Chapter One

Nuclear reactor history

Introduction

1.1 Nuclear reactor history:

The first nuclear reactors were all designed to produce plutonium for their respective nuclear weapons programmers. The development of atomic energy for peaceful purposes and the development of atomic energy for bombs are in much of their course interchangeable and interdependent.

The optimism and almost euphoria about the possible manifold peaceful uses of the atom captured the imagination of writers and scientists, with claims we would see, nuclear powered planes, ships, trains nuclear energy would genetically modify crops and preserve grains and fish.

The cold war enabled nuclear power to be constructed as vital for national security, research into potential safety problems and risks were discouraged.

1.2 Research problem:

The seriousness of the radiation and its effect to human body and environment, if any problem happens in the reactor.

1.3 Aim of the Work:

The aim of this research is to put the nuclear hazard in perspective by an objective overall technical review of the field which will recognize the nature of the hazards, assess their gravity, and attempt to show that appropriate steps are being taken to ensure that the advantages to the community are commensurate with the inevitable risks.

1.4 Research Significance:

The Significance is to ensure the protection of people and the environment against radiation risks by achieving the highest practical safety level of nuclear reactor.

1.5 Research Layout:

This research has come into four chapters. Chapter one is the introduction. Chapter two is theoretical backgrounds of nuclear reactor physics; Chapter three is the main body of the search (safety) and chapter four is results and discussion.

1.6 Methodology:

The methodology of this search is to find suitable arrangements to ensure the complete safety of any one that work in nuclear reactor power plant , and to ensure the safety of nuclear power plant it self .

1.7 Literature Review:

Safety in nuclear reactor must be taken as a series and important procedure, and must have a detached budget and detached managements.

Nuclear safety is a universal requirement, to achieve nuclear safety, means to ensure the protection of people and the environment against radiation risks by achieving the highest practical safety level of nuclear reactor. Defense in depth is implemented by the combination of independent levels of protection.

Chapter Two

Radiated materials

Chapter Two

Radiated materials

2.1 Introduction:

Radiation materials science describes the interaction of radiation with matter a broad subject covering many forms of irradiation and of matter. Some of the most profound effects of irradiation on materials occur in the core of nuclear power reactors where atoms comprising the structural components are displaced numerous times over the course of their engineering lifetimes. The consequences of radiation to core components includes changes in shape and volume by tens of percent, increases in hardness by factors of five or more, severe reduction in ductility and increased embrittlement, and susceptibility to environmentally induced cracking. For these structures to fulfill their purpose, a from understanding of the effect of radiation on materials is required in order to account for irradiation effects in design, to mitigate its effect by changing operating conditions, or to serve as a guide for creating new, more radiation-tolerant materials that can better serve their purpose.

2.2 Definition of Radiation:

Radiation is the energy in the form of electro-magnetic waves or particles, traveling in the air.

If a nucleus is unstable for any reason, it will emit and absorb particles. There are many types of radiation and they are all pertinent to everyday life and health as well as nuclear physical applications.

2.3 Types of Radiation:

Radiation is classified into:

1: Ionizing radiation

2:Non-ionizing radiation

2.3.1 Ionizing radiation:

Definition:

It is a type of radiation that is able to disrupt atoms and molecules on which they pass through, giving rise to ions and free radicals.

Ionizing radiation is produced by unstable atoms. Unstable atoms differ from stable atoms because they have an excess of energy or mass or both.

Unstable atoms are said to be radioactive. In order to reach stability, these atoms give off, or emit, the excess energy or mass. These emissions are called radiation.

Types of Ionizing Radiation:

1: Alpha Particles:

2 neutrons and 2 protons they travel short distances, have large mass

Only a hazard when inhaled.

2: Beta Particles:

Electrons or positrons having small mass and variable energy. Electrons form when a neutron transforms into a proton and an electron :

3: Gamma Rays:

Gamma Rays (or photons): Result when the nucleus releases energy, usually after an alpha, beta or positron transition.

4: X-Rays:

X-Rays occur whenever an inner shell orbital electron is removed and rearrangement of the atomic electrons results with the release of the elements characteristic X-Ray energy.

5: Neutrons:

Neutrons have the same mass as protons but are uncharged.

2.3.2 Non-ionizing Radiation:

Definition:

They are electromagnetic waves incapable of producing ions while passing through matter, due to their lower energy.

All earth surface system components emit radiation---the sun and the earth are the components we are most interested in ,the sun emits radiation composed of high energy infrared radiation, visible light, and ultraviolet radiation collectively known as shortwave radiation (SW),the earth emits radiation composed of lower energy infrared radiation collectively known as long-wave radiation (LW).

Examples on Non-ionizing Radiation Sources:

Visible light, Microwaves, Radios Video Display, Terminals Power, lines Radiofrequency, Diathermy, (Physical Therapy) Lasers.

2.4 Ionizing Versus Non-ionizing Radiation:

Ionizing Radiation:

Higher energy electromagnetic waves (gamma) or heavy particles (beta and alpha), High enough energy to pull electron from orbit.

Non-ionizing Radiation:

Lower energy electromagnetic waves, not enough energy to pull electron from orbit, but can excite the electron.

2.5 Radiation controls:

Basic Control Methods for External Radiation**:**

Time:

Minimize time of exposure to minimize total dose. Rotate employees to restrict individual dose.

And Minimize the time spent handling or in the vicinity of radiation sources.

Distance:

Maximize distance to source to maximize attenuation in air. The effect of distance can be estimated from equations.

Increasing the distance from a radiation source by the use of handling devices will reduce the dose received, since exposure rate decreases as $1/r^2$, where r is the distance from a point source.

Shielding:

Minimize exposure by placing absorbing shield between worker and source.

Radiation can be absorbed by materials placed between the source of the radiation and the user. The type of shielding that is the most appropriate to use depends on the nature of the penetrating power of the radiation.

Factors to consider when selecting materials and design of shielding:

Persons outside the shadow cast by the shield are not necessarily protected. A wall or partition may not be a safe shield for people on the other side, radiation can be "scattered" around corners.

The absorption of high energy beta radiation in high Z materials such as lead and tungsten may result in the production of electromagnetic radiation (bremsstrahlung) which is more penetrating than the beta radiation that produced it, low Z materials such as plastics and glass minimize the production of bremsstrahlung [2].

2.6Radiation Postings:

Radiation use will be labeled on door, work area & storage area , research laboratories, work with very low levels of radioactive materials Safety can check for potential contamination prior to work in a lab that uses radioactive materials as a precaution: wear gloves, safety glasses and wash hands.

Figure (2.1) radiation postings

2.7 Nuclear reactor:

There are many different types of power reactors. What is common to them all is that they produce thermal energy that can be used for its own sake or converted into mechanical energy and ultimately, in the vast majority of cases, into electrical energy.

In these reactors, the fission of heavy atomic nuclei, the most common of which is uranium-235, produces heat that is transferred to a fluid which acts as a coolant. During the fission process, bond energy is released and this first becomes noticeable as the kinetic energy of the fission products generated and that of the neutrons being released. Since these particles undergo intense deceleration in the solid nuclear fuel, the kinetic energy turns into heat energy.

In the case of reactors designed to generate electricity, to which the explanations below will now be restricted, the heated fluid can be gas, water or a liquid metal. The heat stored by the fluid is then used either directly (in the case of gas) or indirectly (in the case of water and liquid metals) to generate steam. The heated gas or the steam is then fed into a turbine driving an alternator.

Since, according to the laws of nature, heat cannot fully be converted into another form of energy, some of the heat is residual and is released into the environment. Releasing is either direct – e.g. into a river – or indirect, into the atmosphere via cooling towers. This practice is common to all thermal plants and is by no means limited to nuclear reactors which are only one type of thermal plant.

2.8 Types of Nuclear Power Reactors:

Nuclear power reactors can be classified according to the type of fuel they use to generate heat.

2.8.1 Uranium–fuelled Reactors

The only natural element currently used for nuclear fission in reactors is uranium. Natural uranium is a highly energetic substance: one kilogram of it can generate as much energy as 10 tons of oil. Naturally occurring uranium comprises, almost entirely, two isotopes: U238 (99.283%) and U235 (0.711%). The former is not fissionable while the latter can be fissioned by thermal (i.e. slow) neutrons. As the neutrons emitted in a fission reaction are fast, reactors using U235 as fuel must have a means of slowing down these neutrons before they escape from the fuel. This function is performed by what is called a moderator, which, in the case of certain reactors (see table of **Reactor Types** below) simultaneously acts as a coolant. It is common practice to classify power reactors according to the nature of the coolant and the moderator plus, as the need may arise, other design characteristics.

Reactor Type	Coolant	Moderator	Fuel	Comment
Pressurized water reactors	Light water	Light water	Enriched uranium	Steam generated in

(PWR, VVER)				secondary loop
Boiling water reactors (BWR)	Light water	Light water	Enriched uranium	Steam from boiling water fed to turbine
Pressurized heavy water reactor (PHWR)	Heavy water	Heavy water	Natural uranium	
Gas-cooled reactors (Magnox, AGR, UNGG)	CO2	Graphite	Natural or enriched uranium	
Light water graphite reactors (RBMK)	Press-urised boiling water	Graphite	Enriched uranium	Soviet design

Table (2.2) reactor types

PWRs and BWRs are the most commonly operated reactors in Organization for Economic Cooperation and Development (OECD) countries. VVERs, designed in the former Soviet Union, are based on the same principles as PWRs. They use "light water", i.e. regular water (H2O) as opposed to "heavy water" (deuterium oxide D2O). Moderation provided by light water is not sufficiently effective to permit the use of natural uranium. The fuel must be slightly enriched in U235 to make up for the losses of neutrons occurring during the chain reaction. On the other hand, heavy water is such an effective moderator that the chain reaction can be sustained without having to enrich the uranium. This combination of natural uranium and heavy water is used in PHWRs, which are found in a number of countries, including Canada, Korea, Romania and India.

Graphite-moderated, gas-cooled reactors, formerly operated in France and still operated in Great Britain, are not built any more in spite of some advantages.

RBMK-reactors (pressure-tube boiling-water reactors), which are cooled with light water and moderated with graphite, are now less commonly operated in some former Soviet Union bloc countries. Following the Chernobyl accident (26 April 1986) the construction of this reactor type ceased. The operating period of those units still in operation will be shortened.

2.8.2 Plutonium-fuelled Reactors

Plutonium (Pu) is an artificial element produced in uranium-fuelled reactors as a by-product of the chain reaction. It is one hundred times more energetic than natural uranium; one gram of Pu can generate as much energy as one tone of oil. As it needs fast neutrons in order to fission, moderating materials must be avoided to sustain the chain reaction in the best conditions. The current Plutonium-fuelled reactors, also called "fast" reactors, use liquid sodium which displays excellent thermal properties without adversely affecting the chain reaction. These types of reactors are in operation in France, Japan and the Commonwealth of Independent States (CIS).

2.8.3 Light Water Reactors

The Light Water Reactors category comprises pressurized water reactors (PWR, VVER) and boiling water reactors (BWR). Both of these use light water and hence enriched uranium. The light water they use combines the functions of moderator and coolant. This water flows through the reactor core, a zone containing a large array of fuel rods where it picks up the heat generated by the fission of the U235 present in the fuel rods. After the coolant has transferred the heat it has collected to a steam turbine, it is sent back to the reactor core, thus flowing in a loop, also called a primary circuit.

In order to transfer high-quality thermal energy to the turbine, it is necessary to reach temperatures of about 300 °C. It is the pressure at which the coolant flows through the reactor core that makes the distinction between PWRs and BWRs.

In PWRs, the pressure imparted to the coolant is sufficiently high to prevent it from boiling. The heat drawn from the fuel is transferred to the water of a secondary circuit through heat exchangers. The water of the secondary circuit is transformed into steam, which is fed into a turbine.

In BWRs, the pressure imparted to the coolant is sufficiently lower than in a PWR to allow it to boil. It is the steam resulting from this process that is fed into the turbine.

This basic difference between pressurized and boiling water dictates many of the design characteristics of the two types of light water reactors, as will be explained below.

Despite their differing designs, it must be noted that the two reactor types provide an equivalent level of safety.

2.8.4 Pressurized Water Reactors:

The fission zone (fuel elements) is contained in a reactor pressure vessel under a pressure of 150 to 160 bar (15 to 16 MPa). The primary circuit connects the reactor pressure vessel to heat exchangers. The secondary side of these heat exchangers is at a pressure of about 60 bar (6 MPa) - low enough to allow the secondary water to boil. The heat exchangers are, therefore, actually steam generators. Via the secondary circuit, the steam is routed to a turbine driving an alternator. The steam coming out of the turbine is converted back into water by a condenser after having delivered a large amount of its energy to the turbine. It then returns to the steam generator. As the water driving the turbine (secondary circuit) is physically separated from the water used as reactor coolant (primary circuit), the turbine-alternator set can be housed in a turbine hall outside the reactor building.

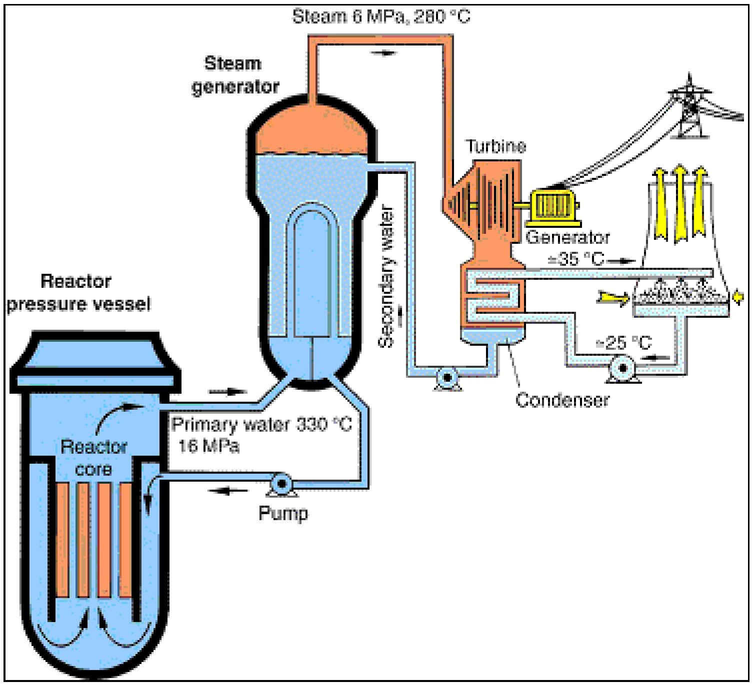

Figure (2.2) Nuclear power plants with pressurized water reactor

2.8.5 Boiling Water Reactors:

The fission zone is contained in a reactor pressure vessel, at a pressure of about 70 bar (7 MPa). At the temperature reached (290 °C approximately), the water starts boiling and the resulting steam is produced directly in the reactor pressure vessel. After the separation of steam and water in the upper part of the reactor pressure vessel, the steam is routed directly to a turbine driving an alternator.

The steam coming out of the turbine is converted back into water by a condenser after having delivered a large amount of its energy to the turbine. It is then fed back into the primary cooling circuit where it absorbs new heat in the fission zone.

Since the steam produced in the fission zone is slightly radioactive, mainly due to short-lived activation products, the turbine is housed in the same reinforced building as the reactor [3] .

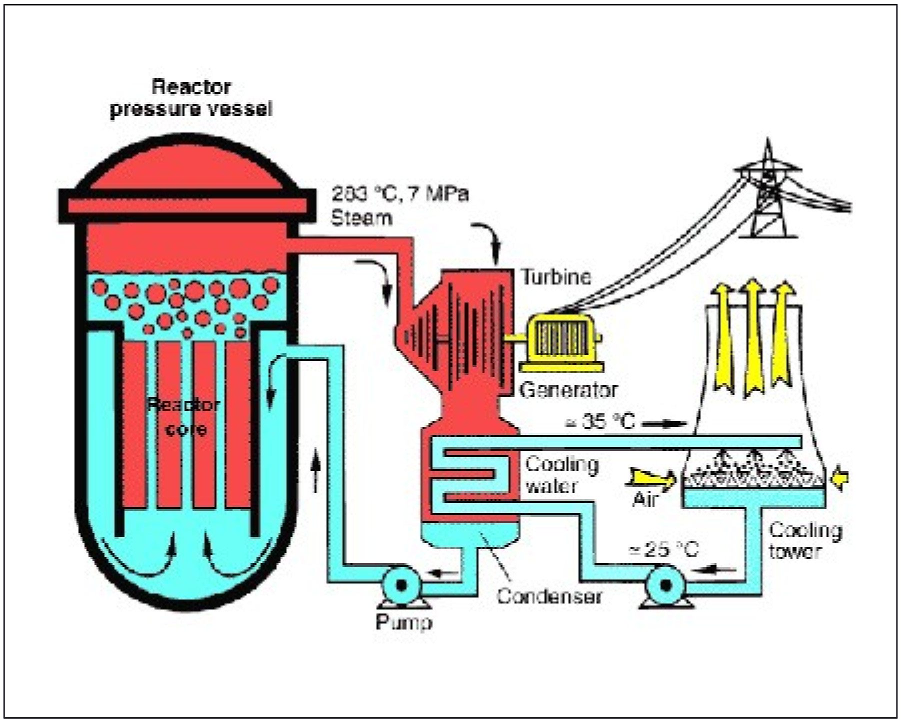

Figure (2.3) nuclear power plant with boiling water reactor

Chapter Three
Nuclear Security

Chapter Three

Nuclear Security

3.1 Introduction:

The licensees of nuclear facilities have primary responsibility for planning and implementing emergency measures within their site boundaries. These emergency measures include corrective actions at the site and protective measures and aid for persons on site. Since facility licensees cannot do this alone, it is a necessary part of the facility’s emergency planning to make advance arrangements with State and local organizations for special emergency assistance such as ambulance, medical, hospital, fire and police services. State and local governments have responsibility for planning and implementing protective actions outside the site boundaries. Radiological response team members from State and local emergency services will be better prepared to carry out these responsibilities with some knowledge of nuclear power plant structure, operations and emergency response procedures.

The teaching points included in this unit should be recognized as a review by those who have completed the radiological series prerequisites or who have experience in the nuclear power industry, you are notified of a site area emergency at a nuclear power plant located nine miles from your town. The meteorologist has confirmed that if a release occurs, the town will be directly in the path of the plume. Part of the town is in the plume exposure pathway and the rest is within the ingestion pathway [4].

3.2 Nuclear Security:

The nuclear security based on three important terms and its:

Prevention

Detection

Response

3.3 Emergency Classification:

Emergencies are classified in four levels accordance to the possible radiological consequences on-site and off-site:

1\ level of emergency or unusual event.

2\ level of emergency or alert.

3\ level of emergency or site emergency.

4\level of emergency or general emergency.

General classification criteria OF specific emergency action levels consider:

- Level of radioactivity release.

- Core damage status.

- Anomalies and failures in technical process,

- Power supply problems.

- Fire.

- Natural events:

(Earthquake, flood, low water, and thunderstorm).

- External events:

(Aircraft crash, nearby transport accident or release of danger materials, site or nearby explosion).

- Person injury with irradiation or contamination,

- Security events.

Figure (3.1) extend of activation depends of emergency level

3.4 Safety Standards:

Definition:

Requirements, regulations, standards, rules, codes of practice or recommendations established to protect people and the environment against ionizing radiation and to minimize danger to life and property. (IAEA)

3.4.1 Technical Standards:

Is an established norm or requirement. It is usually a formal document that establishes uniform engineering or technical criteria, methods, processes and practices.

3.4.2 Safety standards:

Are designed to ensure the safety of products, activities or processes, etc. They may be advisory or compulsory and are normally laid down by an Authority.

3.5 International Standards:

International standard that shown in figure (3.2) are classified to:

3.5.1 Metrological Standards:

e.g:

Length, mass, time, quantity of matter

3.5.2 Written Standards:

e.g:

Naming, describing, specifying, measuring and testing things.

Figure (3.2) international standards.

International Standards can be classified to:

Formal:

Developed by independent experts working under the auspices of a National, Regional or International standards body.

Informal:

Developed by a SDO (Standards Development Organisation) .

Safety standards can be developed by:

1/International Standards Organizations (ISOs).

2/Regional Standards Organizations (RSOs).

3/Standards Developing Organizations (SDOs).

4/National Standards Bodies (NSBs).

3.6 IAEA Standards, Guides and Codes:

A big part of the IAEA´s statutory mandate is the establishment, and promotion, of advisory international standards and guides.

Standards are issued as series publications and cover nuclear safety, radiation protection, radioactive waste management, the transport of radioactive materials, the safety of nuclear fuel cycle facilities and quality assurance.

3.7 Hierarchy of IAEA Safety Standards:

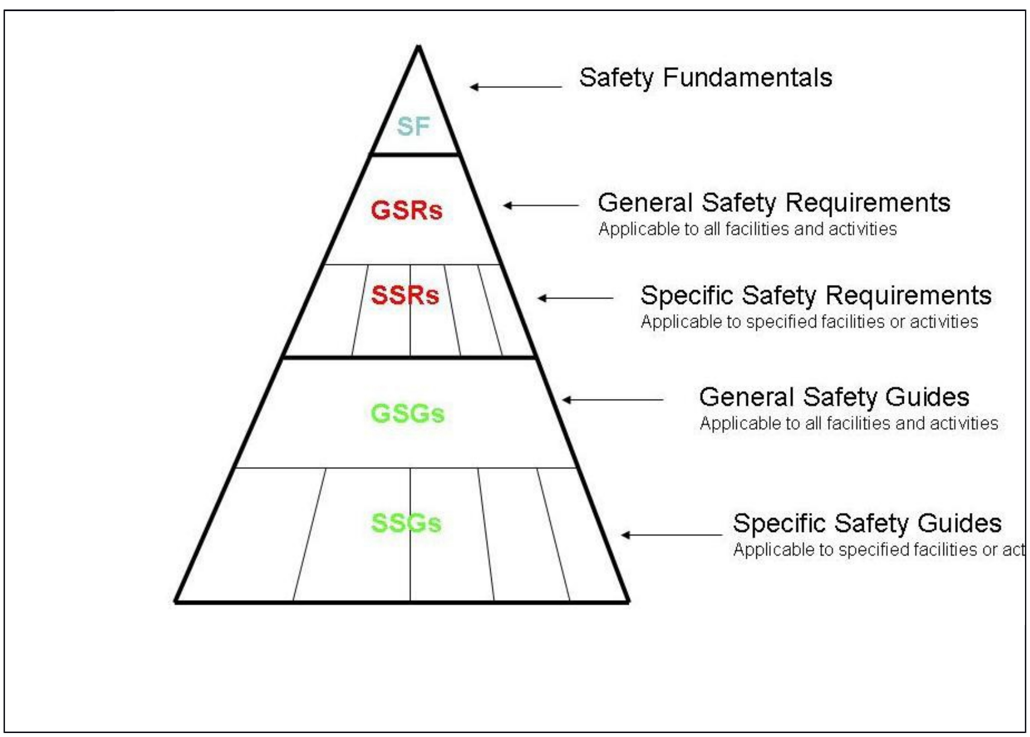

Figure (3.3) Hierarchy Safety Standards of IAEA

The hierarchy of the Safety Standards that shown in figure (3.3) above developed by the IAEA is As follows:

At the top is the Safety Fundamentals which present the basic objective, concepts and principles for safety. The Safety Fundamentals were used as the basis for the development of the nuclear Safety Convention and the Joint Convention on the Safety of Radioactive Waste and Spent Fuel.

The fundamentals are followed by Safety Requirements that must be met to ensure safety. They provide the basis for national laws and regulations.

Each safety requirement is supplemented by a number of Safety Guides which present recommended actions for meeting the Safety Requirements. Safety guides are comparable to national regulatory guides.

In principle safety requirements and guides reflect the best practices of the Member States.

The Safety Standards need to be complemented by national infrastructures and industry standards. IAEA also develops other safety related publications in support of the standards [6].

3.8 Fundamental safety principle:

The Fundamental safety objective is to protect people and the environment from harmful effects of ionizing radiation and, the safety principles have been formulated to achieve the Fundamental Safety objective and its :

1: Responsibility for safety:

The prime responsibility for safety must rest with the person or organization responsible for facilities and activities that give rise to radiation risks.

2: Role of Government:

An effective legal and governmental framework for safety, including an independent regulatory body, must be established and sustained.

3: Leadership and Management for Safety:

Effective leadership and management for safety must be established and sustained in organizations concerned with, and facilities and activities that give rise to, radiation risks.

4: Justification of Facilities and Activities:

Facilities and activities that give rise to radiation risks must yield an overall benefit.

5: Optimization of Protection:

Protection must be optimized to provide the highest level of safety that can reasonably be achieved.

6: Limitation of risks to Individuals:

Measures for controlling radiation risks must ensure that no individual bears an unacceptable risk of harm.

7: Protection of present and future generations:

People and the environment, present and future, must be protected against radiation risks.

8: Prevention of Accidents:

All practical efforts must be made to prevent and mitigate nuclear or radiation accidents.

9: Emergency Preparedness and Response:

Arrangements must be made for emergency preparedness and response for nuclear or radiation incidents.

10: Protective Actions to reduce existing or unregulated Radiation risks:

Protective actions to reduce existing or unregulated radiation risks must be justified and optimized [3].

3.9 Protection Systems Designs and Failure Analyses:

The reactor protection system (RPS) is a safety-related system that is designed to monitor key operating plant variables; and to cause alarms, control rod insertions, or scram, as the 'occasion may require when off-normal conditions occur. The reactor trip system (RTS) is part of the RPS and includes those power is part of the RPS and includes those power sources, sensors, initiation circuits, logic matrices, bypasses, interlocks, racks, panels, control boards, actuation devices, and actuated devices, that are required to initiate reactor shutdown. The RTS automatically initiates control rod insertion when required to assure that acceptable fuel design limits are no exceeded. It is designed to fail safe for most internal component failures. The RTS can also be actuated manually by operator action.

3.10 Source Terms:

The energy contained in the core of a nuclear power plant is not controlled considerable damage can be done to the fuel, cladding, reactor vessel and even the containment.

The plant barrier that normally contain the core radionuclides, even if the reactor is shut down, the substantial energy generated by the decay of fission products (decay heat) can lead to damage to these barriers.

If sufficient quantities of radionuclides are released to the environment as a result of such damage, various off-site health effects may result, this subsection discuses the quantities and characteristics of radionuclide releases to the environment (source terms) and the corresponding levels of plant damage required to produce significant off-site health effects. It also introduces the concept of protective actions, actions that can be taken to reduce the number of off-site health effects that might otherwise result given a severe accident.

3.11 Radionuclide Inventories:

The conventional unit used to quantify the radioactivity of a material is the curie (Ci). One curie of material undergoes radioactive decay at the rate of 3.7x10 t° nuclear disintegrations per second, which is the radioactivity of one gram of pure radium. The corresponding Standard International (SI) unit of radioactivity is the Becquerel (Bq). One Becquerel is one nuclear disintegration per second, so 1 Ci = 3.7x101° Bq.

3.12 Dose Pathways:

Radionuclides would be released to the environment as gases (Kr, Xe, 12) or aerosol particles of water soluble substances such as cesium iodide (CsI), cesium hydroxide (CsOH), and Sr (OH) or slightly soluble oxides of tellurium, ruthenium and lanthanum. Generally, a major release (source term) from a nuclear power plant can be viewed as a cloud (called the plume) of radioactive gases, aerosol particles and water vapor (mist).

3.13 Health Effects:

Radiation exposures can affect the health of exposed individuals. The type of effect, its severity, and the length of time until the effect appears are determined by the total dose received, the rate of exposure, and the exposed organs, and the degree of medical treatment received.

3.14 Protective Actions:

The public can usually be protected from an uncontrolled release of radiological material only by some form of intervention (e.g. evacuation) that disrupts normal living. Such intervention is termed protective action. This subsection presents basic radiation protection objectives and prot active action guides that establish the magnitude of radionuclide releases requiring early protective action. A more complete discussion of protective actions that may be appropriate during or after a severe reactor accident [1].

Chapter four

Effect of distance and angle on radiation intensity

Chapter four

Effect of distance and angle on radiation intensity

4.1 introductions:

The study of the effects of distances and angles on radiation intensity is very importance for safety, therefore it’s important to see how change of distances and angles on radiation intensity.

This work was done at physics laboratory at Sudan University of science and technology on Sunday 29/3/2015.

4.2 materials and methods:

The experiment was done by using co 60 as radioactive source emitting (γ) radiation, the radiation intensity was measured by using Geiger –Muller tube, and the following steps were mode for measurement

1\ the Geiger –Muller counter was mounted such that the g-m tube axis subtends an angle (90) with respect to the radiation and the distance between g-m tubes and is varied 4 times; the corresponding radiation intensity was recorded.

2\ at each distance the angle are changed 5 times.

4.3 results and tables:

1\ Different distances (r)

Θ=0 θ=10

r/cm	I/w/m2
5	69
10	54
15	7

20	80
r/cm	I/ w/m2
5	87
10	51
15	27
20	29

Θ=20 θ=30

r/cm	I/w/m2
5	13
10	44
15	115
20	22
r/cm	I/w/m2
5	15
10	77
15	73
20	22

Θ=40 θ=50

r/cm	I/w/m2
5	30

10	44
15	19
20	20

r/cm	I/w/m2
5	15
10	45
15	88
20	99

$\Theta=60$

r/cm	I/w/m2
5	22
10	19
15	40
20	50

Figure (4.1) radiation intensity at difference distances

2\ Different angles (θ):

R=5

R=10

θ	**I**
0	69
10	87
20	13
30	15
40	0
50	61
60	46

θ	**I**
0	54
10	51
20	44
30	57
40	46
50	38
60	50

R=15

θ	I
0	7
10	27
20	15
30	63
40	50
50	5
60	32

I0 =35w/m2 background radiation.

Figure (4.2) radiation intensity at difference angle

4.4 discussions:

In view of table (4.3.1) and (4.3.2) it's clear that the radiation intensity does not decrease up on increasing laws, also the intensity does decrease, when increasing the angle (θ) regularly also.

This can be easily explained as resulting from the presence of relatively large background.

$I0= 35w/m2$

This strong background may result from the effect of strong source of radiation other that under study.

These strong sources of radiation surely affect the regularity of reading, as for as g-m counter is sensitive to the location and orientation with respect to this source

The strong radiation background may also be related to some cosmic activity like sun magnetic activity which is active during this year 2015.

Such effect is not regular, thus it cause irregular reading.

4.5 conclusions:

The safety of radiation requires distances, angles and background on the radiation intensity.

4.6References:

[1] perspectives on Reactor Safety –Prepared by F. E. Haskin, University of New Mexico -A. L. Camp, Sandia National Laboratories .

[2] Fundamental of nuclear reactor physics by Elmer e. Lewis.

[3] Fundamentals of Radiation Materials Science University of Michigan 1921 Cooley Bldg -2355 Banister Blvd.

[4] Decommissioning of Nuclear Power Plants and Research Reactors- Safety Guide - International Atomic Energy Agency Vienna

[5] Nuclear safety and emergency preparedness www.nek.si, Vrbina 12, 8270 Krško.

[6] International Nuclear Safety Standards written by Dr. Syed Arif Ahmad (Chief Scientist) (PAEC) (Pakistan Atomic Energy Commission).

[7] Nuclear science and technology, series of monograph and text book –written by V. L P A R S E G I A N

Table of Figures