Principle: Interaction of a ray with matter, Imaging, Film and Film processing, Techniques, Types, Area, Penetration, Density, Speed, Characteristic, Exposure, Radiographic, Characteristic Curve, Density, Contrast, Equivalence, Exposure Chart, Radiographic, Radiography, Computed Radiography, Fluoroscopy.
Radiography is used in a very wide range of applications including medicine, engineering, forensics, security etc.

NDT radiography is one of the most important and widely used methods.

It offers a number of advantages over other NDT methods, however, one of its major disadvantages is the health risk associated with ionisation.
In Radiographic Testing, the part to be inspected is placed between the radiation source and a piece of radiation sensitive film.

The radiation source is from either be an X-ray machine or a radioactive source.

This variation in the image darkness can be used to determine thickness of composition of material and would also reveal the presence of any flaws or discontinuities inside the material.

The film darkness will vary with the amount of radiation reaching the film through the test object where dense areas indicate more exposure and areas which indicate less exposure.
Both surface and internal discontinuities can be detected. 

Significant variation in conductivity can be detected.

It has "a very few" limitations.

Very minimal or no part preparation is required.

Permanent test record is obtained.

Good portability especially dry gamma - ray source.
High degree of skill and experience is required for accurate interpretation.

The equipment is relatively expensive.

The process is generally slow.

Highly directional.

Depth of discontinuity is not indicated.

It requires two-sided access to be component.

So, RT is very essential.

For all non-ferrous, so, it is very good.
Nature of Penetrating Radiation

Both X-rays and gamma rays are electromagnetic waves and are on the electromagnetic spectrum. They occupy frequency ranges that are higher than ultraviolet radiation.

In terms of frequency, gamma rays generally have higher frequencies than X-rays as seen.

Electromagnetic radiation acts somewhat like a particle at times in that they occur as small “packets” of energy and are referred to as photons.

The only difference between the various types of electromagnetic radiation is the amount of energy bound in the photons.
Properties of X-rays and gamma rays:

They are not detected by human senses.

They travel in straight lines at the speed of light.

Their paths cannot be changed by electrical or magnetic fields.

They pass through matter until they have a chance to encounter an atomic particle.

They have enough energy to ionize material and cause damage or destruction to living cells.

The degree of penetration depends on the energy of the matter they are traveled through.
X-rays are just like any other kind of electromagnetic radiation. They can be produced in packets of energy called photons.

There are two different atomic processes that can produce X-ray photons. One is called Bremsstrahlung and the other is called K-shell emission.

Both ways of making X-rays involve a change in the state of electrons. However, Bremsstrahlung is easier to understand. Using the classical idea that radiation is emitted when a high velocity electron hits a target changes...
17. Bremsstrahlung Radiation

2) K-Shell Emission Radiation

Gamma Radiation:

Gamma radiation is one of the three types of natural radioactivity. Gamma rays are electromagnetic radiation just like x-rays.

The two types of natural radioactivity are alpha and beta radiation.

Gamma radiation is the product of radioactive atoms. Depending upon the ratio of neutron to proton within its nucleus, an isotop of a particular element may be stable (Stable). Unstable:

- $\alpha$ - Particle
- $\beta$ - Particle
- $\gamma$ - Ray
Activity of Radioactive Material

The quantity which expresses the potential of a radiation product or radioactive material given amount of radioactivity is called Activity. The amount originally defined as that that of any radioactive material that decays at the same rate as a gram of pure radium.

Isotope Decay Rate:

Each radioactive material decays at its own unique rate, which cannot be altered by any chemical or physical processes. A useful measure of this rate is the half-life of the radioactivity.
\[ I_D = \frac{A_0}{\lambda} (1 - e^{-\lambda t}) \]

\( A_0 \) : Decay Fraction

\( H_0 \) : Half Life Value

\( t \) : elapsed time

\[ t = \frac{H_0}{(\log I_D / \log 0.5)} \]

**Intensity or Exposure**

Radiation intensity is the amount of energy passing through a given area that is perpendicular to the direction of radiation travel in a given unit of time. One way to measure the intensity of X-rays or gamma rays is to measure the amount of ionization it causes in air.
The intensity of the influence at any given distance \( d \) in the same strength divided by the area of a sphere having a radius equal to the distance of \( d \).

\[
I_1 = \frac{I_2}{d_2^2}
\]

\( I_1 \) and \( I_2 \) are Intensities at distance \( d_1 \) and \( d_2 \).

**Half Value Layer**: The thickness of any given material where 50\% of the incident energy has been attenuated is known as the half value layer.

\[ 0.5 = 1.e^{-\mu x} \]
HVL = \frac{0.693}{\mu}

Equipment & materials:

X-ray generators:

The major components of an X-ray generator are the tube, the high voltage generator, the control console, and the cooling system.

As discussed earlier, in this manner X-rays are produced by directing a stream of high-speed electrons at a target material such as tungsten, which has a high atomic number.
Radioactive elements are produced by introducing an extra neutron to atom of the desired material.

As the material gets rid of the neutron, energy is released in the form of gamma rays.

Two of the most common sources for industrial gamma ray sources are industrial radiography and

Strontium - 90
Cobalt - 60.

In comparison cobalt produces

An emulsion comparable to a 1.25 MV x-ray with a Strontium 90 x-ray system and in a 460 kV x-ray system.
Radiotherapy basically consists of an X-ray film. For medical radiography, a gelatin emulsion containing radiation-sensitive silver halide crystals is usually coated on both sides of a flexible, transparent, blue-tinted base in layers about 0.012 mm thick.

An adhesive undercoat fuses the emulsion to the film base and a very thin but tough coating covers the emulsion to protect it against minor abrasion. The typical total thickness of an X-ray film is approximately 0.2 to 3 mm.
Selecting the proper film and developing the optimal radiographic technique for a particular component depend on a number of different factors.

- Composition, shape, and size of the part being examined and its location.
- Relative importance of high density and radiographic detail on the economical result.

Film Packaging:

Film can be purchased in a number of different sizes. Packaging options vary in a variety of sizes.
The most basic part is a

individual shell in a box. In

preparation for use, each shell

must be added into a cassette

or film holder in a darkroom to

protect it from exposure.

Film handling:

X-ray film should be

handled carefully to avoid physical

goodie such as pressure, crinkling

bending, folding etc.

Whenever the film are done,
in semi-sterile holder and

examine. Clamping devices are

used.
Radioisotope Sensitivity
Radioisotope Contrast
Radioisotope Definition

Radioisotope Image Density:

\[ \text{Density} = \log \left( \frac{D_0}{D_t} \right) \]

Secondary Source Control

Secondary or leakage radiation must always be taken into consideration when producing a radiograph. The scattered photon cause a loss of contrast and definition. Often, secondary radiation is fought for or radiation given off by an object in the immediate area.
Radiation Health risk.

Types of radiation involved:
- Size of dose received
- Rate at which it dose is received
- Part of the body exposed.
Controlled Radiation exposure

Time.
Distance.
Shielding.
Exposure Limit.
Radiation大纲.

* Rate measuring Instrument.
* Personal dose rate measuring Instrument.