What we have to do for people protection against the radiation in the case of radiological or nuclear emergency?

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Introduction

The main purpose of protective actions in nuclear or radiological accident is to minimize the health effects to the public and workers and other negative consequences.

The practical goals are:

1) to regain control of the situation;
2) prevent or mitigate consequences at the scene;
3) to prevent the occurrence of deterministic health effects in workers and the public;
4) to render first aid and manage the treatment of radiation injuries;
5) to prevent, to the extent practicable, the occurrence of stochastic health effects in the population;
6) to prevent, to the extent practicable, the occurrence of adverse non-radiological effects on individuals and among the population;
7) to protect, to the extent practicable, the environment and property; and
8) to prepare, to the extent practicable, for the resumption of normal social and economic activity.

The strategy to reduce public risk in the case of most severe, reactor core damage accident is:

Before or shortly after release - based on plant conditions

- Evacuate or substantial shelter within 3 - 5 km
- Take thyroid blocking near the plant

After a release

- Prompt monitoring to locate areas requiring further protective actions.
- Restrict consumption of locally grown food to 300 km
- Monitoring to locate where food restrictions and relocation are warranted

Time, distance, and shielding protection from ionizing radiation exposure

There are three general guidelines for controlling exposure to ionizing radiation:

- minimizing exposure time,
- maximizing distance from the radiation source,
- shielding yourself from the radiation source.

Time is an important factor in limiting exposure to the public and to radiological emergency responders. The shorter the period of time an individual stays in a radiation field, the smaller the dose a person will receive. The maximum time to be spent in the radiation environment is defined as the *stay time*. The stay time can be calculated using the following equation:

Stay Time = Exposure Limit/Dose Rate.

Because of this time factor, it is very important to carefully plan the work to be done prior to entering the radiation area. Working as quickly as practicable once there, as well as rotating personnel who are in the radiation area, also will help minimize exposure of individuals.

Distance can be used to reduce exposures. A dramatic reduction in dose equivalent can be obtained by increasing the distance between yourself and the radiation source. The decrease in exposure rate as one move away from the source is greater than one might expect. Doubling the distance from a point source of radiation decreases the exposure rate to 1/4 the original exposure rate. This relationship is called the *inverse square law*. The word *inverse* implies that the exposure rate *decreases* when the distance from the source *increases*. *Square* suggests that this decrease is more rapid than just a one-to-one proportion.

Radiation exposure levels decrease as distance from a non-point source increases, but not in the same mathematical proportions as the inverse square law suggests.

In radiological emergencies where the radiation exposure rates are very high, some *shielding* may be necessary. Shielding is the placement of an "absorber" between you and the radiation source. An absorber is a material that reduces radiation from the radiation source to you. Alpha, beta neutron, or gamma radiation can all be stopped by different thickness of absorbers. Recommendations for shielding procedures should involve careful comparison of the exposure reduced by the shielding with the exposure added due to increased time required to shield the area.

Shielding material can include barrels, boards, vehicles, buildings, gravel, water, or whatever else is immediately available.

Protective actions in nuclear or radiological accident

Nuclear emergency protective actions include:

a. urgent protective actions(*early phase of accident*), which must be taken within hours of an accident to be effective. These include: evacuation, intake of stable iodine tablets and sheltering;

b. longer-term (*intermediate and late phase)* protective actions, which may need to be adopted in a matter of days following an accident. These include: restricting immediate consumption of locally produced food and water, relocation and resettlement.

<u>Evacuation</u>. Evacuation is the urgent removal of the population from a potentially or actually affected area. It is generally the most effective protective action against major airborne releases of radioactive material, but it is not without problems. First, there must be sufficient means of transportation to remove the entire population affected. Then, the road infrastructure must be sufficient to support a mass evacuation without traffic jams. Sufficient police or similar resources must be available to control traffic. And finally, there is the problem of where to keep the evacuated people for several days. In general, it is not recommended that evacuation and accommodation in emergency centres be in effect for more than about seven days. Moreover an evacuation itself takes time to implement, and this time must be built into any decisions to activate.

<u>Administration of stable iodine tablets</u>. When the fuel of a reactor overheats and the fuel cladding fails, large amounts of radioactive iodine can be released. This iodine can be inhaled or can be deposited on vegetables or concentrate in the milk of animals grazing on contaminated grass. Inhaled or ingested iodine will concentrate in the human thyroid gland. High thyroid doses can destroy the thyroid and greatly increase the risk of thyroid cancer, especially in children. The ingestion of radioactive iodine can be prevented by not eating or drinking potentially contaminated food. The dose to the thyroid from inhalation can be reduced by taking stable (non-radioactive)

iodine, called thyroid blocking (iodine prophylaxis). The stable iodine will saturate the thyroid and prevent or reduce its uptake of the radioactive iodine.

The distribution of stable iodine is an effective way to protect against the inhalation of radioactive iodine, provided that it is taken before or early into the release. However, getting the stable iodine to the people is not easy. For example, if the iodine supplies are kept at a central location, as it is in some countries, one has to deal with the logistic difficulties of distributing the iodine to all affected people during an emergency, which is time consuming, people intensive, and may put the emergency workers in charge of the distribution at risk. Pre-distributing the stable iodine has the problems associated with periodic refreshment before end-of-shelf life, updating distribution for new arrivals, and keeping track of transient populations. Also, this protective action requires that large stocks of stable iodine be kept at all times. All this represents real costs in terms of money and people. As shown in this figure, the effectiveness of stable iodine decreases rapidly if it is taken after the period of exposure.

Thyroid blocking is more than 90% effective if administered before or at the time of intake of the iodine. Its effectiveness falls rapidly if given after intake. Therefore, to protect the public from high thyroid doses from inhalation will require administration of thyroid blocking *before or shortly after the release*. Thyroid blocking only protects the thyroid and yet it is the dose to the entire body that is the source of most of the early deaths from a reactor accident. Therefore, care must be taken to be sure that the distribution of thyroid blocking will not delay evacuation or sheltering.

For severe accidents, the dose from inhalation may be high enough to warrant thyroid blocking more than 100 km from the accident. However, for practical reasons, distribution of thyroid blocking may be limited to a smaller area with the greatest risk. Thyroid blocking is considered safe. In response to the Chernobyl accident, the Polish government carried out thyroid blocking to about 18 million people and there were only two serious adverse reactions, both among adults with known iodine sensitivity.

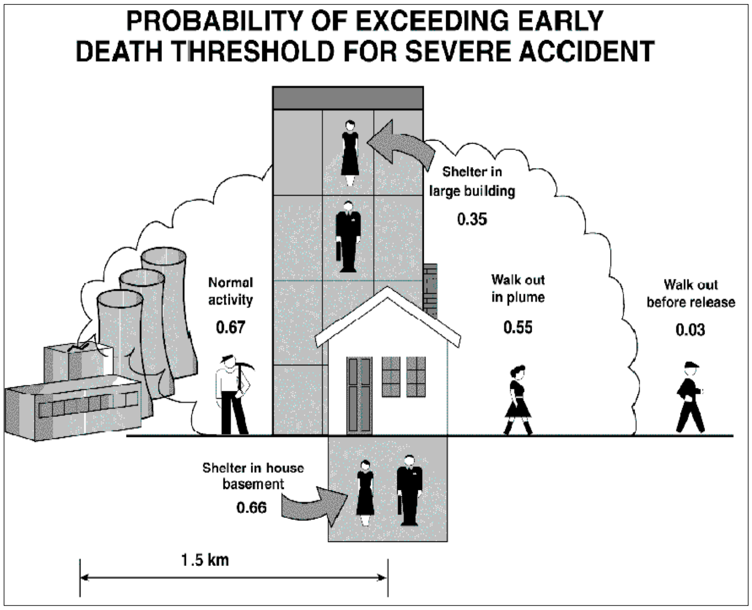
Table 1. Recommended by World Health Organization (**Guidelines for Iodine Prophylaxis following Nuclear Accidents. Update 1999** WHO/SDE/PHE/99.6 English only Dist.: General, World Health Organization Geneva, 1999) single dosage of stable iodine according to age group

Age group	Mass of iodine mg	Mass of KI mg	Mass of KIO3 mg	Fraction of 100 mg tablet
Adults and adolescents (over 12 years)	100	130	170	1
Children (3–12 years)	50	65	85	1/2
Infants (1 month to3 years)	25	32	42	1/4
Neonates (birth to 1 month)	12.5	16	21	1/8

For adults over 40, the scientific evidence suggests that stable iodine prophylaxis not be recommended unless doses to the thyroid from inhalation are expected to exceed levels that would threaten thyroid function. This is because the risk of radiation induced thyroid carcinoma in this group is very low while, on the other hand, the risk of side effects increases with age.

Sheltering. Sheltering involves keeping members of the population indoors, in suitable buildings, to reduce radiation exposure from airborne radioactive material and from the 'ground shine'. Sheltering is not recommended for a period exceeding 48 hours. Substantial sheltering refers to the use of facilities with specially designed shielded walls or basement of large masonry buildings. Ventilation systems with activated charcoal filters to protect against radioactive iodine may also be used in some substantial shelters.

The effectiveness of sheltering to protect against external radiation from the cloud and 'ground shine' depends on the type of dwelling used and on the ability of the population to properly implement the measure. For example, low roofed houses in hot climates tend not to provide a very good protection. In "real life", it is also difficult to ask people to stay confined to their house for more than a couple of days. And as at the Three Mile Island accident, it is quite likely that, in regions where the average family has access to one or more cars, an order to shelter may lead to a spontaneous evacuation. This could cause more difficulties and even more radiological consequences, especially if the evacuation is chaotic and leads to traffic jams during cloud passage.



The decision on which protective action to take is also influenced by the expected effectiveness of that protective action. For example, in USA, the US Nuclear Regulatory Commission approved the staff recommendation that based on the study of severe accidents, evacuation should be used **promptly** as the preventive, or risk reduction measure when significant fuel damage has occurred or is anticipated. This is based on studies that show that prompt evacuation is the most effective protective action and that, for severe accidents, a release could be large and yet leave no time once the release has started to implement an effective protective action strategy to avoid deterministic effects.

This figure shows the results of an analysis of various measures that could be taken to protect the public in response to the most severe type of reactor accident resulting in core melt and early containment failure. This accident results in a very large release. The numbers are the probability of a person receiving a dose to the whole body (bone marrow) in excess of the threshold for early deaths (actually > 2 Sv, here). This shows, for areas within 5km, that the risk of deaths can be reduced to almost zero by starting evacuation at walking speed one hour before the release and substantially reduced by sheltering in a large building. Even walking out in the plume is no worse than basement sheltering in a normal home. This analysis assumes that the *evacuation is conducted at walking speed* and all people in areas with significant levels of contamination are evacuated subsequently within 6 hours.

The longer-term protective actions are inherently very expensive and complex. They require that alternative living arrangements and food supplies be found for a large population. The psychological cost associated with them is great. At Chernobyl, for example, the relocation of rural population to urban areas is believed to be responsible in part for a significant loss of life expectancy due to medical problems associated with the stress of the move. Agricultural countermeasures are especially hard on farmers and producers, who will suffer significant financial losses. Financial compensation is an issue in all cases involving longer-term protective actions.

Temporary relocation and resettlement. Temporary relocation is used when there is a need to keep the population out of the affected area for a period exceeding approximately 7 days but not more than a few months. This measure requires that temporary, but substantial facilities be provided for the affected population. It is expected that the temporarily relocated population will be able to return to their homes in due course. Resettlement however is by definition permanent. It is adopted when the dose to the affected population over a lifetime would exceed a certain criterion.

Agricultural countermeasures. Protective actions related to food include: an immediate ban on the consumption of locally grown food in the affected area; the protection of local food and water supplies by, for example, covering open wells and sheltering animals and animal feed; and the long term sampling and control of locally grown food and feed. Control of milk is particularly important because it is a significant part of the diet of children, as well as concentrating important radionuclides, such as radioiodine.