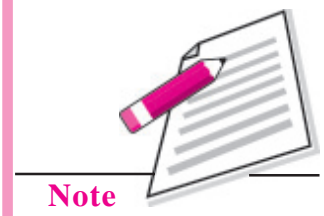

Note

12

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NUCLEAR WARFARE

In the previous module, we have learnt about the various conventional weapon systems held by the Indian Armed Forces. We also learnt about the future military technology. Both conventional weapons and non-conventional weapons are used in present day warfare. Nuclear, biological and chemical warfare are weapons of mass destruction or popularly called WMD. Biological & Chemical weapon systems and warfare are banned under the international rules and treaties. However, the use of these weapon systems by nations cannot be ruled out.

In this lesson we will learn about the nuclear warfare. We will also learn about the various basic terms of nuclear reactions. A brief insight into what is a nuclear weapon and the various effects of nuclear weapon will also be given. The various protection mechanism against the nuclear effects will also be discussed.

Objective

After studying this lesson, you will be able to:

- define the basic terms used in nuclear science;
- explain the energy yield of nuclear explosion;
- list the characteristics of a nuclear explosion;
- explain the effects of a nuclear explosion;
- explain the meaning of nuclear radiation and
- suggest the protective measures to be taken against the effects of a nuclear explosion.

12.1 Basic Terms

12.1.1 Nuclear Energy

In a conventional explosion such as bombs, the energy released results from chemical

reactions of the atoms of hydrogen, carbon, oxygen, and nitrogen present in the high-explosive material. In a nuclear reaction, redistribution or a recombination of the protons and neutrons of the atoms takes place. This produces the energy that is tremendously greater than the conventional energy.

Two kinds of nuclear reactions are used for the production of large amounts of energy in a short time. They are known as 'fission' (splitting) and 'fusion' (joining together). The fission process takes place with some of the heaviest (high atomic number) nuclei such as plutonium, which are split into smaller nuclei. In this process, a large amount of energy is released. Fission, on the other hand, involves some of the lightest (low atomic number) nuclei such as Helium and Hydrogen combining together to release energy.

12.1.2 Fission

When a free (or unattached) neutron enters the nucleus of a fissile atom, it can cause the nucleus to split into two smaller parts. It is accompanied by the release of large amount of energy. This is called the fission process. The materials used to produce nuclear explosions by fission are certain isotopes of Uranium and Plutonium. Uranium consists mainly of two isotopes. The Uranium isotopes are Uranium- 235 (about 0.7 per cent), and Uranium-238 (about 99.3 per cent). Uranium-235 is readily fissile and is commonly used in nuclear weapons. Another isotope, Uranium-233 is also readily fissile. Uranium-233 is made artificially from Thorium-232. Plutonium-239 is yet another fissile isotope used in nuclear weapons made artificially from Uranium-238.

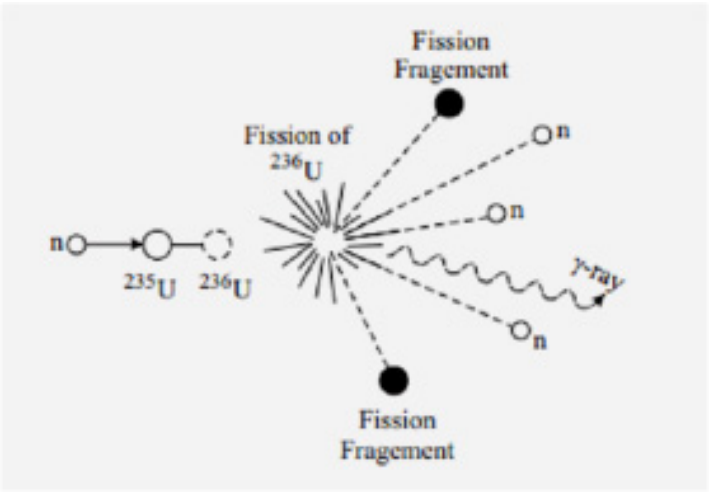


Fig 12.1 – Fission Process

12.1.3 Fusion

In nuclear fusion, a pair of light nuclei unite (or fuse) together to form a nucleus of a heavier atom. For example the fusion of the Hydrogen isotope is known as Deuterium or 'heavy hydrogen'. Under suitable conditions, two Deuterium nuclei may combine to

form the nucleus of a heavier element - Helium, with the release of energy. A nuclear fusion reaction is brought about by means of very high temperature, and they are thus referred to as 'thermo-nuclear processes'.

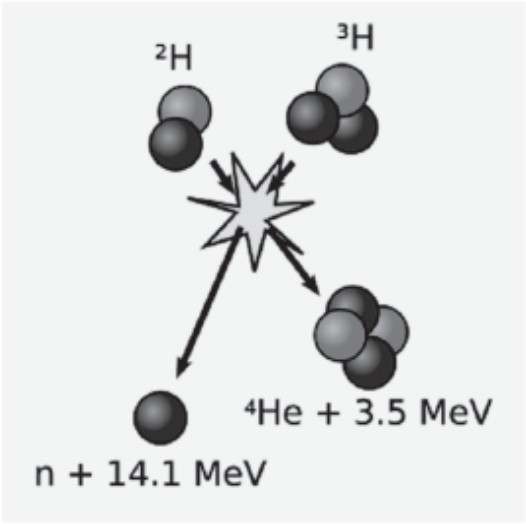


Fig 12.2 – Fusion Process

12.1.4 Chain Reaction

A chain reaction or nuclear chain reaction is a sequence of reactions. A reactive product or by-products from the first reaction followed by additional reactions to take place. In a chain reaction, positive feedback leads to a self-amplifying chain of events. In nuclear chain reaction a high speed neutron is used to bombard the nucleus of the fissile atom. This breaks the nucleus into smaller atoms and in the process also releases additional high-speed neutrons. These high-speed neutrons bombard with the other atoms of fissile material. This process continues to form a nuclear chain reaction. The uncontrolled nuclear chain reaction leads to the release of large amount of heat energy, which causes destruction.

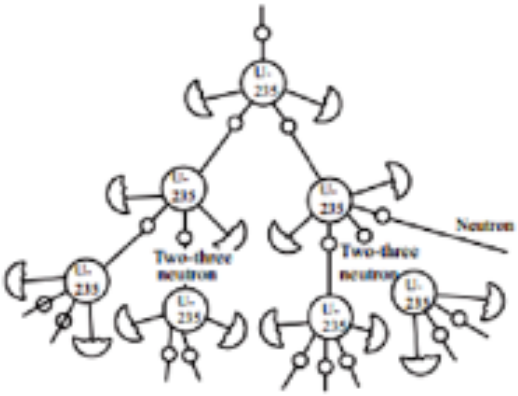


Fig. 12.3

Note

12.2 Energy Yield of Nuclear Explosion

The 'yield' of a nuclear weapon is a measure of the amount of explosive energy it can produce. The yield is expressed in terms of the quantity of TNT that would generate the same amount of energy when it explodes. Thus, a 1 Kiloton (KT) nuclear weapon is one which produces the same amount of energy in an explosion as does 1 kiloton (or 1,000 tons) of TNT. Similarly a one megaton (MT) weapon would have the energy equivalent of 1 million tons of TNT.

12.2.1 Types of Bursts

A nuclear bomb can be made to burst on ground, air or higher in the atmosphere. Depending on the location or point of burst in relation to the surface of the earth, the effects of a nuclear blast varies. The point of nuclear explosion may be therefore classified as follows: -

(a) **Exo-Atmospheric:** A burst occurring outside the earth's atmosphere (over 30kms above the earth's surface) is called an exo-atmospheric burst.

(b) **Endo-Atmospheric:** A burst, which occurs within the earth's atmosphere, is called an endo -atmospheric burst. These can be further divided into:-

(i) **High Altitude Air Burst :** A high altitude burst is defined as the one in which the explosion takes place at an altitude in excess of 30,000 m. At these heights, the air density is so low that the interaction of the weapon energy with the surroundings is markedly different from that at lower altitudes. The effects of blast, thermal and nuclear radiations of such bursts are negligible at ground level but radar and wireless communications may get affected over a large area for a long duration.

(ii) **Air Burst:** When a nuclear explosion takes place below 30,000 m of altitude, the weapon residue immediately incorporates material from the surrounding medium and forms an intensely hot and luminous mass, which is roughly spherical in shape. For an airburst, the height of burst should be such that the fireball does not touch the surface of earth.

(iii) **Surface or Ground Burst :** When the point of burst is such that the fireball touches the surface, then it is a surface burst.

(iv) **Sub-Surface Burst :** When the point of burst is beneath the ground, it is a subsurface burst. A very shallow burst is indistinguishable from a surface burst because the fireball will still be produced above the ground. In a deeper burst, a gas bubble will be formed, instead of fireball.

(v) **Underwater Burst:** When the point of burst is under the sea, it is an underwater burst.

Note

Intext Questions 12.1

1. Fill in the blanks:-
   (a) The chemical reaction in which a pair of light Nuclei unites together to form a nucleus of a heavier atom is called _____ reaction.
   (b) The chemical reaction, which causes the nucleus to split into two smaller parts, is known as _____ reaction.
2. Mention the different types of Endo-atmospheric bursts.
3. What is meant by thermo-nuclear process?

12.3 Characteristics of Nuclear Explosion

The characteristics of a nuclear explosion would vary depending upon the type of burst. They are: -

(a) An intense bright flash.
(b) A fireball.
(c) A thermal heat pulse of thermal radiation.
(d) A pressure wave-giving rise to blast and shock.
(e) Radiation.
   (i) Initial radiation.
   (ii) Residual radiation from neutron induced activity in the ground and the fall-out of radioactive material.
   (iii) Transient radiation effects on electronics (TREE).
(f) Electro-magnetic phenomenon.
(g) A prominent cloud.

ACTIVITY 12.1

Watch the movie "BBC History of World War II Hiroshima". Follow the link:-

https://www.dailymotion.com/video/xlk8my

or

http://www.documentarytube.com/videos/history-of-world-war-ii-hiroshima

Note

Intext Questions 12.2

1. TREE stands for _____

2. Name any two types of radiations.

12.4 Effects of Nuclear Explosion

Understanding the major effects of the nuclear explosion helps us to prepare better if an attack should occur. The effects of flash, heat, blast and radiation depends on the size and type of weapon, the weather conditions (sunny or rainy, windy or still); the terrain and height of explosion. In a nuclear attack, most of the people within a few km of the explosion will be killed or seriously injured by the blast, heat or initial radiation. Similarly, all the other natural and manmade structures will be either completely or almost destroyed. Let us see the effects of Flash, Heat and Blast that occurs from a nuclear explosion.

12.4.1 Flash Effects

- **Dazzle:** The intense flash from a nuclear burst can affect vision at long ranges due to dazzle and eye damage. Dazzle, (sometimes called 'flash blindness') is a temporary loss of vision resulting from the brightness of the visible burst. It will only be of significance to personnel unaffected by other nuclear effects. As a guide, in daylight only those facing the burst are likely to be dazzled for about two minutes. At night, dazzle will affect those facing the burst for about 10 minutes and those facing away for about three minutes.
- **Eye Damage:** Retinal burns occur when the eye lens focuses the fireball image on to the retina. Shallow burns heal completely. Deep burns lead to permanent blind spots. However, sight is not normally lost completely.

12.4.2 Heat or Thermal Effects

Heat is a principal casualty producing effect. It is likely that some 50% of nuclear weapons casualties will suffer burns: -

(a) To exposed skin unprotected from the thermal pulse.

(b) From charred or burnt clothing and/or local fires.

- **Degree of Burns in Personnel :-**
  - First Degree- involve the top layer of skin.
  - Second Degree- involve the first two layers of skin.
  - Third Degree - involve all layers of the skin and cause permanent tissue damage

Note

- **Heat Effects on Materials:** The thermal pulse delivers a large quantity of heat in a very short time. Damage will be related to the amount of heat absorbed. Fires started by the ignition of paper, fabric, netting, vegetation and other combustible material are likely to cause a major secondary hazard.

12.4.3 Blast and Shock Effects

The pressure wave from a nuclear explosion causes a blast wave in the air and a shock wave through the ground. It is likely to produce 35% casualties.

- **Effect on Personnel:** The human body has lot of resistance to the blast overpressure. The main danger is from indirect effects, such as: -
  - The collapse of buildings and field defences or overturning of vehicles.
  - The impact of flying debris.
  - Injuries caused to personnel by being picked up and flung by the wind.
- **Damage to Infrastructure:** The damage suffered by equipment and installations is likely to be:-
  - Antenna broken off; cables stretched and severed.
  - Vehicles, aircraft and equipment overturned.
  - Buildings and field defences collapses.
  - Earthworks collapsed by the ground shock wave.
  - Supplies, equipment and weapons blown away by the winds.
- **Terrain Effect:** The most significant terrain effect will be the falling down of structures and trees. Pressure wave follows ground undulations; hence terrain affords little protection from blast and shock.

The estimated size of the damage caused by the 16 KT and 22 KT atomic bombings of Hiroshima and Nagasaki is schematically depicted for you.

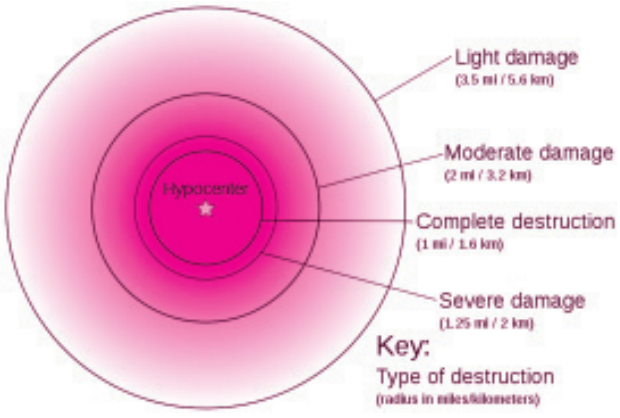


Fig 12.4 - An estimate of the size of the damage caused by the 16 KT and 22 KT atomic bombings of Hiroshima and NagasakiFig 12.3- Nuclear Chain Reaction

Note

12.5 Nuclear Radiation

Nuclear radiation is divided into two categories:

(a) **Initial:** Initial radiation is defined as that emitted during the first minute following detonation. It consists of gamma radiation and neutrons produced during fission or fusion, which irradiate material.

(b) **Residual:** Residual radiation is that which remains after one minute, post detonation. It is essentially neutron induced activity and 'fallout' of radioactive material.

When a nuclear weapon detonates, many neutrons are released. These cause imbalances in the nucleus of weapon material, the atmosphere and in the elements they interact. Many of these substances become radioactive resulting into emission of alpha and beta particles accompanied by gamma radiation. The ground area beneath a nuclear burst can become highly radioactive due to this process.

12.5.1 Nuclear Fallout

A fireball contains vapourised weapon residue. Radioactivity is induced into this fireball material by neutron bombardment. As the fireball rises, it will cool and form a cloud, which stabilizes in height and size. At the same time, the radioactive particles in the cloud begin to fall back towards earth. These particles travel along with the wind to settle and form areas of radioactive contamination. If rain falls through the radioactive cloud, water falling on ground also contaminates the ground and is called 'rainout'.

12.5.2 Radiation Effects on Personnel

All forms of nuclear radiation can cause injury to man. Cell death or damage is caused by ionization of body cells by gamma radiation. Blood cells, the stomach lining and the skin are more readily damaged than bones and muscle. Beta particles on or close to the body cause 'beta burns' in the form of lesions or blisters, which can take long time to heal and are open to infection. Alfa particles cause intense ionization of body cells, if in contact. Any radioactive particles ingested or otherwise admitted to the body may be toxic, in addition to the hazards created from radiation.

- **Symptoms of Radiation Damage:** The symptoms of radiation effects in personnel are usually described as 'radiation sickness'. Some of them are given below: -
  - Initial symptoms of headache, nausea, vomiting, diarrhea and general malaise.
  - A symptom-free period with apparent recovery.

Note

- The development of latent symptoms such as loss of hair and appetite, sore throat, fever, hemorrhages, prolonged incapacitation or death.

- **Radiation Sickness:** The human body has some ability to repair the damage caused by radiation but this is not complete. Radiation doses have a cumulative effect. A person receiving a dose of 100 centi Grays (cGys) on three occasions accumulates a total of 300 cGys (Gray is the unit of measure of nuclear radiation. It is also called rads). The damage and symptoms, however, depend not only on the dose but also on the rate of receipt each time and the interval between exposures. Individuals are affected by radiation to different degrees, hence radiation dose figures should only be regarded as a guide: -
  - Below 150 cGys - no long term effects for most personnel.
  - From 150 to 450 cGys - some incapacitation with possible death.
  - From 450 to 800 cGys - incapacitation and death most likely in the ensuing weeks.
  - Above 800 cGys - severe incapacitation and certain death.

12.5.3 Radiation Effects on Electronics

The initial radiation pulse mainly consists of gamma rays and neutron flux. When they directly interact with electronic components, a phenomenon called Transient Radiation Effect on Electronics (TREE) occurs. The pulse of high-energy gamma rays lasts for a fraction of a second. It may destroy semiconductor devices by direct interaction. The neutron flux accompanying the gamma rays can affect semiconductors by changing their electrical characteristics such that performance is temporarily or permanently altered.

12.5.4 Electromagnetic Phenomena

Electromagnetic phenomena are immediate effects of a high altitude airburst or air burst. They can be divided into following categories: -

- **Atmospheric Ionization:** A nuclear explosion causes ionization of the atmospheric layers and changes their electrical characteristics. This disturbs the transmission of electromagnetic waves from radio and radar equipment, which pass through these disturbed areas. Periods of disruption may be short (a few seconds), but some systems could be blacked out for several hours until earth's magnetic field returns to normal.
- **Electro-Magnetic Pulse (EMP):** EMP is a very powerful burst of broadband radio energy of very short duration. It is harmless to man. The very high energy associated with EMP can cause damage to electrical and electronic equipment,

which may be permanent, interruptive or transient. For example it may cause: -

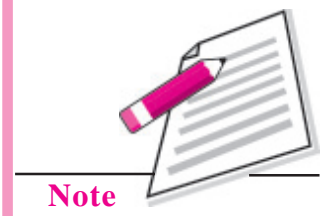
- Breakdown of insulation in cables and components
  - Tripping of relays and circuit breakers
  - Burnout of components within equipment
  - Corruption or clearance of electronic data stores
  - Explosive failure of susceptible equipment, which may cause human injury as a secondary effect.

12.5.3 The Fireball and the Radioactive Cloud

(i) **The Fireball:** A nuclear explosion leads to the liberation of a large amount of energy in a very small period of time within a limited quantity of matter. Because of the great heat produced by the nuclear explosion, all the materials are converted into the gaseous form. These gases cause tremendous pressure and lead to the formation of an extremely hot and highly luminous (incandescent) spherical mass of air and gaseous weapon residue, which is called the fireball. The surface brightness decreases with time, but after about a millisecond, the fireball from a 1-MT nuclear weapon, would appear to an observer, 80 kilometers away, to be many times brighter than the sun at noon.

(ii) **The Radioactive Cloud:** While the fireball is still luminous, the temperature in the interior is so high that all the weapon materials are in the form of vapour. As the fireball increases in size and cools, the vapour condenses to form a cloud, also called the mushroom cloud, consisting of solid particles of the weapon debris, as well as many small drops of water derived from the air sucked into the rising fireball.

Fig 12.5 – Mushroom Source : wikipedia.com



Note

Intext Questions 12.3

1. Fill in the blanks.
   (a) EMP stands for _____.
   (b) The electromagnetic phenomena consist of _____ and _____.
   (c) Degree of burns in personnel is classified as _____.
2. Mention the different categories of radiations.
3. List the initial symptoms of radiation sickness.

12.6 Protective Measures to be Taken Against the Effects of a Nuclear explosion

If you are in a city that is about to be hit by a nuclear missile, is there anything you can do that will increase your chances of survival? It entirely depends on where you are when the blast happens. Close to the fireball, the thermal energy is so intense that infrastructure and humans are incinerated. Underground bunkers and other facilities would do little as they too would be almost completely destroyed and there would be barely a physical trace that one ever existed. However, if you are a few miles away from the explosion your chances of survival are better.

12.6.1 The protective measures

Measures can be classified as individual protection and collective protection. The Individual Protective Equipment (IPE) or Personal Protective Equipment (PPE) consists of the following:-

(a) Two piece over-garment (coat and trousers) worn over Battle Dress or Uniform;

(b) Mask and respiratory protection consisting of filter canister with HEPA filter (which provides protection against radiological and biological particulates) and a charcoal filter (which provides protection against chemical weapon vapors);

(c) Gloves;

(d) Over-boots;

(e) Additional components like detection equipment, individual decontamination kit and antidotes for chemical hazard events

Fig 12.7 - Individual Protective Equipment

12.6.2 The collective protection

The collective protection is provided by construction of Nuclear Biological and Chemical (NBC) protected underground shelters. The shelter should be well stocked with food, water, medicines and should have working phone lines, a radio and other communication devices.

Intext Questions 12.4

1. IPE or PPE consists of (a) _____, (b) _____, (c) _____, (d) _____ and (e) _____.
2. The protective measures can be classified as _____ and _____.
3. Which essential materials should be stocked the by NBC Shelters.
4. Which type of communication facilities should the shelters have collective for protection ?

What You Have Learnt

- Simple and basic science of fission and fusion behind nuclear explosions and how it is used in a nuclear bomb;
- The various military terms of types of bursts which are Exo atmospheric and endo Atmospheric bursts of the nuclear bomb.
- What happens when a nuclear bomb is exploded. The bomb explodes into a mushroom shaped cloud giving intense head and blast. Then there is the nuclear fallout;

Note

- The effects of a nuclear bomb on humans and materials, which includes the blast, heat, radiation and electro magnetic effects;
- The protection required to be taken at the individual and collective level along with the quipment required in both the cases.

Terminal Exercises

1. Explain a nuclear chain reaction.
2. Explain radiation effects on personnel and infrastructure.
3. Distinguish between a Fireball and a Radioactive Cloud
4. What type of protective measures should be taken against the effects of a nuclear explosion?

Answers to Intext Questions

12.1

1. (a) Fusion
   (b) Fission
2. (i) High Attitude (ii) Air Brust (iii) Surface as Ground Bust
   (iv) Under Water Brust
3. A nuclear fission reaction is brought about by means of very high temperature. This is reffered as thermo-nuclear process.

12.2

1. Transient radiation effects on electronics
2. Initial radiation and Residual radiation

12.3

1. (a) Electro-Magnetic Pulse
   (b) Atmospheric Ionization and Electro-Magnetic Pulse
   (c) I Degree, II Degree and III Degree
2. Initial and residual
3. Headache, nausea, vomiting, diarrhea and general malaise

12.4

1. (a) Two piece over garment
   (b) Mark and respiratory protection
   (c) Gloves
   (d) Over-boots
   (e) Additional components
2. (i) Individual protection
   (ii) Collective Protection
3. Food, water, medicines
4. Working phones, a radio and other communication devices