UDC 621.039 : 539.16 : 727.5 : 658.382.3

Ref. No. : ISO/R 1710-1970 (E)

ISO

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

ISO RECOMMENDATION

R 1710

FUNDAMENTAL PRINCIPLES FOR PROTECTION IN THE DESIGN AND CONSTRUCTION OF INSTALLATIONS FOR WORK ON UNSEALED RADIOACTIVE MATERIALS

1st EDITION
July 1970

Printed in Switzerland

Also issued in French and Russian. Copies to be obtained through the national standards organizations.

BRIEF HISTORY

The ISO Recommendation R 1710, *Fundamental principles for protection in the design and construction of installations for work on unsealed radioactive materials*, was drawn up by Technical Committee ISO/TC 85, *Nuclear energy*, the Secretariat of which is held by the American National Standards Institute (ANSI).

Work on this question led to the adoption of Draft ISO Recommendation No. 1710 which was circulated to all the ISO Member Bodies for enquiry in October 1968. It was approved, subject to a few modifications of an editorial nature, by the following Member Bodies :

Australia	Greece	Sweden
Belgium	Hungary	Thailand
Brazil	Iran	Turkey
Canada	Israel	U.A.R.
Chile	Italy	United Kingdom
Colombia	Netherlands	U.S.A.
Czechoslovakia	Poland	U.S.S.R.
Denmark	Romania	Yugoslavia
France	South Africa, Rep. of	
Germany	Spain	

The following Member Bodies opposed the approval of the Draft :

New Zealand
Switzerland

This Draft ISO Recommendation was then submitted by correspondence to the ISO Council, which deciced to accept it as an ISO RECOMMENDATION.

ISO Recommendation R 1710 July 1970

FUNDAMENTAL PRINCIPLES FOR PROTECTION IN THE DESIGN AND CONSTRUCTION OF INSTALLATIONS FOR WORK ON UNSEALED RADIOACTIVE MATERIALS

1. SCOPE

This ISO Recommendation gives the principles for protection to be applied in the design and construction of an installation in which work will be carried out on unsealed radioactive materials.

Principles relating to the working of these installations are excluded from the scope of this ISO Recommendation. However, when the correct application of these principles implies the use of components which should be specified from the start of construction, those components are mentioned in the text below.

The sites referred to by this ISO Recommendation are all scientific, medical, or industrial installations for work on unsealed radioactive materials, with the exception of nuclear reactors for which the regulations are of a special nature.

The principles intended to prevent a criticality accident or to minimize its consequences are the subject of ISO Recommendation R 1709, *Principles of criticality safety in handling and processing fissile materials.*

2. GENERAL PRINCIPLES

The aim of protection is to ensure that persons working inside an installation and those working outside or living in the neighbourhood receive dose equivalents as low as possible and, in any case, not exceeding the maximum limits permissible for workers or population.

To achieve this aim it is necessary not only to observe a certain number of precautions pertinent to work but also to specify some requirements particular to the design and construction of the building. The precautions which are stated in this document proceed from the following general principles :

(*a*) protection against external irradiation* may be obtained

- by shielding;
- by distance;
- by limiting the duration of exposure;
- or by a combination of these means.

(*b*) protection against contamination may be obtained

- by confinement, for example, by limiting the volume or surfaces which may become contaminated, and by preventing this contamination from spreading into the atmosphere of adjacent rooms or being carried there by the movement of persons or objects;
- by preventing, through wearing appropriate equipment, direct exposure of persons to contamination or by limiting the duration of this exposure;
- by decontaminating surfaces and cleaning the atmosphere of working areas to minimize contamination;
- by monitoring and controlling the activity of liquid and gaseous wastes;
- by taking special precautions for the disposal of radioactive solid wastes;
- or by a combination of these means.

* In this document external irradiation is intended to mean the irradiation produced by a source external to the organism and not constituted by an atmospheric contamination.

3. CLASSIFICATION OF INSTALLATIONS ACCORDING TO THE WORK TO BE PERFORMED THERE

The severity of the requirement to be complied with during design and construction in pursuance of the above principles will be related to the kinds and activities of material likely to be used during work.

In this document, a distinction is made between installations for work with high, moderate, and low activities without fixing any precise limits : in fact, it seems preferable to leave it to the authorities of each country to fix these limits. However, an example of the application of the division into three categories is given in Appendix Y for the radiochemical laboratories.

4. PRINCIPLES RELATING TO INSTALLATIONS FOR WORK ON HIGH ACTIVITY

4.1 Distribution of areas

4.1.1 *Division into zones.* The application of the general principles mentioned in section 2, and particularly the care of containing contamination, leads the designer to the isolation of the most dangerous areas from those less dangerous, thus dividing the inside of an installation into several zones in which, due to the expected risk of irradiation or contamination, the foreseen conditions of work will be different.

Four fundamental zones are distinguished in the layout of an installation; these are, in increasing degree of risk :

ZONE 1, which must be designed and constructed in such a way that, in circumstances of normal operation, the annual doses* received by workers continuously staying in this zone do not exceed 3/10 of the annual maximum permissible doses.

Criterion for external irradiation (in the absence of any risk of atmospheric contamination) : level such that the dose which could be received in the above-mentioned conditions does not exceed 1.5 rem per year for the most sensitive organs.

Criterion for atmospheric contamination (in the absence of any risk of external irradiation) : annual mean less than 3/10 of MPC** applicable to workers for a 40 hours presence week.

ZONE 2, which must be designed and constructed in order to ensure a sufficient containment of contamination towards zone 1 or outside and so that, in circumstances of normal operation, the annual doses received by workers continuously staying in this zone, if they may exceed 3/10 of annual maximum permissible doses, do not exceed these annual maximum permissible doses.

Criterion for external irradiation (in the absence of any risk of atmospheric contamination) : level such that the dose which could be received in the above-mentioned conditions does not exceed 5 rems per year for the most sensitive organs.

Criterion for atmospheric contamination (in the absence of any risk of external irradiation) : quarterly mean less than MPC** applicable to workers for a 40 hours presence week.

ZONE 3, where, as the risks are higher than in zone 2, the annual dose received by workers who might stay there continuously could exceed the annual maximum permissible dose so the stay in this zone will be subject to a limit of duration or subject to the wearing of special equipment. Zone 3 must be designed and constructed in order to allow this condition of work and to ensure a sufficient containment of contamination towards zones 1 and 2 or outside.

Criterion for external irradiation (in the absence of any risk of atmospheric contamination) : level such that the dose received during continuous stay would exceed 5 rems per year for the most sensitive organs.

Criterion for atmospheric contamination (in the absence of any risk of external irradiation) : the quarterly mean may exceed the MPC** applicable to workers for a 40 hours presence week.

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* Throughout the text, "dose", used for convenience, stands for "dose quivalent".

** Maximum permissible concentration.

ZONE 4, where, in normal circumstances of working, the levels of irradiation or contamination may be so high that the zone must be designed and constructed so that its access is forbidden during utilisation and so that a sufficient containment of contamination, towards the other zones or the outside, and a protection against external irradiation are ensured.

NOTE. – In some installations, the designer will have to take care that a given site may change class according to the kind and quantity of the radioactive material handled. For example an experimental laboratory may be used for a variety of work. The design will take into account the most dangerous work foreseeable. (See also the comments in Appendix Z.)

4.1.2 *Colour code**. If it is found useful to associate colours with zones in order to identify the latter, or to mark them, or to put a sign on them, use

- for zone 2 : green
- for zone 3 : yellow-orange**
- for zone 4 : red

Zone 1 may remain colourless***.

4.1.3 *Arrangement of zones*

(*a*) In principle the zone of the highest class should be surrounded, in decreasing numerical order, by zones of lower classes.

(*b*) If a zone 1 is adjacent to zones 3 or 4 there should be a division making it impossible to have direct uncontrolled access from one zone to another, and ensuring safety under all conditions.

In particular, when a zone 4 is separated from the outside only by a wall or a roof, this partition should be of a strength and a tightness sufficient to avoid the spread of contamination, whether accidental or otherwise.

4.1.4 *Movement of personnel*

(*a*) Passage between the areas in the installation should be arranged in such a way that it is possible to pass only from a lower class to a higher class of zone when entering, and vice versa when leaving.

(*b*) Passages between zones of different classes should be defined and fitted in such a way as to provide them, when necessary, with means of inspection and decontamination and, possibly, changing-rooms for special clothing.

In particular, provision should be made before zone 2 for a changing room containing one part reserved for outdoor clothing and another part reserved for working clothing and a means of inspection and decontamination between them; this changing room should, in principle, be situated between zones 1 and 2 but may sometimes be situated at the entry to zone 1.

(*c*) The number, location and type of emergency exits to be installed should be specified without losing sight of the necessity to maintain control over radioactive risks.

(*d*) The location and the details of fitting of sanitary installations and first aid posts should be specified in such a way as to reduce as far as possible risks of spreading contamination. Sanitary installations should not be placed in zones 3 or 4.

4.1.5 *Flow of materials*

(*a*) To minimize the risk of contamination spreading, it is desirable that the approach of radioactive objects and substances to zones 2 and 3 should be different from that of personnel.

(*b*) Removable panels adjoining equipment in which large amounts of radioactive materials are handled should be provided to aid the repair, or renovation, of such facilities.

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* The utilization of this colour code does not imply that it is necessary to paint the areas with these colours.

** It is possible to abbreviate this to "orange".

*** It is preferable to save "white" for areas found in some installations, nuclear or not, carefully protected from all dust, all contamination and all outside radiations due to the delicate work carried out there. It has already become customary to call them "white areas".

4.2 Ventilation

Ventilation should ensure in each room a sufficient airing to hold atmospheric contamination at a level consistent with the zone to which the room belongs.*

A permanent pressure drop** should be provided from each zone to any adjacent zone of higher class of risk, with the possible provision of air locks. An appropriate interlock should prevent the simultaneous opening of the air lock doors.

In particular, at openings communicating with a zone of class 4 not provided with an air lock, a flow of air of sufficient speed should be maintained in the direction indicated above to prevent the spread of contamination.

The supply air from outside should be filtered through coarse filters, and the exhaust air should be discharged to the atmosphere through "absolute" filters. The source of supply air from outside should be so placed as to preclude the recirculation of exhaust air from other parts of the installation.

A control panel with easy access should be provided for use in emergency.

4.3 Radioactive effluents and wastes

If necessary, provision should be made for the evacuation and storage of radioactive effluents and waste resulting either from work carried out in zones of class 2 or above or from the decontamination of personnel, objects and areas.

(*a*) Gaseous wastes should be cleaned through gas scrubbers and dust filters. The provision of monitoring or sampling devices should also be specified and fitted, before discharging the so treated effluents to the atmosphere.

(*b*) For liquid effluents a separate pipeline system and a separate evacuation system should be specified for each of the three following categories : radioactive effluents, suspect effluents, inactive effluents. Evacuation should be arranged as follows : the first are passed into a treatment installation or collected in tanks to be treated later, or if they include only short life radionuclides, to wait for their activity to be low enough to throw them away; the second category are passed into tanks enabling sampling to be carried out before discharge or treatment with radioactive effluents; only the third category are disposed of directly to the normal waste outlets. Nevertheless, when there are only a few suspect effluents, it should be possible to dispose of them with active effluents.

Adequate drainage should be provided in locations where spillage of radioactive materials can occur or where large volumes of water may be needed for decontamination.

As far as practicable, liquid effluents should flow by gravity.

Provide sample taps on all effluent streams and storage tanks, even if not planned for immediate use.

If possible, care should be taken that pipelines for active effluent do not pass through areas accessible to personnel. If it is not possible to ensure this, protection should be given both against irradiation and against contamination (for example by means of devices for leakage recovery).

All underground or outside effluent lines should be marked so that later work will not result in breaking these pipes.

(*c*) For solid waste, a storage and packaging area should be specified if necessary.

4.4 Health physics rooms

Special areas reserved for health physics personnel engaged in protective work against radiation should be arranged and placed at the points where they are most effective. Rooms should also be reserved for analyses and countings.

* For guidance, the air change is usually 2 to 5 volumes per hour in zone 2; 5 to 10 volumes per hour in zone 3 and may reach some tens of volumes per hour in zone 4 when this zone is not an air-tight enclosure.

** For guidance, this drop of pressure may be of several tenths of a millibar for zone 2, 0.5 to 1 mbar for zone 3; 1.5 to 4.5 mbar for zone 4.

4.5 Monitoring and warning devices

(*a*) The post for fixed monitoring equipment for activity of atmosphere and exposure rate should be specified and fitted out (with possibly warning and recording devices).

(*b*) At all points where there is passage from one zone to another of lower activity and at points of contact with the outside, the necessary arrangements should be made for the possible siting of inspection devices.

(*c*) Visual and audible alarms should be installed in every working area where external radiation levels or airborne contamination could rise beyond the level permissible in the facility concerned.

4.6 Selection and use of materials

4.6.1 *Structural materials*

(*a*) CRITERIA FOR SELECTION. Apart from normal mechanical characteristics, the materials should be selected with regard to their fire resistance and, possibly, their ability to ensure effective protection either against external irradiation or against an accidental spread of contamination.

(*b*) USE OF MATERIALS IN BUILDING SHIELDED CELLS. The thickness of walls, floors, and ceilings should be calculated taking into account the level of the risk of irradiation in the areas or enclosed space and the danger which exists in neighbouring areas.

Provision should be made for tappings in walls (pipelines, passages of material, control levers) in such a way as to reduce to a minimum the risks of radiation leakage.

The sealing of enclosures intended to contain alpha or beta emitters should be specified.

The same criteria should be applied to windows and other vision devices to the inside of manipulation enclosures as for the adjacent walls.

4.6.2 *Surface materials*

(*a*) CRITERIA FOR SELECTION. Surface materials should be selected or the condition of the surfaces of structural materials mainly used should be defined in relation to all or some of the following qualities :

- ease of decontamination;
- behaviour under the action of radiation;
- fire resistance;
- resistance to any chemical reagents likely to be used;
- absence of susceptibility to contamination (absence of porosity, resistance to surface scratches, etc.).

(*b*) USE OF MATERIALS. Recesses or projections should be kept down as far as possible and any equipment should be eliminated which reduces the possibility of access to part of the surface. Surfaces should be so connected that in general sharp corners and any shapes conducive to accumulation of dust are avoided.

4.6.3 *Sealing materials*

(*a*) CRITERIA FOR SELECTION. Apart from normal mechanical characteristics, the materials should be selected with regard to their heat and fire resistance and to their behaviour under irradiation.

(*b*) USE OF MATERIALS. The seals should be arranged to facilitate the detection of leaks, for example by the provision of double seals with a facility to monitor the inter-space for leakage.

4.6.4 *Windows.* Windows used to light areas in zone 3 and those used to light areas in zone 2 where the most toxic substances are handled should have a sufficient strength and should not be openable.

4.7 Miscellaneous safety provisions

In view of the particularly grave risks due to the spreading of contamination in the case of fire, devices necessary to prevent this or to reduce its consequences should be provided. Particularly, for the filtration of the air discharged to the atmosphere, the use of filters which are either incombustible or are protected against fire in an equivalent manner, should be specified.

Electrical conduits should be sealed in order not to act as ventilation ducts.

Process lines should be effectively isolated from water supply lines.

The inadvertent back filling of process lines should be prevented by check valves; precautions should also be taken to avoid undesirable siphoning.

When water is used as a shield, as, for instance, in some storage facilities, the necessary provisions should be made to prevent accidental drainage.

In case of a power failure, emergency lighting should be installed and an emergency power supply provided to equipment essential to maintain safety and the stoppage of which might cause an accident.

5. PRINCIPLES RELATING TO INSTALLATIONS FOR WORK ON MODERATE ACTIVITY

5.1 Distribution of areas

An installation for work on moderate activity comprises one zone 1, one zone 2 and sometimes a small zone 3. Thus the compartment which in a laboratory of moderate activity is reserved for the decontamination of glove boxes, and in which special protective clothing is worn, constitutes a zone 3.

The provisions indicated in clause 4.1 should be applied to installations for work on moderate activity bearing in mind the fact that they do not possess a built-in zone 4.

However, it is not necessary to arrange for a flow path for radioactive objects and substances distinct from that for the movement of personnel.

5.2 Ventilation

5.3 Radioactive effluents and wastes

5.4 Health physics rooms

5.5 Monitoring and warning devices

The specifications mentioned in clauses 4.2, 4.3, 4.4 and 4.5 are also applicable to installations for work on moderate activity.

5.6 Selection and use of materials

5.6.1 *Structural materials.* The danger of external irradiation does not in general play a part in the selection and use of materials.

Materials should be selected for fire resistance.

If windows are intended to light working areas, use windows which cannot be opened.

5.6.2 *Surface materials.* The criteria for the selection of these materials and their use should be those indicated in clause 4.6.2.

5.7 Miscellaneous safety provisions

The safety provisions indicated in clause 4.7 also apply to installations for work on moderate activity when appropriate.

6. PRINCIPLES RELATING TO INSTALLATIONS FOR WORK ON LOW ACTIVITY

6.1 Distribution of areas

(1) *General arrangements.* A laboratory for work on low activity contains only zone 1.

Provision should be made for a room or area fitted with monitoring equipment for inspection of contamination of hands and clothes, and in which will be kept the work clothing to be worn by the personnel while at work.

(2) *Flow of materials.* The circulation of radioactive objects and substances is not generally carried out in a path distinct from that reserved for the movement of personnel.

6.2 Ventilation

Provision should be made for ventilation, without necessarily providing filtering devices at the air inlet and outlet openings. It is not necessary that operating areas be at lower pressure than adjacent areas or outside.

6.3 Radioactive effluents and wastes

These installations do not generally contain a system of pipelines for radioactive effluent; if necessary, suspect effluent should be able to be passed into tanks, for sampling before discharge or treatment.

6.4 Health physics rooms

Specialized rooms are not necessary in installations for work on low activity.

6.5 Monitoring devices

The posts for possible fixed monitoring equipment for activity of atmosphere and radiation intensity should be specified and fitted out.

6.6 Selection and use of materials

(1) *Structural materials for walls, floors, etc.* The danger of external irradiation does not come into the selection and use of materials. They should be selected for fire resistance.

Ordinary windows can be used for giving light to these areas; the windows should normally be kept closed.

(2) *Surface materials.* Surface materials should be chosen and used in such a way that working areas can be maintained in a good state of cleanliness, and they should be able to be readily decontaminated.

6.7 Miscellaneous safety provisions

Although the consequences of a fire or other accident may be less severe in this category of installations, the safety provisions indicated in clause 4.7 may usefully apply, when appropriate to installations for work on low activity.

In particular, provisions should be made to avoid a fire or to minimize its consequences.