabrication and Installation

Sheet lead is not structurally self-supporting, so must be mounted to prevent sagging by its own weight. For lead thicknesses up to 3.5 mm, sheet lead can be readily shaped around round and small rectangular ducts, say 24-inch maximum diameter or width, with all joints overlapped at least ½ inch. To hold these lead sheets in place, 1-inch wide iron bands should be placed around the periphery of the duct on approximately 12-inch centers, care being taken not to cut into the lead when the bands are bolted up.

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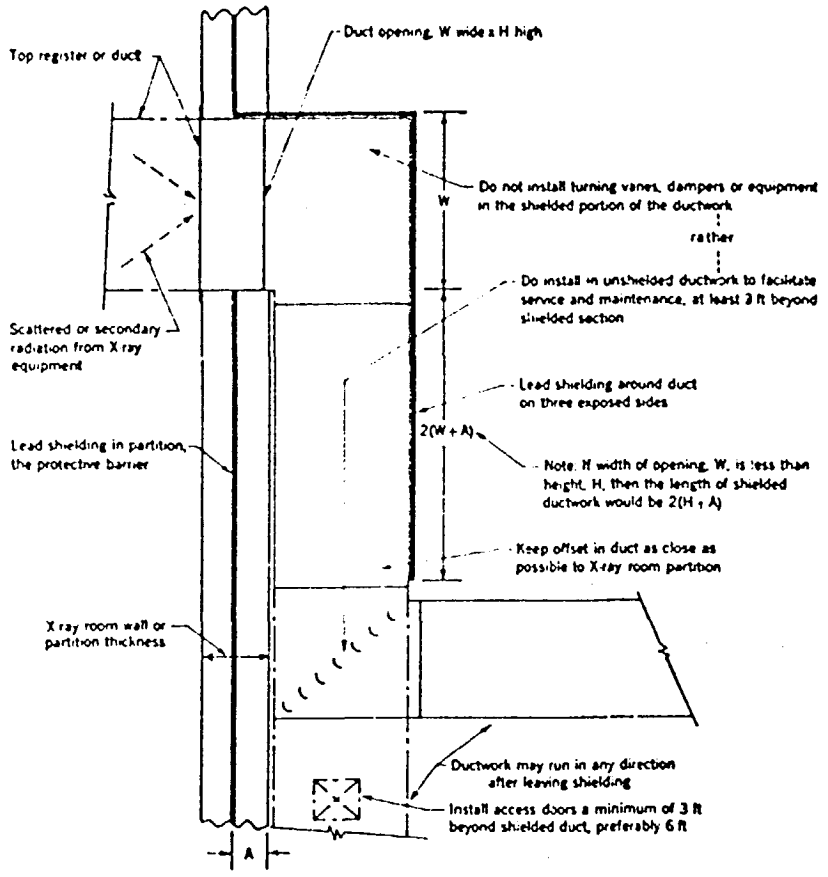

Fig. 1. Plan view of duct running through partition of X-ray room, exposed to secondary or scattered radiation.

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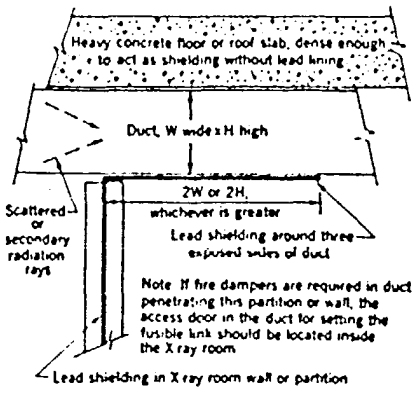
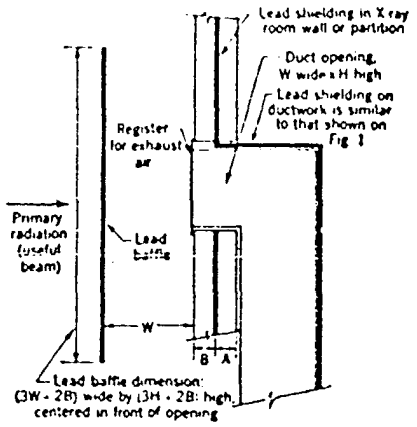


Fig. 2. Elevation of section through X-ray room partition where duct opening is exposed to secondary radiation.



Note: Where duct runs straight without offset, lead shielding is similar to that shown on Fig. 2

Fig. 4. Plan view of duct running through partition of X-ray room, exposed to primary radiation.

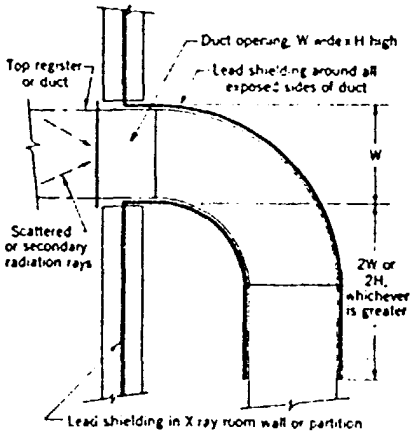
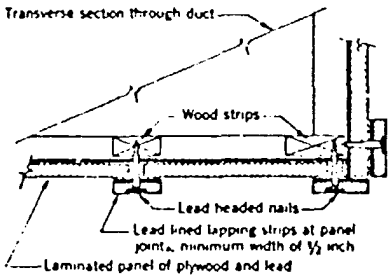


Fig. 3. Plan view of radius elbow in ductwork running through partition of X-ray room, exposed to secondary or scattered radiation.



Note: Let duct rest on wood strips for support. Substantial trapeze hangers should be used for supporting shielding enclosure. Hanger rods must be rigid enough to prevent any sway of the enclosure.

Fig. 5. Construction of laminated panel enclosure around shielded ductwork.

RADIATION PROTECTION AT WALL OPENINGS FOR DUCT OR PIPE

When lead thickness is greater than 3.5 mm or duct width exceeds 24 inches, lead shielding should be laminated on a plywood or similar structural core, which is made in sections or panels to conform to the sides of the duct. The laminated sections are mechanically fastened at the seams and corners. These joints are lapped with sheet lead angles or lead strips, the width of which is twice the thickness of the lead, but not less than ¾ inch in any case. Nails, bolts, screws or other fasteners used to secure the lead sheet or panel must be covered with lead of thickness equal to the lead sheet. Lead headed nails may be used as shown in Fig. 5.

For lead shielding of 1.0 mm or less, flexible leaded vinyl sheets can be used for easy forming to complex shapes and contours. The flexible leaded vinyl sheets can be applied in layers where heavier than 1.0 mm lead shielding is required. If the duct has a flexible connection or is made of a flexible material, the flexible vinyl sheets could be applied over it more readily than other forms of shielding.

Duct hangers are best installed on the outside of the lead shielding so that the hanger rods or straps do not have to pierce the shielding. The lead shielding adds considerably to the weight of the duct and the hangers should be substantial, with such adequate anchoring in the slab above as fish plates. For rectangular ducts, trapeze hangers would be the most practical. For design purposes, estimate each 1/16 inch of lead at 4 lb per sq ft.

Tests for radiation leakage are usually made after the room is finished and the equipment is installed. It is very important to install all shielding properly during the course of construction because of the expense in making corrections to the finished protective barrier. Moreover, equipment such as dampers should never be put in the shielded section of the ductwork, as repairs to this equipment would be very costly if the shielding must be dismantled.

A simple way to avoid penetration of the protective barrier's lead lining by pipes or wires is to offset them as close behind the lead lining as possible so that they can be backed with a lead sheet of sufficient size to prevent passage of the rays at any angle. This lead patch method is also used for electric switch boxes located in the wall.

Medical Installations

The extent of the protective barrier for medical installations is summarized below so that the air conditioning designer can tell whether ducts or pipes running through such spaces are likely to be a problem. For medical radiographic and fluoroscopic rooms the lead shielding generally does not extend above a line 7 ft. 0 in. from the finished floor; and if the service lines and ducts can be located above this line, shielding around them is obviously unnecessary. For X-ray therapy rooms, lead shielding may extend to the ceiling or structural slab. The ceiling or slab above and the floor may also be lead lined, depending upon output of the machine and other conditions. For industrial X-ray work, wall shielding may extend to the ceiling. Both ceiling and floor in some cases will require lead lining.

For shielding in supervoltage rooms, special conditions may apply. In any event, the radiological physicist should be consulted to design the proper protection. Where concrete is considered for the shielding material, it is often more practical to use lead of equivalent value for the shielding of openings. Where recesses occur in concrete barriers for equipment, lead backing, equivalent to the thickness of the concrete removed, should be provided.

Bibliography

Of the many publications available on the subject of radiation protection, these two are the most useful:

1. Medical X-ray Protection Up to Three Million Volts, Handbook No. 76, National Bureau of Standards, 1961;

2. Radiation Protection, Lead Industries Association, 292 Madison Avenue, New York, N. Y.

In addition, the New York City Health Department publishes the New York City Health Code requirements dealing with radiological hazards (Article 175).