NET SHAPES
INVESTMENT CASTINGS

NDT

Liquid Penetrant Inspection
Magnetic Particle Inspection
Radiography

- **Penetrant Oil Types**
- Type-I Fluorescent dye
- Type-II Visible dye
- Advantages and Disadvantages

- **Penetrant Oil Methods**

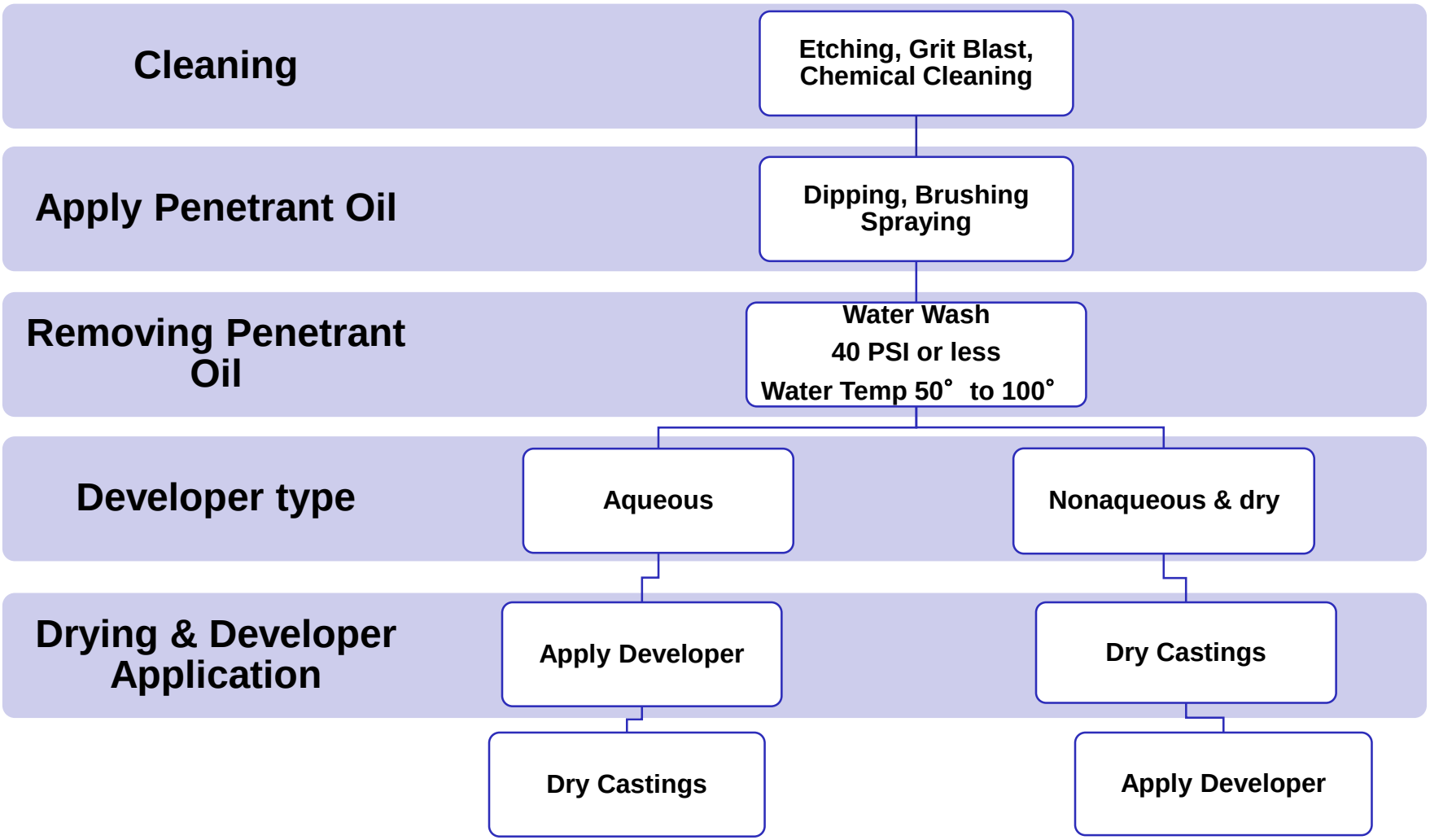
- **Method-A Water Washable**
- **Method-B Post Emulsifiable, Lipophilic**
- **Method-C Solvent Removable**
- **Method-D Post Emulsifiable, Hydrophilic**

- **Penetrant Oil Sensitivity levels**
- Sensitivity Level ½ Very low
- Sensitivity Level 1 Low
- Sensitivity Level 2 Medium
- Sensitivity Level 3 High
- Sensitivity Level 4 Ultrahigh

- **Developers**

- Form a Dry powder
- Form b Water-soluble
- Form c Water-suspendable
- From d Nonaqueous for type I fluorescent
- Form e Nonaqueous for type II visible dye

Liquid Penetrant Inspection



Pre-Cleaning Methods

1. Chemical Cleaning
2. Mechanical cleaning
3. Grit blast
4. Etching

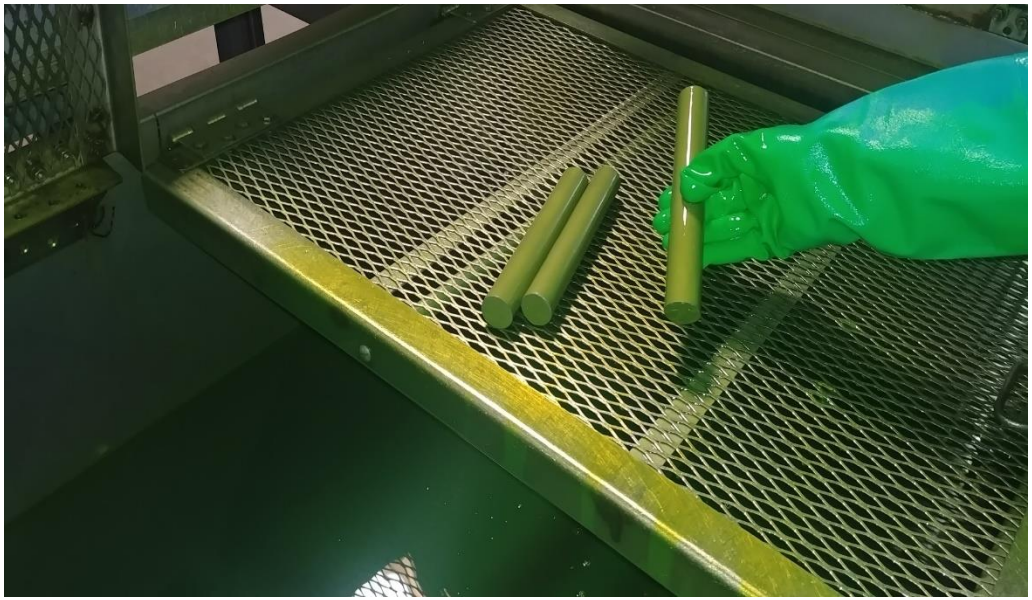
Grit Blasting

Grit blasting without etching may be an acceptable cleaning method if it can be demonstrated that a sufficiently fine abrasive (150 grit or finer) will not cause peening and can be removed by detergent or alkaline cleaner.

How do we prove that grit blasting will not mask any surface indications

Applying Penetrant Oil

1. Spraying
2. Dipping
3. Brushing



Penetrant dwell time

- Dwell time shall be 10 min to 20 min depending on customer requirements.
- Oil temperature shall be in the range of 50° to 125° unless otherwise specified.
- No pooling allowed on the castings.
- If castings are dwelling for more than 2 hours, penetrant oil must be reapplied as required.
- Casting may not be submerged in penetrant oil for more than ½ the required dwell time.

Removing water washable penetrant oil

- Manual spray- Water pressure shall not exceed 40 PSI
- Water temperature shall be between 50° and 100° F
- A coarse spray shall be used at a minimum distance of 12 inch's.
- Caution shall be used to insure casting are not over washed.
- If over washing occurs, all castings shall be dried and reprocessed.
- Over washing is evident if there is no background on the casting surface.

Removing post-emulsifiable penetrant oil

- Apply Emulsifier- Emulsifiers can be applied by immersion or flowing, brushing shall not be used.
- Maximum dwell times unless other wise specified is 3 min. for type 1 and 30 sec. for type 2 penetrant oils.
- Dwell time must be established experimentation.
- Emulsifier dwell time shall be stopped by water spray or immersion.

Applying Developer

- Dry developer
- Casting must be dried in a circulating oven at a maximum temperature of 160°
- Casting should only be dried Intel warm to the touch.
- Casting shall then be placed in a dust chamber and evenly coated on all surfaces.

- Aqueous Developers
- Castings shall be dipped in the aqueous developer and then placed in the dryer.

- Developer dwell times are from 10 to 20 min

Evaluation of penetrant indication

- When sizing indication to the customer acceptance criteria, carefully wipe the indication with a solvent dampened cotton swab or brush.
- Immediately measure the indication using a measuring or comparator.
- If the indication dose not immediately bleed back, reapply developer for the original dwell time prior to reviewing.
- Upon completion of the final inspection post clean casting in accordance's with the customer specifications.

Liquid Penetrant Inspection

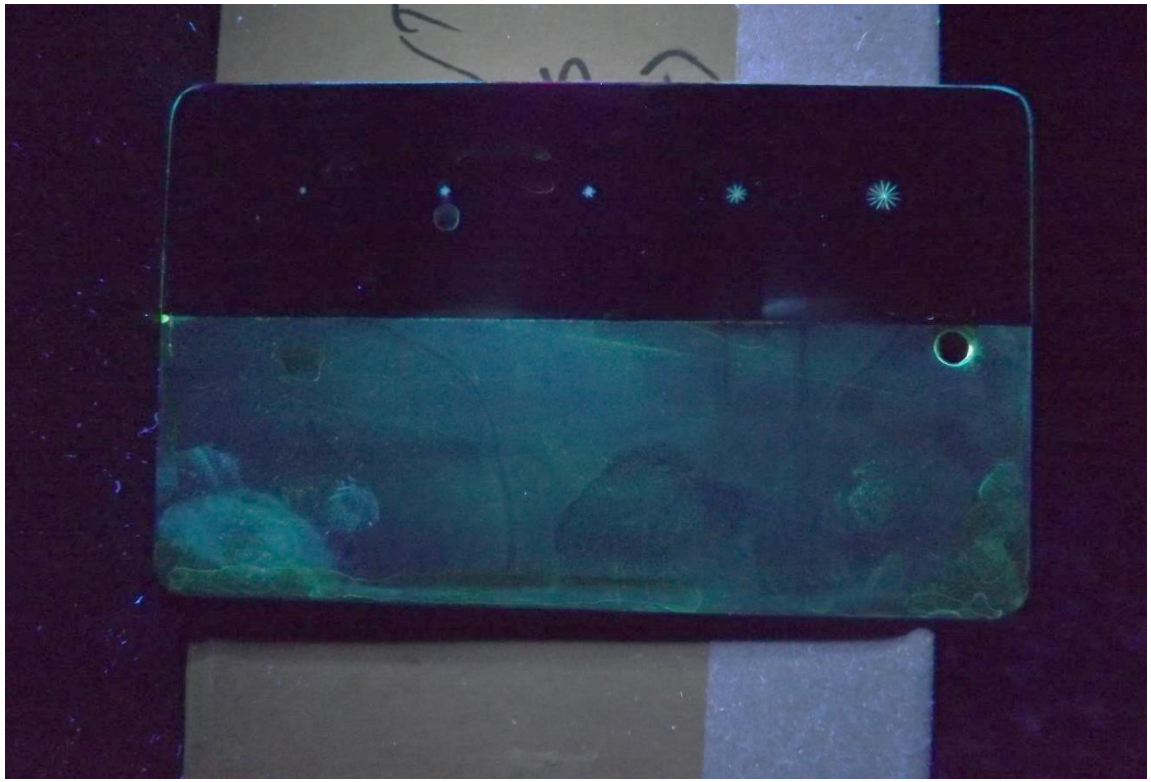
System performance

Penetrant system performance Shall be run daily prior to Processing final castings.

Compare tam panel to photography must have the same amount of stars as the first time the panel was processed.

Panel must be processed quarterly and reviewed for size of indication. Indication can not change more than ± 20%

SHERWIN PSM-5 TAM # 146040-1 S/N 37017



Question on Liquid Penetrant Process

Magnetic Particle Inspection

Advantages of magnetic particle inspection

1. Can find indication on the surface and just below the surface
2. This method is very good at finding surface cracking
3. For in service examination , plating or coatings do not have to be removed

Disadvantages of magnetic particle inspection

1. Can only used on ferromagnetic material
2. Is not very good at detecting indication that are not linear.

Types of magnetization

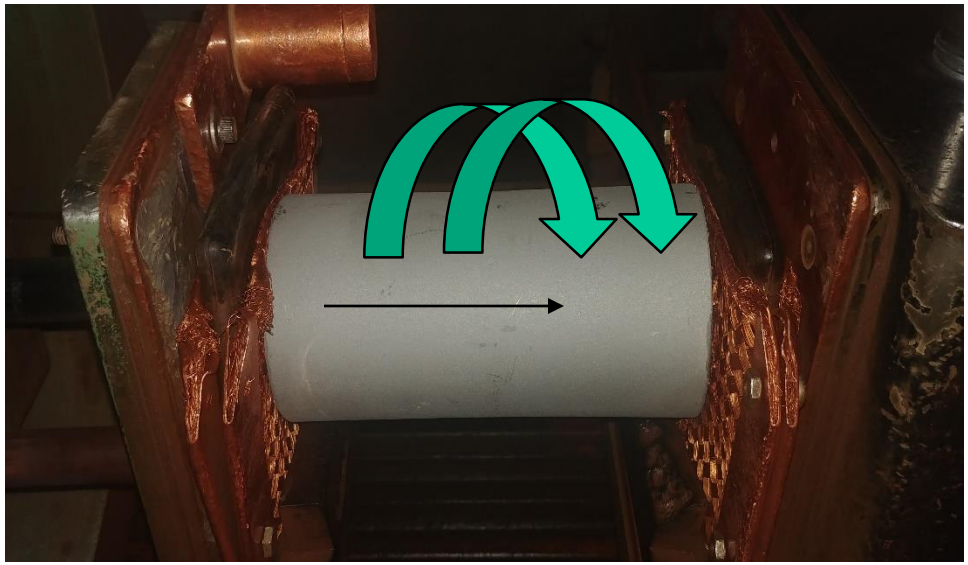
1. Direct Magnetization

Direct magnetization is done by passing current directly thought the casting that is under exanimation.

2. Indirect Magnetization

Indirect magnetization is accomplished by pass current around the casting under exanimation by means of a coil or cable wrap.

Head Shoot



Head shoot is a form of Direct magnetization.

Current is passed thought the Casting causing a circular field around the part.

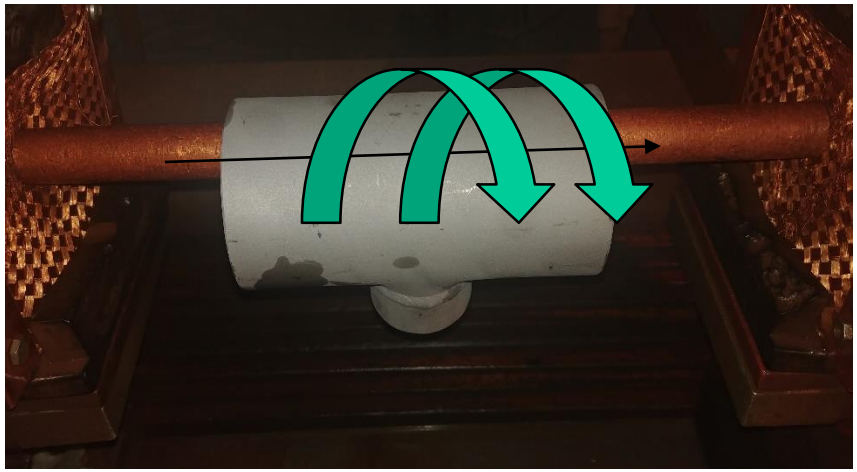
Any indication that are at a 45° to 90° angle of the current will be detected.

Caution must be used to ensure that the curt is not flowing when Contact is being made or removed from the casting being inspected.

This will result in arching the casting.

Magnetic Particle Inspection

Central conductor shoot



Central conductor shoot is a form of In-direct magnetization.

Current is passed thought the central conductor and not thought the casting causing a circular field around the part.

No current is passing thought the casting eliminating the risk of damaging casting.

Central conductors also allows you to get a magnetic field inside the casting.

Magnetic Particle Inspection

Coil Shoot

Coil shoot is a form of In-direct magnetization.

Current is passed around the casting causing a longitudinal field around the part.

Any indication that are at a 45° to 90° angle of the current will be detected.

No current is passing thought the casting eliminating the risk of damaging casting.

The Coil shoot must be the last shoot in your mag technique.

How to check if you have adequate magnetic field.

1.Tangential field strengths 30 gauss or greater measured at the part surface are normally adequate magnetization levels for magnetic examination when using the Hall Effect probe gauss meter.

2. Artificial flaw notched shim (QQI's) shims shall be placed in the area(s) of interest with the flaw side toward the surface of the part to be examined.

Magnetizing current of approximately 300-800 amps per inch of cross-sectional area

Magnetic Particle Inspection

De-magnetization of the casting

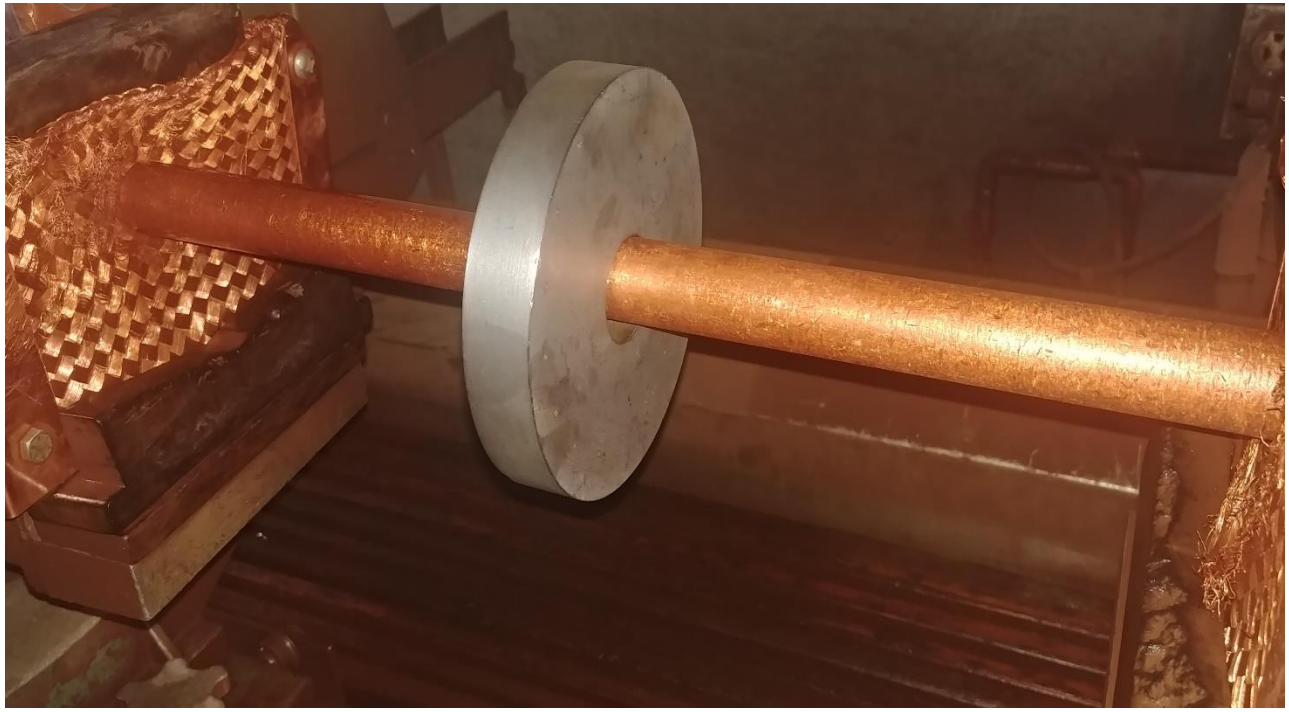
De-magnetization of the casting is done by pass the casting thought a energized coil using alternating current.

All castings shall be de-magnetized after final inspection. The max residual magnetization shall be less than 3 gauss.

Reasons casting must be de-magnetized.

1. **Can effect assembly castings are installed in.**
2. **Will effect welding of the casting.**
3. **Will collect chips during the machining process.**

Ketos and Tool Steel Ring



Required to be proceed daily to check sensitivity on the mag unit.

Must have the original certification and the heat treat certification.

Magnetic Particle Inspection

Ketos and Tool Steel Ring processing requirements

AS 5282 Steel Ring		Ketos 01 Tool Steel Ring	
Not to exceed amperage. May be less. FWDC Amperage	Minimum Number of Holes Indicated	Not to exceed amperage. May be less. FWDC Amperage	Minimum Number of Holes Indicated
500	3	1400	3
1000	5	2500	5
1500	6	3400	6
2500	7		
3500	9		

Must see the same amount of holes every test.

Magnetic Particle Inspection

Wet Suspension Concentration

Check every 8 hours, at shift change, or when used.

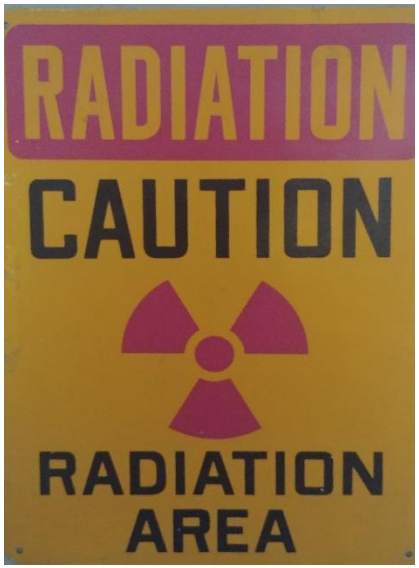
Agitate the particle suspension a minimum of 30 minutes to ensure uniform distribution of particles throughout the bath.

Demagnetize the sample and place in a vibration free area and allow to settle for at least 60 minutes

0.1 - 0.4 ml in a 100 ml bath sample

Questions on Magnetic Particle Inspection

What is Radiation



X-rays and Gamma rays are in a family of waves that are called electromagnetic waves. Radio waves, infrared light, visible light, X-rays, and Gamma rays are all part of the electromagnetic family.

Wavelength is described as the distance between the pecks of the wave.

These waves can very tremendously in length. Some radio waves are several miles long while X-rays and gamma ray are measured in Angstrom units.

Angstrom unit is equal to .00000001 centimeters.

Main Properties of X-rays & Gamma

X-rays & Gamma rays have the following properties:

1. Invisibility; they cannot be perceived by the senses
2. They travel in straight lines and at the speed of light
3. They cannot be deflected by means of a lens or prism
4. They can pass through matter and are partly absorbed in transmission.
5. They are ionizing, that is, they liberate electrons in matter
6. They can impair or destroy living cells

Gamma rays

Vs.

X-rays

Gamma rays

Advantages

1. Do not need a power source
2. Cost
3. Portable

Disadvantages

1. Can not turn off.
2. Can not adjust penetrating power.
3. Have to calculate half life.

X-rays

Advantages

1. Can adjust the KV and MA
2. When the x-ray unit is turned off it stops producing X-rays
3. Faster with the proper turn table setup.

Disadvantages

1. Requires power source
2. Cost.
3. Requires cooling system

X-ray equipment

1. Have a sources of electrons
2. Have a means to accelerating the electrons
3. Have a target

X-rays are generated when high speed electrons impacts the target and release some of there kinetic energy in a process know as bremsstrahlung (or the braking curve)

The fast the electron is traveling the stronger the resulting X-ray.

Most of this energy is converted in to heat, therefore X-ray unit most be equipped with good cooling systems,

Absorption

1. Photoelectric effect - low energy photons .5 Mev or less

2. Compton effect – medium energy photons .1 to 3.0 Mev

3. Pair production – high energy photons 1.02 Mev and higher

Scatter Radiation

Inherent Unsharpness

Inherent unsharpness is generated by the liberation of free electron when the photon is pass thought the film.

Internal Scatter

Internal scatter happen when the photon are passing thought the casting that is being x-rayed

Side Scatter (under cut)

Side scatter is caused by the photons striking the sides of the x-ray cabinet

Back Scatter

Back scatter is caused by the photons passing thought the film and scatting back from the table or floor.

Geometry and unsharpness

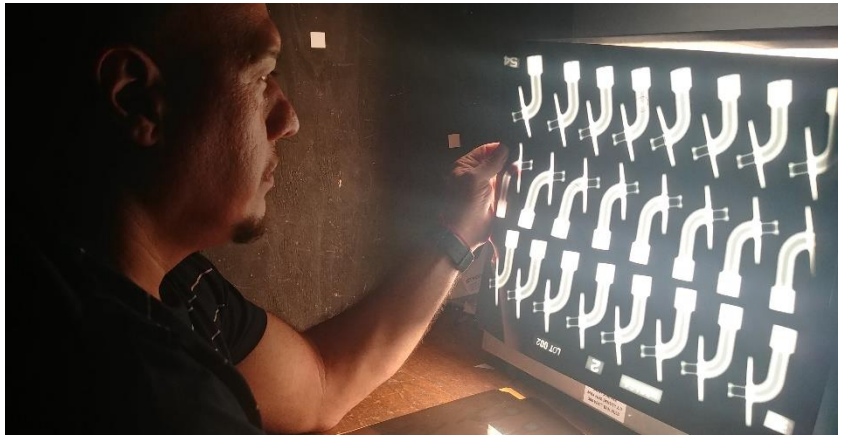
The combination of the radiation source to the top of the object under test distance, the effective focal spot size and the top of the object under test to the film plane shall be such as not exceed the following geometrical unsharpness parameters.

Material thickness up to 2.00”	Maximum U_g = .020”
Material thickness > 2.00” to 4.00”	Maximum U_g = .030”
Material thickness > 4.00”	Maximum U_g = .040”

Methods to reduce geometric unsharpness

1. Increases source to film distance.
2. Reduces focal spot size.
3. Decrease film to casting distance.

Radiography



Reading room conditions

Ambient White Light Intensities

Ambient white light intensities measured at the x-ray film viewing port shall not exceed three (3) foot/candles.

If the interpreter comes in from full sunlight, he or she shall wait at least five (5) minutes for dark adaptation before attempting interpretation.

If the eyes of the interpreter are subjected to the full brightness of the illuminator during changes of radiographs, at least thirty (30) seconds of re-adaptation time shall be necessary.

Reference Radiographs

E 192 Reference radiographs of investment steel castings.

1/8 plate to be used on wall thickness of ¼ of an inch and under

3/8 plate to be used on wall thickness of over ¼ to ½ inch.

3/4 plate to be used on wall thickness of over ½ to 1 inch.

E155 Reference radiographs for Aluminum and magnesium castings

1/4 plate to be used on wall thickness of ½ inch and under.

3/4 Plate to be used on wall thickness over ½ inch to 2 inches.

Training and Certification of NDT personnel

MINIMUM FORMAL HOURS OF TRAINING/LEVEL

Discipline Level	1	2	3
Liquid Penetrant	16	16	32
Magnetic Particle	16	16	32
Radiography	40	40	80

MINIMUM EXPERIENCE REQUIREMENTS

Level	1	2	3
Liquid Penetrant	130 hours	270 hours	4 years
Magnetic Particle	130 hours	400 hours	4 years
Radiography	200 hours	600 hours	4 years

The hours of experience for certification to Level 2 are considered to be in addition to those required for Level 1 certification.

Testing of NDT personnel (NAS 410)

GENERAL EXAMINATION

For all levels of certification the general examination shall consist of a minimum of forty written questions which test the candidate's knowledge of the basic principles and theory

SPECIFIC EXAMINATION

For all levels of certification the specific examination shall consist of a minimum of thirty open book questions which test the candidate's knowledge of the equipment, operating procedures, specifications and test techniques encountered in the specific work assignment.

PRACTICAL EXAMINATION

The practical examination for Level 2 candidates shall demonstrate their proficiency by preparation (set-up), inspection and evaluation of at least 1 test sample per technique and 2 test samples of differing configurations per method.

Candidates for certification shall be required to achieve a score of not less than 70% on the general and specific examinations, and average score of not less than 80% overall.

Questions