Industrial Radiography Testing & Technique Safety for Human Body 2020-2023

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Abstract:
The use of Industrial Radiography for examining the quality of Weld joints is very popular worldwide. In India, many welding activities like construction and laying the huge pipelines for gas and water transportation and distribution as well construction of storage tanks are performed. The objects are working under high pressure and therefore, it is important to produce the weld beads with high quality. Industrial radiography uses ionizing radiation to view objects in a way that cannot be seen otherwise. The method has grown out of engineering, and is a major element of non-destructive testing (NDT) to inspect materials for hidden flaws. The radiation caused by these facilities is very dangerous however, with the use of new technologies and proper protection, risks of injury and death associated with radiation can be greatly reduced. Use or radiation sources are associated with a certain amount of radiation hazard. With proper card, this can be minimized. Radiation hazards may be broadly classified as external hazards an internal hazard. External hazards occur when the source of radiation is outside the body and internal hazards arise when the source for radiation gets into the human system. Hazard evaluation is necessary in order to adopt suitable measures to control radiation exposure. The problem of internal hazard does not arise in the use of X-ray equipment. It is considerably easy to estimate the external radiation hazard and there are a number of devices suitable for this purpose.

Keywords: *Radiography*, ICRP Safety, PIPE, Procedure, IQI, ASMT.DIN, Camera, Lock, NDT, TAEC, SFD Ionizing Radiation, Radiographic Inspection, mR , HVT AND TVT**,** Radiation Devices Register, Safety, atomic number (Z) , Weld defects.

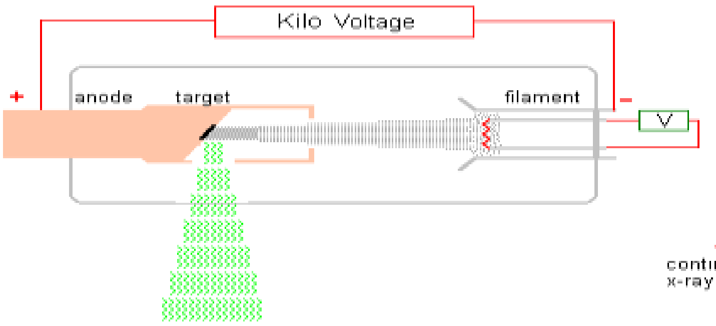
1. Introduction:

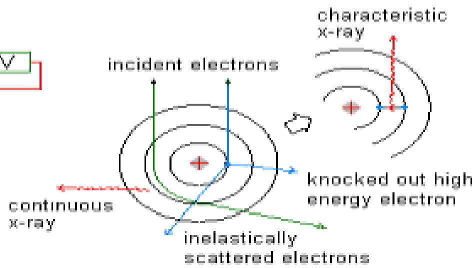
All materials in the universe are made of different elements. Hydrogen, oxygen, iron, iridium, gold, lead is some of the elements we are familiar with. Atom is the smallest part of an element. An atom has a positively charged central portion called 'nucleus'. It also has negatively charged electrons going around the nucleus, in different orbits. The nucleus has two types of particles - protons which are positively charged and neutrons which do not carry any charge. An atom is electrically neutral as the number of protons in its nucleus is equal to the number of electrons in the orbits. Structures of some atoms are shown in The number of protons in an atom is known as its atomic number (Z). Every atom of a particular element has definite number of protons e.g., aluminum has 13, cobalt has 27, iridium has 77 protons. Radiography is non-destructive testing (NDT) method to find out the internal discontinuities present in a component or assembly. It is based on differential absorption of penetrating radiation by the part being inspected. The basic principle for the detection of anomalies using radiographic testing

International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

method is the difference in radiation absorption coefficients properties exhibits by different materials. The images are captured in a recording medium. The recording medium used may be X-ray film, phosphorous imaging plates, diodes etc. Industrial X-ray films are the common recording medium used for these applications' the last five decades, non-destructive testing (NDT) methods have gone from being a simple laboratory curiosity to an essential tool in industry The first goal of this paper is to discuss who should be the appropriate person to take prime responsibility for safety when radiography is performed. The second is to briefly re-visit an event where a source had to be retrieved from a difficult location. Some lessons learnt at that time have been published more importantly; the experience strongly suggests that some developments in gamma camera design are wrong.

“Radiation is such a powerful and dangerous divine rays that humans cannot see by themselves, coming in contact with it can cause serious illness or death to a person”. Dr. HARDEV





2. Industrial X Ray sources :

X - rays are electrically generated radiation and the energy of the emitted radiation can be controlled. X rays are produced when electrons traveling at high speed looses energy by collision with matter or change of direction.

The usual type of x ray tube is a glass, ceramic or metal ceramic housing, where the spacing of electrodes and the degree of vacuum is such that no flow of electrical charge between the cathode and anode is possible until the filament is heated. The filament when heated with a suitable low voltage Controlled supply, emits electrons and thus forms the cathode or negative Electrode. The positive electrode is a solid block of copper with a tunnel at One end and a piece of tungsten embedded on the inside face of the tunnel End. The tungsten is the target or focal spot. A controlled high voltage is Applied between these electrodes, drives the electrons rapidly towards the Target. The sudden stopping of these rapidly moving electrons in the surface of the tungsten target results in generation of x rays. Much of the energy Appears in the form of heat and intense heat is produced on the target. Many of the electrons knock out orbital electrons from the target atoms while others get deflected by the positive charge of the nucleus.

These actions generate characteristics and continuous x-rays respectively. The continuous spectrum generates sufficient energy to penetrate materials and form the x-ray image. The machine is generally used for a shorter 'on' time followed by sufficient 'off ' time for air cooling. The machine cannot be operated continuously without efficient cooling arrangement and is generally achieved by water circulation. The generated x rays have all the energies within the emitted spectrum. The lower energies contribute greatly towards image contrast and sensitivity and the radiograph is superior when compared to gamma rays. Sensitivity of 1% can be achieved in most cases. The intensity of radiation [mR / min] mainly depends on the number of electrons emitted by the heated filament and is controlled by the current passing through it. The energy of radiation [keV] depends on the voltage applied between the anode and the cathode and is selected considering the material, its thickness and radiographic sensitivity requirements. Machines most commonly used are 160 to 400 kV [Tank type] with 4 to 8 mA beam current within the portable range and 2 to 6 meV and more [Betarons and Linear accelerators] in the high energy range. Portable machines generate either directional or panoramic beam. Most of the machines are not suitable for working at heights and with all types of exposure setups. Linear Accelerators and Betterton's uses different tube arrangements and methods of electron acceleration. The heat generation is also less and the JME 6 mev Betterton can operate without external cooling. The high energy machines are heavy, very costly and the energy of radiation cannot be adjusted continuously.
If X-ray is less, then gamma is more, if it is beneficial, then if it is used incorrectly, it is more harmful.
DR. HARDEV

3. Procedure for radiography performed in the refinery by contractors
Some properties of X and gamma rays are given below:
1. They are electromagnetic radiations like visible light.
2. They travel at the speed 300000 km per second.
3. They affect photographic films.
4. X-rays have continuous energies, whereas, gamma rays have discrete energies.
5. They can be scattered and reflected.
6. They can penetrate matter, penetration is less, if a) the absorber thickness is
7. more, b) absorber atomic number is higher and c) absorber density is higher.
8. They can damage living tissues.
9. They can also cause ionization and excitation in the medium through which they travel.

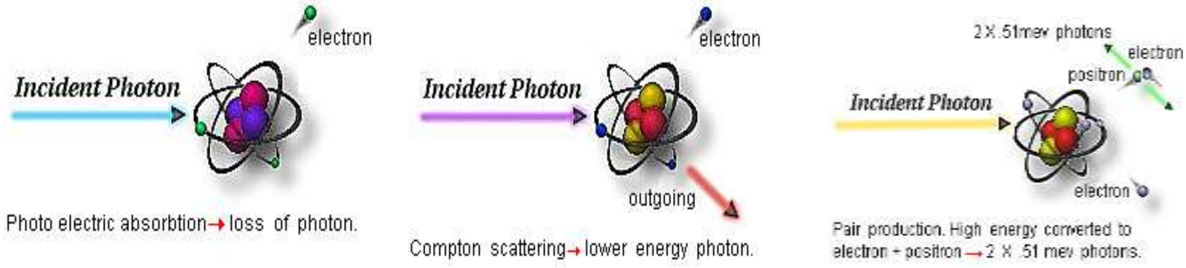
Visible light X-rays and gamma rays are electromagnetic radiations. They are similar in nature. They travel at the same speed (300,000 km/sec.) in air. They differ in energy and origin of production. They are all called photons.
Energy Of Radiations:
All radiations have energy. Energies of various radiations (αβγ) are usually specified in electron volts.
One electron volt is the energy given to a single electron as it moves across a potential difference of one volt.

1 eV = 1 electron volt = 1.6 x 10-12 erg.
1 KeV = 1 kilo electron volt = 1.6 x 10-9 erg.

1 MeV = 1 million electron volt = 1.6 x 10-6 erg.

Radiation is such a powerful and dangerous divine rays that humans cannot see by themselves, coming in contact with it can cause serious illness or death to a person. Dr. HARDEV

3.4 Supervisor: The person in direct control of the job of which radiography is a part. This would typically be a Refinery or Contract engineer, a refinery maintenance supervisor or a mechanical contractor's supervisor.



4.0 The photoelectric effect is an interaction between a gamma ray (photon) and an orbital electron. The gamma radiation losses its complete energy to the electron and the electron is removed from its orbit. This electron is called photoelectron. This electron being a charged particle easily gets absorbed in the medium. This interaction is predominant at lower energies and it decreases with increases in energy. It increases with increase in atomic number of the object. Hence, higher atomic number materials, like lead, uranium, tungsten, etc. absorb gamma radiations better than lower atomic number materials, like plastic aluminum, iron, etc.

In Compton effect, gamma radiation interacts with a free electron. The gamma radiation gives a part of its energy to the electron and travels in different direction (get scattered) with decreased energy. The electron moves in another direction. This effect is predominant at medium energies and it is not dependent on the atomic number of the material.

When and electron is removed from its orbit, the atom looses one negative charge. In other words, the atom gets positively charged or ionized. Hence, this process known as Ionization.

When an electron is raised from an inner orbit to an outer orbit, the electron gets extra energy. In other words, the atom gets excited. Hence, this process is called **Excitation.** Alpha, beta and gamma radiations can directly or indirectly cause ionization and excitation in material with which they interact. Hence, these radiations are ionizing radiations.

The intensity of radiation reduces while passing through any material. In case of X and gamma radiations, the attenuation follows and exponential law:

$$\mathbf{I = I0e^{-\mu x}}$$

Where, Io is the intensity of the incident radiation beam

Io is the intensity of the beam emerging after traversing a thickness x of the material and

μ is known as linear attenuation coefficient.

It is defined as the fractional decrease in intensity per unit thickness of the material. If the energy region of 100keV to 1.5 MeV is considered, the attenuation of efficient decreases with increase in energy and it increases with increase in atomic number of the absorber material. Hence, lower energy radiations are better absorbed and higher atomic number material are go absorbers.

International Journal for Multidisciplinary Research (IJFMR)

E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

5.0 TABLE 1.HVT AND TVT VALUES FOR X AND GAMMA RADIATIONS

	Material							
Radio-isotope	**Concrete**		**Steel**		**Lead**		**Uranium**	
	HVT	TVT	HVT	TVT	HVT	TVT	HVT	TVT
	cm	cm	cm	cm	cm	Cm	cm	cm
Iridium-192	4.6	14	12.25	4	0.48	1.6	0.31	1.0
Cobalt-60	6.6	21.8	2.0	6.6	1.2	4.0	0.7	2.2
X-rays	HVT	TVT	HVT	TVT	HVT	TVT	HVT	TVT
	mm	mm	mm	mm	mm	Mm	mm	mm
100kV	16	55	1.2	3.8	0.25	0.84	NA	NA
150kV	22	70	2.3	7.6	0.29	0.96	NA	NA
200kV	26	86	3.8	12.7	0.42	1.4	NA	NA
250kV	28	90	5.4	17.7	0.86	2.9	NA	NA

Half value Thickness (HVT)

The thickness of the material, usually called absorber, (e.g. steel, lead, depleted uranium, etc.) needed to reduce the intensity of radiation to half its initial value is
known as the Half Value Thickness **(HVT).**

The HVT depends on the energy of radiation and the nature of the absorber. In the case of X-ray, the HVT value for any kV depends to some extent on the amount of inherent filtration of the X-ray tube. However, the value of HVT for a given material can be taken as constant for heavily filtered beam.

As higher atomic number materials reduces the intensity to half of the original intensity.

Two HVT reduces the intensity to___________

½ X ½ = $(½)^2$ i.e., 1/4 of the original intensity.

In general, **'n'** HVT reduces the intensity to **$(½)^n$**

(Recall the decrease of radioactivity with time).

The reduction in radiation intensity with absorbers of different half value thickness.

Tenth Value Thickness (TVT)

Tenth value thickness is the thickness of any material needed to reduce the radiation intensity to one tenth of its initial value. Similarly, Two TVT reduces the intensity to

1/10 x 1/10 = $(1/10)^2$ i.e., 1/100 of the original intensity.

Generally 3.3 HVT reduces the intensity by a factor of 10,

Hence, 1TVT = 3.3 HVT

HVT and TVT values in different materials, for X and gamma radiation, are given in Table1.

Example 1) The radiation level at a place, due to an iridium-192 source is 10 mR/h. What is the thickness of steel required reducing the level to 2.5 mR/h?

ANS: Radiation level at the place = 10 mR/h.
One HVT reduces the level to 10: 2 = 5 mR/h.
One more HVT reduces the level 5: 2 = 2.5 mR/h.
Two HVT of Steel for iridium-192 = 2 x 1.25 cm = 2.5 cm.

Example 2) What is the thickness of lead required reducing the radiation intensity at a place, due to cobalt-60 source from 1000 mR/h. to 5 mR/h?

ANS: Radiation level at the place = 1000 mR/h.
One HVT reduces the level to 1000: 10 = 100 mR/h.
One more TVT reduces the level 100: 10 = 10 mR/h.
One HVT added to this reduces the level to 10: 2 = 5 mR/h.
Two TVT and one HVT of lead for coablt-60 radiation = 2 x 4 + 1 x 1.2 cm = 9.2 cm.

6.0 . Biological Effects of Radiation

Cell:

Cells are the units of living organisms. All tissues are made of cells. Adult human body consists of about 1014 cells. Cells of different organs carry out the functions specific for those organs. For example, nerve cells are responsible for transmitting electrical impulses from one part of the body to the other; liver cells are responsible for metabolizing the food we take and preparing nutrition for all other tissues in the body; red blood cells carry oxygen and nutrition to all tissues.

Cells of different tissues have different sizes and shapes. However, in general, they all contain a central nucleus (with the exception of red blood cell), surrounded by a viscous fluid called cytoplasm. The nucleus contains chromosomes which constitute an array of several million genes. The chromosomes control all the functions of the cell and hence, of the tissue. The cytoplasm contains various membrane systems and other components that are necessary for the function of the cell.

Cell Division:

Cells originate of multiply from preexisting cells by the process of cell division. For example, a human being, like any other animal, develops from a single cell, which is formed by the fusion of two germ cells, one from the father and the other from the mother. During the nine-month period of pregnancy, this cell undergoes a number off cell divisions. The new cell in turn specializes deform various organs of the fetus (unborn baby). After birth, cell division continues until the organs attain adult proportions. Cells in many tissues of the body have life span shorter than that of the body, as a whole. For example, blood cells, skin cells, intestinal cells etc. have life span ranging from a few weeks to a few days. They wear out and die. They are continuously replaced for the proper function of this tissue. Hence, even in an adult, cell division continues in some tissues. Tissues undergoing cell division are more sensitive to radiation than others. From the point of view of radiation hazard, cells can be classified into two groups: a) Somatic Cells, b) Germ Cells.

Germ cells are the ones involved in reproductive process. They are sperms in the male and eggs in the female, All other cells in the bodies are ‘somatic cells’.

Biological Effects Of Radiation

When radiation passes through body, it transfers some of its energy to the cells in the form of ionizations and excitations, which in turn lead to a number of chemical changes. Generally, these chemical changes are harmful to the cells. Depending upon the seriousness of the harm, a cell either dies or gets modified. All the biological effects of radiation arise from these two effects on cell - cells Death or Cell modification.

Radiation can cause breaks in chromosomes. Majority of these breaks get repaired, but certain breaks may lead to loss or rearrangement of genetic material which can be seen under a microscope. Such events are called chromosome aberrations.

Biological effects of radiation are classified into two groups, depending upon the type of cells damaged. They are somatic effects and hereditary effects. As the name itself suggests, somatic effects arise from damage to somatic cells and they occur in the tissues of the exposed person (e.g., effects on skin, blood, lung bone, thyroid, etc.) Hereditary effects arise from damage caused to the germ cells and occur in the progeny of the irradiated person. Somatic effects can be further divided into early and late effects.

Early Somatic Effects

Whenever the body is exposes to radiation, some cells are killed and some are modified. At low doses, since only a few cells are killed, the body can cope up with the loss and hence no immediate effects are seen. However, as dose increases, more and more cells get killed and this results in radiation sickness, nausea (feeling like vomiting), vomiting, fatigue, etc., within a few hours or irradiation. However, these effects are transient and disappear after a few hours. As dose increase further, the effects appear quicker, are more server and last longer. At sufficiently high doses, the damage caused to important organs such as blood forming organs intestine, etc. is so severe, and the patient will not be able to recover. Anemia, infection and high fever would occur, leading to death. Fifty percent of the persons exposed to a dose in range of 3-5 Gy; die within a period of 60 days. This is known as “LD50/60”.At still higher doses, death occurs earlier. Instead of the whole body, if only a part of the body exposed the, damage the confined to the exposed part. Depending upon the part of the body exposed, different local effects at different doses are produced Skin is the most frequently exposed organ. Doses less than 5 Gy can cause only a transient (temporary) Erythema which lasts for 1-2 days.

Higher doses of the order of 10 Gy can cause depilation, fixed Erythema and very high doses cause dry or wet desquamation depending upon the severity of loss of epidermal basal cells, within 3-6 weeks (10-25 Gy.) Doses higher than 25 Gy leads to leads to late phase of Erythema during 8-16 weeks, finally leading to necrosis. When large areas of the skin are exposed as in the case of beta radiation burns, death can occur in a manner similar to that by thermal burns. For example, if skin is exposed as in the case of beta radiation burns, death 6 Gy of Z or gamma radiation, reddening of the skin takes place within a few days. This is known as skin in addition to Erythema, hair falls off, leading to epilating. Another sensitive organ is the reproductive organs-testes in male and ovaries in female. Due to death of the germ cells sterilization results. This may be temporary or permanent depending upon the dose. When eyes are exposed, the cells in the lens are killed leading to the opacity of the lens, which is called cataract. Unlike the other effects which appear within a few days of weeks after exposure, cataract formation takes a mean latent period of 2 to 3 years.

In brief, radiation exposure may lead to various types of early somatic effects depending upon whole or only part of the body is exposed. The characteristic of the early somatic effects are:

1. they do not occur below a certain dose (threshold dose),

2. severity of the effect increases with dose and
3. they appear within a short time after exposure (except cataract).

It is generally assumed that the exposure takes place within a short time - minutes to hours (acute exposure). If the doses are protractor (chronic exposure), then the threshold doses will be much higher the effectiveness of radiation decrease due to the recovery process.

The threshold doses for early effects are generally, much higher than doses received by persons during normal working conditions. Hence, when proper working conditions are practiced these early effects of radiation do not occur. However, accidents such as holding sources by bare hands, hiding stolen sources in pockets, etc. leading to serve skin burn and tissue damage have been reported.

Late somatic effects

The most important late somatic effect is cancer. When the irradiated cell is modified rather than killed it may develop into cancer, after a prolonged delay. The delay may very from 5 years (blood cancer) to 30 years or more (lung cancer). Unlike the case of early effects, the probability of cancer resulting from radiation increases with every increment of dose, probably without any threshold. Radiation is not the only agent which induces cancer. A number of chemical agents (such as tobacco and its fumes, as in beedi and cigarette smoke and biological processes can also induce cancer. Compared to these, radiation is a week carcinogen. However cancers induced by radiation are indistinguishable from those induced by other agents.

Heredity Effects

Hereditary effects may result when the irradiated germ cell is modified rather than killed and if it also participates in the reproductive process. under such circumstances, the damage caused to the genetic material in the modified germ cell will be transmitted to the subsequent generations. As in the case of cancer, there is probably no threshold dose for hereditary effects. Even though radiation is found to induce hereditary effects in experimental animals, there is no conclusive evidence of the same in man.

Furthermore, nature incidence of hereditary defects in man is quite high. Mutations in germ cells could lead to a variety of skeletal abnormalities leading to malformations, neonatal cataract and a variety of genetic diseases associated with mental retardation (e.g. Downs Syndrome). Fetus and children are generally known to be more sensitive than adults to all effects of radiation In normal radiation work, it is necessary to ensure that the risk of radiation induced cancer and hereditary defects are kept at acceptable limits.

Operational Limits

Every profession has its own risks and benefits. While radiation can be applied to a number of beneficial purpose, it can produce early and late harmful effects in the exposed persons. Hence, it is necessary to set up safety standards in the use of radiation. The international Commission Radiological Protection (ICRP) sets guidelines in this respects in the form of annual dose limits of individuals. Since the early effects have dose thresholds, they can be easily prevented by setting the dose limits below the threshold.

On the other hand late effects such as cancer and hereditary effects have no threshold, which means that there is no dose below which they can be completely prevented. Hence, in setting up the dose limits, it should be ensured the risk of cancer and hereditary defects do not exceed certain acceptable limits for whole body exposure, as well as for some specific organs. The average effective dose (whole body) should not exceed 20 millisievert per year limited to 30 millisievert for a particular year. Since, it is desirable to keep the risks well below the acceptable limits, the ICRP recommends that the dose limits should be considered as the upper limits and the actual doses received must be kept **As Low As Reasonably Achievable (ALARA).**

TABLE 2 DOSE LIMITS

Dose Limit		
Application	**Occupanational**	**Public**
Effective Dose	20 mSv/year, Average over defined period of 5 years, with not more 100 mSv/five years	1 mSv/year

5. Production Of X-Rays:

X-rays and gamma radiations are similar in nature, biological effects and action on photographic film. Gamma rays are emitted by the nucleus of radioisotope, whereas, X-rays are produced outside the nucleus when high energy electrons interact with atoms (target). When these electrons interact with the field near the nucleus, they are stopped or deflected with lesser energy. The difference in energy between the incident electron and the deflected electron is given out in the form X-rays. The energy of X-rays depends upon the closeness of the electron path to the target nucleus. Hence, X-rays are produced with continuous energy, with a maximum equal to the energy of the incident electrons. X-rays production increases with increase in atomic number of the target atom. It also increases with increase in the incident electron energy. In an X-ray machine, the electrons, emitted by the heated filament, are made to strike a tungsten target placed, at higher voltage, with respect to the filament. As a result of interaction between the electrons and target atoms X-rays are produced.

7. Exposure preparations :

Radiation source / energy : is selected based on test material absorption, thickness to be examined and type of the film. Optimum contrast with minimum 2% recording sensitivity are the requirements.

Visual examination : Visually detected surface imperfections which will produce images on the radiograph shall be rectified before shooting.

Segment marking : The weld length is divided into suitable number of segments A –B / 0 –1 etc and marked such that the marks remain on the object till the weld is accepted. Identical segment marking is necessary on the source side and the film side of the object for accurately positioning the film and other accessories around the weld.

Film Size : shall be at least 2” more than the length of the segment to be examined. Width shall be sufficient to record the weld, all markers and the complete pentameter outline.

SFD : Minimum SFD is to be calculated using the SFD equation. Thumb rule, 10 times the object thickness and 1.1 X length of the film, which is greater. Recommended minimum SFD is

15”.

Location Markers : shall be placed on the marks near the weld, in sequence 1, 2, 3 / A, B, C etc on the source side of the object, unless a predetermined overlapping length between successive films is used.

Identification Markers : as required, shall appear in each film, placed near the weld.

Pentameter : 2 % of the thickness being examined. Can also be selected from the table of the applicable specifications / procedures. Weld reinforcement to be included in pentameter selection. Pentameter must be attached to the source side of the object.

Wire type : to be fixed near the location marker and across the weld, the thinnest wire in the set towards the location marker.

Hole type : to be fixed near the location marker, 3.2 mm away and parallel to the weld, 2T hole towards the location marker.

Shim : used to simulate the weld reinforcements, to be placed under the hole type pentameter only, thickness of the shim should be nearly equal to the total weld reinforcement. Shim may be single or staked thin sheets and must be larger than the size of the pentameter.

Set up : Location markers are fixed on the source side marks and radiograph identification markers are fixed near the weld using adhesive tapes. The applicable pentameter is fixed on the source side and near a location marker also with tapes. The film is then attached in close contact with the surface, opposite to the source side using magnets or adhesive tapes.

Using a magnetic supporting stand, the exposure point of the source guide tube is secured exactly at the central axis of the segment under examination and at a distance equal to the SFD. The object should be positioned such that the recording plane of the film is perpendicular to the imaging radiation beam. The film is then irradiated through the object for the required exposure time.

Panoramic exposures : This is also a single wall technique used for hollow circular components where the inside of the bore is accessible for centering the source point. Circumferential weld joints in pipes and pressure vessels are frequently examined using this technique. The entire joint is recorded in a single exposure. A roll film or a number of films are used with 1” overlap between successive films. Location markers are fixed at regular intervals. Identification markers are fixed as required. Minimum three pentameters must be attached at 120^0 to each other.

“Testing is a plan whivh when done repeatedly gives new or old results, we call it testing ” Dr.Hardev

Strict Control of exposure parameters is absolutely necessary.

Calculating SFD:

$$SFD = \frac{\text{Source size X thickness}}{\text{allowed unsharpness}} + \text{thickness}$$

Selecting 2 % IQI :

Wire dia = part thickness / 50

Strip thk = part thk in inches X 20

part thk in mm X 0.8 or Table

International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

ASTM wire diameter in Inches :

Set A	Set B	Set C	Set D
1- .0032	6 - .010	11 - .032	16 - .100
2 - .004	7 - .013	12 - .040	17 - .126
3 - .005	8 - .016	13 - .050	18 - .160
4 - .0063	9 - .020	14 - .063	19 - .200
5 - .008	10 - .025	15 - .080	20 - .250
6 - .010	11 - .032	16 - .100	21 - .320

DIN penetrameter set:

1ISO - 7	6ISO - 12	10ISO - 16
3.2	1.0	0.4
2.64	0.8	0.32
2.0	0.66	0.25
1.6	0.5	0.2
1.32	0.4	0.165
1.0	0.32	0.15
0.8	0.25	0.1 mm

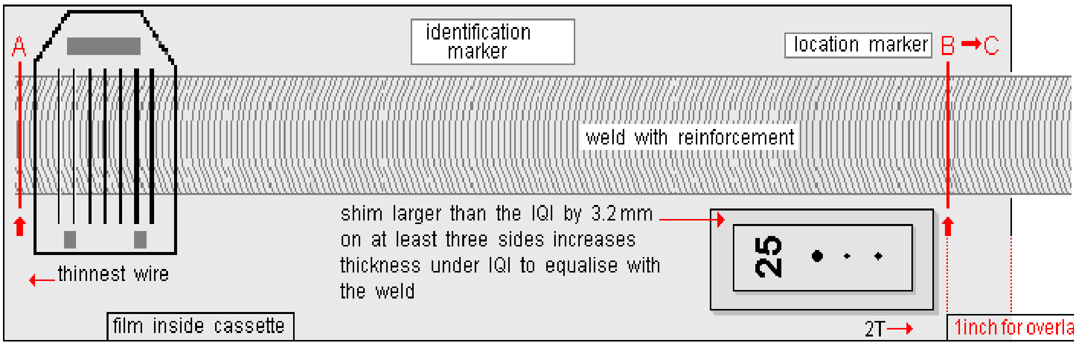
Exposure time in minutes, SFD in CM :

$$t = \frac{\text{Film Factor} \times 2^{\text{thkns / HVT}} \times \text{SFD}^2 \times 60}{\text{Curie} \times \text{RHM} \times 100^2}$$

or Exposure chart from the manufacturer.

“Technique is a simple and clear way to do any work in less time and achieve good skill ’’ Dr. Hardev

“Technology is the process by which humans make problems easy and simple to solve and provide a new direction by using solutions. ” Dr.Hardev



A further alternative often proposed is to restrict radiography to the night shift. When there is a large amount of radiography to be done this may be the only way to achieve it without disrupting the work schedule, but that is another issue. While this can help with safety caution is still necessary. Even when the plant is said to have been vacated the responsibility to assure that it is in fact vacated is unchanged. Even when others have gone there still may be some work continuing by plant inspectors and engineers or even people hiding and asleep! The urgency may be reduced compared to a lunch time shot, but the need for assurance is not. There are fewer people available to assist, and those who are on site at the end of a late shift may not be in a co-operative frame of mind. At this refinery we have a procedure that clearly delegates prime responsibility for safety to the job supervisor. There was significant resistance to the concept at first, but this was based on poor appreciation of the practicality of leaving it to the radiographer. Where the job supervisor is a contractor the response is mixed. However if all sites had the same requirement (or, to put it another way, responded to their obligations in this regard under the workplace health and safety legislation or equivalent) it should quickly become just a part of the job. It is recommended that the code be amended by including a reference to the over-riding responsibility of the owner in assuring that the work is conducted safely.

8.0 Conclusions:

The focus on safety issues in the public eye, the press and legislation is ever increasing, and the potential consequences of even a minor incident involving radiation are rising proportionally. The incidents that have occurred on our site strongly suggest that similar un-reported incidents have occurred elsewhere. Changes in attitude and action are needed. Radiographic testing involves the use of ionizing radiation, which can be harmful if not properly managed. Therefore, **several safety measures are necessary to protect workers and the environment**. Shielding: Barriers made of lead or other dense materials are used to absorb radiation and protect nearby areas. It is not suggested that what has been proposed above is the only possible solution. The essential points are for the management of sites where radiography is performed: To be clear as to where responsibility lies; to ensure those responsible have understood and accepted the responsibility; to ensure those responsible have the resources (including information) needed and are in a position to achieve what is expected.
The situation with the gamma camera lock (section 3) is, in my view, that the gamma camera lock must be installed on the delivery port instead of the control port.

9.0 SUMMARY”

1) Beta radiations can be absorbed completely. But X and gamma radiations cannot be absorbed completely.

2) Interactions of X and gamma radiations, in any material, are similar.

3) X and gamma radiations undergo three types of interactions in any materials: Photoelectric effect, Compton effect and Pair production.

4) For energies of interest in industrial radiography, only photoelectric effect and Compton interactions are important.

5) PHOTOELECTRIC EFFECT is important at low energies. It decreases as energy of radiation increases. It increases as atomic number of the absorbing material increases.

6) COMPTON EFFECT is important at low energies. It decreases with energy. It does not very with the atomic number of the absorbing material.

7) IONIZATION is a process, in which electrons are knocked off (removed) from an atom.

8) EXCITATION is a process, in which electrons are raised from an inner orbit to an outer orbit.

9) Alpha, beta and gamma radiations can cause ionization or excitation. Hence, these radiations are called IONIZING RADIATIONS.

10) Higher atomic number material, like lead, uranium, absorb X and gamma radiations better than lower atomic number material, like plastic, aluminum

11) HALF VALUE THICKNESS (HVT) of any material reduces the radiation intensity at a place of half of the original intensity.

12) TENTH VALUE THICKNESS (TVT) of any material reduces the radiation intensity at a place to one tenth of the original intensity.

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