



**DOSAGE AND DISTRIBUTION OF POTASSIUM IODIDE
TABLETS (A THYROID BLOCKING AGENT)
IN RADIATION EMERGENCIES**

REGULATORY GUIDE

PAKISTAN NUCLEAR REGULATORY AUTHORITY

For Further Details

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ABSTRACT

Stable Iodine is useful during radiation emergency response when radioiodine is released or anticipated for release following a nuclear reactor accident. It is recommended to be taken to saturate the thyroid gland with stable (non-radioactive) iodine; it blocks the gland's ability to further absorb radioiodine. This document provides the guideline for licensees/operating organizations on dosage and distribution of Potassium Iodide (KI) tablets during response to a radiation emergency.

1 BACKGROUND

Under section 39(2) of PNRA Ordinance 2001 (III of 2001), the Government of Pakistan has recognized role and responsibilities of Pakistan Nuclear Regulatory Authority (PNRA), to ensure, coordinate and enforce preparation of emergency plans for actions to be taken following foreseeable types of nuclear incidents that might affect the public. Such plans should include arrangements for reporting and communication, the coordination of action between the various public bodies involved, the training of personnel and the provision of necessary facilities and instrumentation [1]. Section 8-4(a) of PNRA Regulations on Management of a Nuclear or Radiological Emergency “PAK/914 (Rev.0)” [2]states:

“The licensee shall take urgent protective actions to prevent to the extent practicable the occurrence of severe deterministic health effects and to avert doses”.

The most commonly considered urgent protective actions in a nuclear or radiological emergency are evacuation, decontamination of individuals, sheltering, respiratory protection, iodine prophylaxis and restriction of the consumption of potentially contaminated foodstuffs.

2 INTRODUCTION

The document provides regulatory guidelines for the use of Potassium Iodide (KI) Tablets to reduce the uptake of radioiodine by thyroid in radiation emergencies involving the release of radioactive iodine (radioiodine) following a nuclear reactor accident. The guidance is provided on KI dosage and the projected radiation exposure at which the drug should be used.

This document is for the use of licensees and all other concerned departments regarding the safe and effective use of potassium iodide (KI) tablets in addition to other public health protective measures in the event that radioiodine is released into the environment.

3 OBJECTIVE

The objective of this regulatory guide is to provide guidance on dosage and distribution strategy of KI tablets during a radiation emergency involving the release of radioiodine to licensees and Off-site authorities involved in response to such emergencies. The distribution plan for KI tablets thus developed should be an integrated part of (existing) overall emergency plans of licensees. This guide is aimed at protecting workers, emergency responders and the public effectively from the consequences of radiation accident involving the release of radioiodine from a nuclear facility.

4 SCOPE

This guide covers technical as well as medical aspects related to distribution and administration of KI tablets. It is not only intended for the use of licensees/operating organizations but also for the Off-site response authorities such as district management, emergency response workers, and relevant technical/scientific experts, in consultation with licensees. It includes comprehensive guidance on dosage, distribution, procurement, storage, precautions and contraindications regarding the use of KI tablets.

5 POTASSIUM IODIDE (KI)

5.1 Overview

Potassium Iodide is a stable compound (non-radioactive isotope) of iodine in the form of a salt. Its chemical formula is KI. Stable Iodine prophylaxis is a protective action for which preparedness arrangements can be made as part of the overall emergency response plan, and that can protect specifically against internal exposure from inhalation and ingestion of radioiodine. The term “iodine prophylaxis” refers to the blocking of the uptake of radioiodine after nuclear accidents and not to the correction of dietary deficiency.

Stable KI is useful for radiological emergency response when radioiodine significantly constitute the radioactive material being released or anticipated for release; it can be taken orally to saturate the thyroid gland with stable (non-radioactive) iodine. It blocks the gland's ability to absorb radioiodine released following a nuclear reactor accident. The licensee of nuclear power plant / research reactor should keep the inventory of KI tablets proportional to the number of plant workers and general public residents in Precautionary Action Zone (PAZ)¹ according to dosage as recommended in Table 1. A delay in taking KI tablets will reduce or eliminate its effectiveness in blocking the uptake of radioiodine by the thyroid gland. This increases the radiation dose to the thyroid, which increases the risk of thyroid cancer. KI is about 95% effective in blocking radioiodine deposition in the thyroid if it is taken several hours before, during, or immediately after inhalation or ingestion of radioiodine. The effectiveness of KI reduces to 50% (approx.) when it is taken about four (04) hours after exposure. The ability of KI tablets to block uptake of radioiodine is essentially nonexistent if it is taken about eight (08) hours after exposure. As long as significant exposure continues, KI should be taken in correct daily dosages [3].

¹ “Precautionary Action Zone - PAZ” means an area around a facility for which arrangements have been made to take urgent protective actions in the event of a nuclear or radiological emergency to reduce the risk of severe deterministic health effects off the site. Protective actions within this area are to be taken before or shortly after a release of radioactive material or an exposure on the basis of the prevailing conditions at the facility.

5.2 Radiation Risk from Radioiodine

The radioactive isotopes of iodine (radioiodine), along with other radionuclides, could give rise to external radiation exposure from radioactive material present in radioactive cloud, deposited on the ground, skin and clothing. However, a major concern is the internal radiation exposure following incorporation and uptake in the thyroid. This will occur through inhalation of contaminated air or ingestion of food stuff and drinks. Absorption through skin is another possible route, but negligible in comparison with inhalation.

KI is effective against radioiodine only and provides no protection from any other inhaled or ingested mixed fission products that are also released during a loss of containment accident. However, exposure should always be limited by rapid evacuation from the contaminated area. Typically buildings do not provide adequate shelter from penetrating radiation exposure during a release.

Evacuation is the primary protective action in the event of a release of radioactive material to the environment whereas KI is a supplement to evacuation and is

recommended to be used only in the event of an actual or imminent release of radioiodine within the PAZ.

5.3 Precautions and Contraindications

The administration of KI at thyroid blocking doses is generally safe for most adults and children if taken in appropriate doses. Potential side effects of KI are negligible; however persons with known iodine hypersensitivity, or in iodine-sensitive conditions should avoid KI.

Other precautions to consider include:

- a) Pregnant or nursing women should avoid repeated dosage and should be treated under direction of physician.
- b) The benefits of KI outweigh the risks to babies but they should be medically monitored for transient hypothyroidism (deficiency of thyroid activity). Without immediate treatment, transient hypothyroidism may cause mental retardation.
- c) The KI in breast milk can pose a risk of hypothyroidism in nursing infants; nursing babies exposed to KI through direct treatment or nursing should be medically monitored for transient hypothyroidism.

5.4 Administration of KI to the General Public

Members of the general public who are capable of evacuation must evacuate when instructed. Evacuation must not be delayed in order to locate a supply of KI tablets within the evacuation area. Administration of KI tablets should not delay evacuation in any case. If evacuation is completed without exposure to radioiodine, it is not necessary to take KI tablets.

The licensee should develop KI distribution plan as part of (existing) emergency plans for distribution and administration of KI tablets within the PAZ. The involvement of off-site authorities may be considered by the licensee and included in the KI distribution plan.

5.5 Administration of KI to Emergency Workers

Emergency workers should be notified in advance, for administration of KI tablets according to the requirements of the licensee emergency response plan. Those, who need to enter an evacuated area through which the plume passes, will be advised by the licensee to take KI tablets when such a release of radioiodine is imminent or in progress, that is projected to deliver a dose to the worker's thyroid in excess of the dose limits [4].

5.6 Reference Levels for KI

The generic optimized intervention value for iodine prophylaxis is 100mGy of avertable committed absorbed dose to the thyroid due to radioiodine [2, 4].

Doctors, Paramedical staff and, individuals for whom evacuation is not feasible, such as patients, should be administered KI by the hospital management in consultation with licensee. The final decision should be taken by the hospital management. The KI distribution plan of the licensee should also include the above mentioned aspect.

The reference levels for different population groups for consideration in planning stable iodine prophylaxis, as recommended by WHO [5] are included in Table 1.

Table1: Reference Levels for Different Population Groups for Consideration in Planning Stable Iodine Prophylaxis

Population Group	Exposure Pathways to be Considered	Reference Levels
Adults over 40 years	inhalation	5Gy (projected dose to the thyroid)
Adults over 18 to 40 years	inhalation	100mGy (avertable dose to Thyroid)
Infants/ Neonates, Children over 3 to 12 years, Adolescents Over 12 to 18 years, Pregnant and Lactating Women	Inhalation (and ingestion ²)	10mGy (avertable dose to Thyroid)

5.7 KI Dosage Recommendations

To minimize the risk of potential side effects, only the recommended dosage should be taken. One KI dose protects against uptake of radioiodine by thyroid for about 24 hours. Taking more than a single dose at any one time, increases the risk of side effects without providing additional benefits. If circumstances prevent an individual from evacuating and he/she is exposed to the airborne radioactive plume release, it is recommended that the appropriate KI dose should be taken once every day for the duration of the radioactive plume exposure period. If at all possible, the first dose should be taken prior to the plume exposure or soon after the initial exposure and should continue every day until exposure to the radioactive plume no longer exists. Authority recommends the single dosage plan of “Iodine Prophylaxis” according to the age group devised by WHO [5] as given in Table 2.

Table 2: Recommended Single Dosage of Stable Iodine Prophylaxis According to Age Group

Age Group	Mass of Iodine (mg)	Mass of KI (mg)	Fraction of 100 mg tablet
Adults and Adolescents (over 12 years)	100	130	1
Children (3-12 years)	50	65	1/2
Infants (1 month to 3 years)	25	32	1/4
Neonates (birth to 1 month)	12.5	16	1/8

² “Ingestion of milk by infants”, where alternative supplies cannot be made available.

The downward KI dose adjustment by age group is based on body size considerations and adheres to the principle of minimum effective dose.

The recommended standard dose of KI for all school-age children is the same (65 mg). However, adolescents approaching adult size (i.e., >70 kg) should receive the full adult dose (130 mg) for maximal block of radioiodine uptake by thyroid. Note that adults over 40 years of age need to take KI only in the case of a projected large internal radiation dose to the thyroid (5Gy) to prevent hypothyroidism [5]. Neonates ideally should receive the lowest dose (16 mg) of KI. Repeated dosage of KI should be avoided in the neonate to minimize the risk of hypothyroidism during critical phase of brain development. Babies may be administered with appropriate volume of diluted solution of KI tablets in milk, formula (baby food/cereal), or water. The tablets can be crushed and mixed with fruit juice, jam, milk or similar substance.

5.7.1 Pregnant Women

The maternal thyroid gland is stimulated during pregnancy, especially the first trimester. The fraction of radioactive iodine taken up by the thyroid is increased as compared to other adults. Thus, there is a greater need to protect the thyroid gland of the pregnant woman. During the second and third trimesters, the thyroid gland of the developing fetus takes up and stores iodine in increasing amounts. Iodine passes readily across the placenta, and thus, after the first trimester, the fetal thyroid gland can be exposed to radioactive iodine through placenta, but it can also be protected by stable iodine taken by the mother. While there are physiological differences between the trimesters, there is no need for a different policy for intervention. Throughout pregnancy, the number of stable iodine doses should be kept to the minimum needed to provide adequate protection against inhaled radioactive iodine. No negative consequences are to be expected after one or two doses of stable iodine. For prolonged dosage, careful estimation is required based on results confirming active hyperthyroidism in mother, results of monitoring of new born for thyroid function in late pregnancy.

5.7.2 Lactating Females

Iodine is actively transported to the milk. As much as ¼ of the iodine taken by the mother may be secreted in the milk within 24 hours. An excess of stable iodine can block the transport to a certain extent. However, if the infant is administered stable iodine, it will be protected from radioactive iodine in the milk for the next day. Therefore, stable iodine prophylaxis for lactating mothers can be decided upon by the same criteria as for other young adults, to protect the woman herself.

6 PROCUREMENT, STORAGE AND DISTRIBUTION

Licensee is solely responsible for procurement, maintenance of stock and distribution of KI tablets to the plant personnel and to the affected population residing within the PAZ according to the approved KI distribution plan. The stock should be maintained taking in consideration number of plant personnel, number of residents in PAZ and dosage enough for thirty (30) days duration. (Thirty days duration is considered taking worst design basis accident conditions).

People who receive KI tablets should be provided with approved copies of KI drug and dosage information. Information brochure should be prepared in national/local

language, and it should answer questions on the use of KI tablets.

6.1 Storage and Shelf-Life

The KI tablets should be stored, protected from air, heat, light and moisture. Heat or moisture may cause the medicine to break down. The expiry date of KI tablets should be mentioned on packing/bottle and stock should be periodically checked for this. The minimum shelf-life for Potassium Iodide tablets is five (5) years (approx) [5] however it remains effective for decades if stored properly. After five years the iodine content may be checked and the shelf life extended. Following should be considered for the storage of KI tablets:

- a) Keep bottle tightly closed or the wrapper intact.
- b) Keep out of reach of children.
- c) Store away from heat or direct light.
- d) Avoid freezing.
- e) Do not refrigerate.
- f) Do not use beyond the expiry date.

6.2 KI Distribution Plan

It is recognized that evacuation is the most effective means of assuring protection of the public in the unlikely event of an accident at a nuclear power plant/ research reactors. Providing KI tablets to the general public is an effective supplemental protective measure to evacuation. Therefore, it is recommended that KI distribution plan should be developed. Efforts should focus on public education on the use of KI tablets. The KI distribution plan should be reviewed and revised on the basis of lessons learned through conducting periodical emergency drills/ exercises.

7 SIDE EFFECTS OF KI

When this medicine is used for a short time at low doses, side effects usually are rare. Check with your doctor as soon as possible if any of these effects are observed, hives (skin complaint), joint pain, swelling of arms, face, legs, lips, tongue and/or throat, swelling of lymph glands.

In case of prolonged use, side effects are burning of mouth or throat; confusion, headache, increase watering of mouth, irregular heartbeat, metallic taste, numbness, tingling pain or weakness in hands or feet, soreness of teeth and gum, sores on skin, symptoms of head cold, unusual tiredness, weakness or heaviness of legs.

Other side effects may occur that usually do not need medical attention. These side effects usually subside during treatment as the body adjusts to the medicine. However, doctor should be consulted, if any of the following; such as diarrhea, nausea, vomiting and stomach pain etc., continue or are bothersome.

At the WHO dosages recommended in Table2, an adverse reaction rate of less than 1 in 10 million children and less than 1 in 1 million adults is expected. However, Potassium Iodide should not be used by people allergic to iodine. According to the WHO, contraindications for use of potassium iodide are:

- a) Past or present thyroid disease (e.g. active hyperthyroidism),
- b) Known iodine hypersensitivity,
- c) Dermatitis herpetiformis, and
- d) Hypocomplementaemic vasculitis.

8 ADDITIONAL CONSIDERATIONS IN PROPHYLAXIS AGAINST THYROID RADIOIODINE EXPOSURE

Certain principles should guide emergency planning and implementation of KI prophylaxis in the event of a radiation emergency. After the Chernobyl accident, across the affected populations, thyroid radiation exposures occurred largely due to consumption of contaminated fresh cow's milk (this contamination was the result of milking the cows grazing on fields affected by radioactive fallout) and to a much lesser extent by consumption of contaminated vegetables. In this or similar accidents, for those residing in the immediate area of the accident or otherwise directly exposed to the radioactive plume, inhalation of radioiodine may be a significant contributor to individual and population exposures. As a practical matter, it may not be possible to assess the risk of thyroid exposure from inhaled radioiodine at the time of the emergency. The risk depends on factors such as the magnitude and rate of the radioiodine release, time spent by residents in PAZ, wind direction and other atmospheric conditions, and thus, may affect people both near to and far from the accident site.

For optimal protection against inhaled radioiodine, KI should be administered before or immediately coincident with passage of the radioactive cloud. KI may still have a substantial protective effect even if taken 3 or 4 hours after exposure. Furthermore, if the release of radioiodine into the atmosphere is prolonged, then, even delayed administration may bring in benefits by reducing (to some extent) the total radiation dose to the thyroid.

Prevention of thyroid uptake of ingested radioiodine, once the plume has passed and radiation protection measures (including KI) are in place, is best accomplished by food control measures and not by repeated administration of KI. Because of radioactive decay, grain products and canned milk or vegetables from sources affected by radioactive fallout, if stored for weeks to months after production, pose no radiation risk, thus KI prophylaxis at the time of consumption is not required.

Isotopes of iodine (I^{131} , I^{132} , I^{133}) are likely to be important components of the release from a severe accident. Physical half-life of I^{132} , and I^{133} are 2.3 hours and 20.80 hours respectively. Physical half-life of I^{131} is 08 days, the average biological half-life value of I^{131} as recommended by the ICRP is 80 days, and effective half-life is 7.6 days [6].

As time is of the essence in optimal prophylaxis with KI, timely administration to the public is a critical consideration in planning the emergency response to a radiation accident and requires a ready supply of KI.

9 REFERENCES

1. Government of Pakistan, "Pakistan Nuclear Regulatory Authority Ordinance", Ordinance No. III, GoP, Islamabad (2001).
2. Pakistan Nuclear Regulatory Authority, "Regulations on Management of a Nuclear or Radiological Emergency", PAK/914, PNRA, Islamabad (2008).
3. Department of Health & Human Resources, Bureau for Public Health, "Policy, Distribution and Use of Potassium Iodide (Thyroid Prophylaxis)", West Virginia, (2003).
4. International Atomic Energy Agency "International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources", Safety Series No. 115, IAEA, Vienna (1996).
5. World Health Organization, "Guidelines for Iodine Prophylaxis following Nuclear Accidents: Update 1999", WHO, Geneva, (1999).
6. J. A. Tuszynski and J. M. Dixon "Biomedical Applications of Introductory Physics", pp 358, Wiley, New York (2002).

10 GLOSSARY

- (a) “**accident**” means any unintended event, including operating errors, equipment failures or other mishaps, the consequences or potential consequences of which are not negligible from the point of view of protection or safety.
- (b) “**action level**” means the level of dose rate or activity concentration above which remedial actions or protective actions should be carried out in chronic exposure or emergency exposure situations. An action level can also be expressed in terms of any other measurable quantity as a level above which intervention should be undertaken.
- (c) “**activity**” means the quantity A for an amount of radionuclide in a given energy state at a given time, defined as:

$$A(t) = dN/dt$$

Where dN is the expectation value of the number of spontaneous nuclear transformations from the given energy state in the time interval dt.

Arrangements (for emergency response): The integrated set of infrastructural elements necessary to provide the capability for performing a specified function or task required in response to a nuclear or radiological emergency. These elements may include authorities and responsibilities, organization, coordination, personnel, plans, procedures, facilities, equipment or training.

- (d) “**Authority**” means the Pakistan Nuclear Regulatory Authority established under section 3 of the Ordinance 2001.
- (e) “**avertable dose**” means the dose that could be averted, if a countermeasure or set of countermeasures were to be applied.
- (f) “**chronic exposure**” means exposure persisting in time.
- (g) “**collective dose**” means an expression for the total radiation dose incurred by a population, defined as the product of the number of individuals exposed to a source and their average radiation dose. The collective dose is expressed in man-sieverts (man-Sv).
- (h) “**decontamination**” means the removal or reduction of contamination by a physical or chemical process.
- (I) “**dangerous source**” means a source that could, if not under control, give rise to exposure sufficient to cause severe deterministic effects. This categorization is used for determining the need for emergency response arrangements and is not to be confused with categorizations of sources for other purposes.
- (J) “**deterministic effect**” means a health effect of radiation for which generally a threshold level of dose exists above which the severity of the effect is greater for a higher dose. Such an effect is described as a 'severe deterministic effect' if it is fatal or life threatening or results in a permanent

injury that reduces quality of life. Examples of deterministic effects include erythema and acute radiation syndrome (radiation sickness).

- (k) “**dose**” means a measure of the radiation received or 'absorbed' by a target. The quantities termed absorbed dose, organ dose, equivalent dose, effective dose, committed equivalent dose or committed effective dose are used, depending on the context.
- (l) “**dosage**” means schedule for administration of a medical preparation(e.g. potassium iodide) in a prescribed amount.
- (m) “**emergency**” means a non-routine situation or event that necessitates prompt action, primarily to mitigate a hazard or adverse consequences for human health and safety, quality of life, property or the environment. This includes nuclear and radiological emergencies and conventional emergencies such as fires, release of hazardous chemicals, storms or earthquakes. It includes situations for which prompt action is warranted to mitigate the effects of a perceived hazard.
- (n) “**emergency plan**” means a description of the objectives, policy and concept of operations for the response to an emergency and of the structure, authorities and responsibilities for a systematic, coordinated and effective response. The emergency plan serves as the basis for the development of other plans, procedures and checklists.
- (o) “**emergency preparedness**” means the capability to take actions that will effectively mitigate the consequences of an emergency for human health and safety, quality of life, property and the environment.
- (p) “**emergency procedures**” means a set of instructions describing in detail the actions to be taken by response personnel in an emergency.
- (q) “**emergency response**” means the performance of actions to mitigate the consequences of an emergency for human health and safety, quality of life, property and the environment. It may also provide a basis for the resumption of normal social and economic activity.
- (r) “**emergency services**” means the local off-site response organizations that are generally available and that perform emergency response functions. These may include police, fire fighters and rescue brigades, ambulance services and control teams for hazardous materials.
- (s) “**emergency worker**” means a worker who may be exposed in excess of occupational dose limits while performing actions to mitigate the consequences of an emergency for human health and safety, quality of life, property and the environment.
- (t) “**exposure**” means the act or condition of being subject to irradiation. Exposure can be either external exposure (irradiation by source outside the body) or internal exposure (irradiation by source inside the body). Exposure can be classified as either normal exposure or potential exposure; occupational, medical or public exposure; and, in intervention situations,

either emergency exposure or chronic exposure. The term exposure is also used in radiodosimetry to express the amount of ionization produced in air by ionizing radiations.

- (u) “**emergency zones**” means the precautionary action zone and/or the urgent protective action planning zone.
- (v) “**initial phase**” means the period of time from the detection of conditions that warrant the performance of response actions that must be taken promptly in order to be effective until those actions have been completed. These actions include mitigatory actions by the operator and urgent protective actions on and off the site.
- (w) “**intake**” means the process of taking radionuclide into the body by inhalation or ingestion or through skin.
- (x) “**intervention**” means any action intended to reduce or avert exposure or the likelihood of exposure to sources which are not part of a controlled practice or which are out of control as a consequence of an accident.
- (y) “**intervention level**” means the level of avertable dose at which a specific protective action is taken in an emergency or a situation of chronic exposure.
- (z) “**ionizing radiation**” means for the purpose of radiation protection, radiation capable of producing ion pairs in biological materials.
- (aa) “**generic intervention level-GIL**” means a predetermined intervention level specified for a particular intervention. For example, the GIL for distribution of stable iodine recommended in the Basic Safety Standards is 100mGy. GIL’s are primarily intended for planning purposes.
- (bb) “**hyperthyroidism**” means excessive functional activity of the thyroid gland.
- (cc) “**hypothyroidism**” means deficiency of thyroid activity.
- (dd) “**KI and KIO**” means potassium iodide and potassium iodate, respectively, the two chemical forms of stable iodine recommended for protection against exposure to radioiodine.
- (ee) “**licensee**” means the holder of current license.
- (ff) “**limit**” means the value of a quantity used in certain specified activities or circumstances that must not be exceeded.
- (gg) “**longer term protective action**” means a protective action that is not an urgent protective action. Such protective actions are likely to be prolonged over weeks, months or years. These include measures such as relocation, agricultural countermeasures and remedial actions.
- (hh) “**off-site**” means outside the site area.
- (ii) “**on-site**” means within the site area.
- (jj) “**practice**” means any human activity that introduces additional sources of

exposure or exposure pathways or extends exposure to additional people or modifies the network of exposure pathways from existing sources, so as to increase the exposure or the likelihood of exposure of people or the number of people exposed.

- (kk) “**Precautionary Action Zone – PAZ**” means an area around a facility for which arrangements have been made to take urgent protective actions in the event of a nuclear or radiological emergency to reduce the risk of severe deterministic health effects off the site. Protective actions within this area are to be taken before or shortly after a release of radioactive material or an exposure on the basis of the prevailing conditions at the facility.
- (ll) “**predistribution**” means distribution to and supervised storage at local centre, such as police stations, hospitals, schools, fire stations, from where distribution to individuals can readily be made at short notice.
- (mm) “**protective action**” means an intervention intended to avoid or reduce doses to members of the public in emergencies or situations of chronic exposure.
- (nn) “**public exposure**” means exposure incurred by members of the public from radiation sources, excluding any occupational or medical exposure and the normal local natural background radiation but including exposure from authorized sources and practices and from intervention situations.
- (oo) “**response organization**” means an organization designated or otherwise recognized as being responsible for managing or implementing any aspect of an emergency response.
- (pp) “**sievert**” means the SI unit of equivalent dose and effective dose. It is expressed as (Sv) and is numerically equal to 1 J/kg.
- (qq) “**site area**” means a geographical area that contains an authorized facility, activity or source and within which the management of the authorized facility or activity may directly initiate emergency actions. This is typically the area within the security perimeter fence or other designated property marker. It may also be the controlled area around a radiography source or a cordoned off area established by first responders around a suspected hazard.
- (rr) “**source**” means anything that may cause radiation exposure, such as by emitting ionizing radiation or by releasing radioactive substances or materials, and can be treated as a single entity for protection and safety purposes.
- (ss) “**stable iodine**” means non-radioactive isotope of iodine.
- (tt) “**stochastic effect (of radiation)**” means a radiation induced health effect, the probability of occurrence of which is greater for a higher radiation dose and the severity of which (if it occurs) is independent of dose. Stochastic effects may be somatic effects or hereditary effects, and generally occur without a threshold level of dose. Examples include thyroid cancer and leukemia.

(uu) **“worker”** means any person who works, whether full time, part time or temporarily, for an employer and who has recognized rights and duties in relation to occupational radiation protection.(A self-employed person is regarded as having the duties of both an employer and a worker)



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