

PCN GEN Appendix Z2 Issue 1 rev B dated 14<sup>th</sup> July 2009

## COMPENDIUM OF SPECIMEN EXAMINATION QUESTIONS

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# PRODUCT TECHNOLOGY THEORY

## Composite Materials

**Anaechoic polymers are used for:**

- a) impact resistance
- b) rigidity
- c) acoustic reflectivity
- d) acoustic absorption

**Lack of bond between two layers of carbon fibre is generally termed as:**

- a) lamination
- b) delamination
- c) roving
- d) marcelling

## Castings

**A large cavity at the centre of a cast section is most likely to be:**

- a) a gas hole
- b) a cold shut
- c) shrinkage
- d) hot tear

**Large smooth voids or porosity in a casting results from:**

- a) turbulent flow of metal during pouring
- b) segregation of alloy constituents
- c) gas evolved before and during solidification
- d) hot tearing in the thick sections of the casting

**Discontinuities which originate in the cast ingot can often be reduced by a process which closes and welds the voids, as well as breaking up inclusions, this process is:**

- a) machining
- b) welding
- c) forging
- d) cold extrusion

**A uniform rounded cavity in a cast section is most likely to be:**

- a) a gas hole
- b) a cold shut
- c) shrinkage
- d) hot tear

**A casting discontinuity which is caused by gas release or the evaporation of moisture during solidification is:**

- a) microshrinkage
- b) porosity
- c) porous segregation
- d) hydrogen induced porosity

## **Wrought Products**

**Pipelines carrying fluids containing sand and mineral particles are susceptible to:**

- a) cavitation
- b) weld root erosion
- c) stress corrosion cracking
- d) hydrogen embrittlement

**Poor forging temperature or too great a reduction in section can give rise to rupturing of the material, this is called a:**

- a) lap
- b) seam
- c) burst
- d) inclusion

**The failure of turbine blades at the junction of the blade and larger section where it will be attached to the rotor can often be ascribed to cyclical stresses which are concentrated in this region. The failure mechanism is called:**

- a) stress rupture
- b) intergranular fretting corrosion
- c) fatigue
- d) hot tearing

**Discontinuities which originate in the cast ingot can often be reduced by a process which closes and welds the voids, as well as breaking up inclusions, this process is:**

- a) machining
- b) welding
- c) forging
- d) cold extrusion

**An example of a wrought product could be:**

- a) a casting
- b) a forged section
- c) a weld
- d) none of those listed above

**In open die forging the top and bottom dies are called, respectively, the:**

- a) tup and anvil
- b) cope and drag
- c) head and foot
- d) hammer and anvil

## **Welds**

**A lack of fusion defect orientated perpendicular to the test surface is most likely to occur in which of the following processes?**

- a) electroslag welding
- b) TIG welding
- c) MIG/MAG welding
- d) oxy-acetylene welding

**Which of the following is a weld defect?**

- a) porosity
- b) hot tear
- c) lamination
- d) burst

**Gross worm hole porosity which breaks the surface of a submerged arc weld is most likely caused by:**

- a) damp flux
- b) poor current connection
- c) work oxide films
- d) variation in joint fit-up

**Which of the following will not be found in a TIG welded joint?**

- a) porosity
- b) slag
- c) crater cracking
- d) incomplete penetration

**Hydrogen cracking, due to the break down of water molecules creating hydrogen which dissolves in the weld metal and HAZ, is most likely to occur in which of the following welding processes?**

- a) TIG
- b) MIG
- c) sub-arc
- d) MMA

**The welding process which would be chosen for its rapid deposition rates, high welding speeds and deep penetration quality joints is:**

- a) electroslag
- b) manual metal arc
- c) submerged arc
- d) TIG

**A common cause of solidification cracking in welds made with high deposition rate processes is:**

- a) hydrogen entrapment
- b) contaminated flux or shielding gas
- c) weld preparation has an unsatisfactory depth to width ratio
- d) operator error

**Slag inclusions are a common weld defect. Such defects will not be found in:**

- a) MMA welds
- b) TIG welds
- c) submerged arc welds
- d) cored wire MIG/MAG welds

**The heat treatment process which is employed to give a soft ductile product, by recrystallisation of the material, is termed:**

- a) tempering
- b) hardening

- c) stress relieving
- d) annealing

**Poor through thickness ductility in rolled plate, often associated with non-metallic inclusions, gives rise to:**

- a) lamellar tearing
- b) reheat cracking
- c) uniform porosity
- d) hydrogen cracking

## **Solid Railway Axles**

**Longitudinal defects on the surface which are less than 0.5mm deep may be removed by polishing in a longitudinal direction. The maximum number of defects which can be removed during rectification is:**

- a) two
- b) five
- c) eight
- d) ten

**Axles are made from steel and are produced by:**

- a) an electric process
- b) a basic oxygen process
- c) both A and B above
- d) the Bessemer process

**Discontinuities which originate in the cast ingot can often be reduced by a process which closes and welds the voids, as well as breaking up inclusions, this process is:**

- a) machining
- b) welding
- c) forging
- d) cold extrusion

**Forging of axles is not done at temperatures above:**

- a) 1260 degrees Celsius
- b) 1500 degrees Celsius
- c) 1750 degrees Celsius
- d) 2000 degrees Celsius

**The minimum height of scroll or block stamps on axle ends shall be:**

- a) 4mm
- b) 6mm
- c) 8mm
- d) 10mm

## **Running Rail**

**Rails are made from steel and are produced by:**

- a) forging
- b) extrusion

- c) pultrusion
- d) rolling

**The height of the branding marks on the web of a rail must be at least:**

- a) 5mm
- b) 10mm
- c) 15mm
- d) 20mm

**What, during the manufacture of rail, forms the nucleus of a tache ovale?**

- a) water entrapment
- b) hydrogen flakes
- c) shatter cracks
- d) stress

## **LEVEL 3 KNOWLEDGE OF THE REQUIREMENTS FOR PCN CERTIFICATION**

**The minimum additional period of experience required for the holder of a PCN level 1 eddy current testing certificate to be eligible for the level 2 eddy current testing examination is:**

- a) 3 months
- b) 12 months
- c) 9 months
- d) 6 months

**Candidates who fail to achieve 70% in one section of the initial examination but who achieve a composite grade of 80% or more are eligible for:**

- a) one retest of the failed part
- b) two retests of the failed part
- c) one retest of any two parts selected by the test centre
- d) one retest of any two parts selected by the candidate

**PCN candidates shall have near distance acuity, corrected or uncorrected, in at least one eye, such that the candidate is capable of reading:**

- a) Jaeger number 1 letters at not less than 30 cm
- b) Jaeger number 1 letters at not more than 30 cm
- c) Jaeger number 1 letters at 300mm
- d) Jaeger number 1 letters at 30cm

**To ensure continuity, it is recommended that the application for renewal of level 2 PCN certification should be submitted:**

- a) six months prior to expiry
- b) between eight and four months prior to expiry
- c) at least 56 days prior to expiry
- d) on the expiry date



# ALTERNATING CURRENT FIELD MEASUREMENT (ACFM)

## Level 1 General Theory of the ACFM Method

The reactive inductance of a coil is measured in:

- a) volts
- b) OHMS
- c) MHOS
- d) Henrys

Conductivity of a material is affected by:

- a) the air gap between probe and specimen
- b) its chemical composition
- c) equipment sensitivity settings
- d) all of the above

The opposition to flow of AC is called:

- a) reluctance
- b) inductance
- c) impedance
- d) resistance

Which of the following test frequencies would produce eddy currents with the deepest penetration?

- a) 200 Hz
- b) 1 MHz
- c) 10 kHz
- d) 50 kHz

## Level 1 Sector Specific Theory of ACFM Testing of Welds

Variations in probe speed:

- a) have no deleterious effect on results
- b) will cause changes in signal amplitude
- c) may result in incorrect defect assessment
- d) both B and C

Which three items of information are required for off-line sizing of a defect?

- a) i, ii, vi
- b) i, iv, vi
- c) ii, iii, v
- d) iii, v, vi

Where:

- i) = measured length between markers
- ii) = page number
- iii) = probe direction
- iv) = probe file
- v) = clock position
- vi) = coating thickness

**What is the standard operating frequency of the ACFM equipment?**

- a) 5 kHz
- b) 5 MHz
- c) 5 Hz
- d) none of the above

## **Level 2 General Theory of the ACFM Method**

**When the applied voltage and current through a circuit are in phase the:**

- a) current leads voltage by 90 degrees
- b) current and voltage have the same value
- c) voltage leads current by 90 degrees
- d) none of the above

**The term used to define the value of H field required to decrease the residual magnetism in a material to zero is:**

- a) coercive force
- b) magnetising force
- c) back emf
- d) the overlap value

**When the voltage applied to a circuit and the current through the circuit both reach their maximums at the same time the voltage and current are:**

- a) additive
- b) in phase
- c) regenerate
- d) out of phase

## **Level 2 Specific Theory of the ACFM Testing of Welds**

**Which of the following conditions is the most important when selecting reference standard specimens?**

- a) the specimen should be the same size and shape as the component under test
- b) the surface finish and material specification should conform to the component under test
- c) the backwall of the specimen should be at least 50 mm in depth
- d) none of the above

**By using smaller sensing coils you would expect:**

- a) no measurable difference
- b) larger signals
- c) improved discrimination of defect features
- d) less access capabilities

**When a semi elliptical crack is in an applied uniform AC magnetic field parallel to its surface length, what is the magnitude of the magnetic field at the crack centre in the same relative to uniform field on the surface?**

- a) less than the uniform field
- b) greater than the uniform field
- c) the same as the uniform field
- d) zero

**Which of the following normally has no effect on crack depth sizing when using the ACFM technique?**

- a) crack angle to the surface
- b) multiple cracking
- c) geometry signals
- d) material changes

**Which one of the following normally has no effect on crack sizing accuracy using ACFM?**

- a) coating thickness (non conducting)
- b) line contacts (cracking bridging)
- c) multiple cracking
- d) crack aspect ratio >2:1

**An upwards movement in the butterfly plot trace will show:**

- a) no movement in the Bx trace
- b) downward movement in the Bx trace
- c) movement to the right on the Bx trace
- d) upwards movement by the Bx trace

### **Level 3 General Theory of the ACFM Method**

**Commercial eddy current equipment may be designed to detect changes in:**

- a) specific gravity
- b) sub-surface cavities
- c) grain direction
- d) electrical conductivity

**When a non-ferrous material is passed through two comparative encircling coils a false defect free indication can arise when the defect is:**

- a) filled with water
- b) deep but very narrow
- c) long and uniform
- d) short and wide

**Impedance of an AC system used for eddy current testing is a combination of:**

- a) inductive reactance, resistance and capacitive reactance
- b) inductive reactance and capacitive reactance only
- c) resistance and capacitive reactance only
- d) frequency and phase

**The effect of lift-off on the impedance of a test coil is used principally when designing:**

- a) crack detectors
- b) coating thickness meters
- c) conductivity meters
- d) ACPD crack depth instruments

## **Level 3 Specific Theory of the Application of the ACFM Method in the Testing of Welds**

No examples are presently available. Multiple choice answer questions will be derived from the same syllabus as those for level 2, but will generally be more complex.

## **EDDY CURRENT TESTING**

### **Level 1 General Theory of the Eddy Current Method**

**The depth of eddy current penetration is dependent on:**

- a) shape of probe being used
- b) area of the item under inspection
- c) thickness of the item under inspection
- d) test frequency

**The reactive inductance of a coil is measured in:**

- a) volts
- b) OHMS
- c) MHOS
- d) Henrys

**Conductivity of a material is affected by:**

- a) the couplant used between probe and specimen
- b) its chemical composition
- c) equipment sensitivity settings
- d) all of the above

**The opposition to flow of AC is called:**

- a) reluctance
- b) inductance
- c) impedance
- d) resistance

### **Level 1 Sector Specific Theory of the Application of the Eddy Current Method in the Testing of Wrought Products & Welds**

**To lessen the effects of the proximity of a material of different permeability:**

- a) a couplant should be used
- b) wrap a layer of masking tape around probe coil
- c) use a shielded probe
- d) reduce the sensitivity until no indication is obtained from dissimilar material

**To carry out in-service inspection of a painted surface:**

- a) the paint must be removed
- b) ensure paint is in good condition and make allowance for lift-off
- c) only high frequency probes can be used with lift-off compensation
- d) only low frequency ring probes are suitable

**Variations in probe speed:**

- a) have no deleterious effect on results
- b) will cause changes in signal amplitude
- c) may result in incorrect defect assessment
- d) both B and C

**A high frequency pencil probe will only locate defects which:**

- a) have measurable depth
- b) are surface breaking
- c) in materials of a very high permeability
- d) are close to changes of geometry

**Level 2 General Theory of the Eddy Current Method**

**When the applied voltage and current through a circuit are in phase the:**

- a) current leads voltage by 90 degrees
- b) current and voltage have the same value
- c) voltage leads current by 90 degrees
- d) none of the above

**In eddy current test systems where encircling coils are used, coupling efficiency is referred to as:**

- a) lift-off
- b) edge factor
- c) fill factor
- d) phase differentiation

**The term used to define the value of H field required to decrease the residual magnetism in a material to zero is:**

- a) coercive force
- b) magnetising force
- c) back emf
- d) the overlap value

**When the voltage applied to a circuit and the current through the circuit both reach their maximums at the same time the voltage and current are:**

- a) additive
- b) in phase
- c) regenerate
- d) out of phase

**Level 2 Sector Specific Theory of the Application of the Eddy Current Method in the Testing of Wrought Products & Welds**

**Which of the following conditions are not important when selecting specimens to be used as a reference standard?**

- a) the specimen should be the same size and shape as the piece to be tested
- b) the specimen should have the same heat treatment as the piece to be inspected
- c) the surface finish of the specimen should be the same as the piece to be tested
- d) If the material is aluminium the surface should be anodised

**One main advantage of CRT displays over meter reading equipment is that:**

- a) it can be pocket size
- b) it allows separation of many test variables
- c) it is simple to use
- d) test variables cannot be separated

**It is possible to use phase analysis equipment for:**

- a) the location of internal or external flaws
- b) location of internal defects only
- c) location of support plates
- d) both A and C are impossible

**The impedance of an AC system used for eddy current testing is a combination of:**

- a) inductive reactance, resistance and capacitive reactance
- b) inductive reactance and capacitive reactance only
- c) resistance and capacitive reactance only
- d) none of the above

### **Level 3 General Theory of the Eddy Current Method**

**Commercial eddy current equipment may be designed to detect changes in:**

- a) specific gravity
- b) sub-surface cavities
- c) grain direction
- d) electrical conductivity

**When a non-ferrous bar is passed through two comparative encircling coils a false defect free indication can arise when the defect is:**

- a) filled with water
- b) deep but very narrow
- c) long and uniform
- d) short and wide

**Impedance of an AC system used for eddy current testing is a combination of:**

- a) inductive reactance, resistance and capacitive reactance
- b) inductive reactance and capacitive reactance only
- c) resistance and capacitive reactance only
- d) frequency and phase

**The effect of lift-off on the impedance of a test coil is used principally when designing:**

- a) crack detectors
- b) coating thickness meters
- c) conductivity meters
- d) AC crack depth instruments

## **Level 3 Sector Specific Theory of the Application of the Eddy Current Method in the Testing of Wrought Products**

**During testing the secondary magnetic field developed by the eddy currents:**

- a) totally cancels the coils magnetic field
- b) totally reinforces the coils magnetic field
- c) partially reinforces the coils magnetic field
- d) partially cancels the coils magnetic field

**The impedance of a test coil can usually be represented by the vector sum of:**

- a) inductive reactance and resistance
- b) capacitive reactance and resistance
- c) inductive reactance and capacitive reactance
- d) inductance and capacitance

**The inductive reactance of a test coil depends upon which of the following?**

- a) frequency, coil inductance, coil resistance
- b) coil inductance
- c) coil resistance and inductance
- d) frequency and coil inductance

## **LIQUID PENETRANT TESTING**

### **Level 1 General Theory of the Liquid Penetrant Method**

**Which of the following would assist the penetrant to enter sub-surface cracks in a component?**

- a) the materials surface finish
- b) the penetrant viscosity
- c) the inherent surface tension
- d) none of the above

**The only discontinuities which penetrant testing can detect are:**

- a) sub-surface
- b) surface breaking
- c) internal
- d) contaminant filled

**The term used to define the period of time that a developer has been applied is:**

- a) attraction time
- b) development time
- c) dwell time
- d) drain time

## **Level 1 Sector Specific Theory of the Application of the Liquid Penetrant Method to General Engineering Products**

**Consumables of a toxic nature may:**

- a) not be used at any time
- b) be used on site work only
- c) be used in accordance with the manufacturer's instructions
- d) be used in small amounts

**All surfaces to be examined using penetrant flaw detection should be initially:**

- a) welded
- b) painted
- c) clean
- d) sandblasted

## **Level 2 General Theory of the Liquid Penetrant Method**

**The property of a liquid which affects the speed of flow is:**

- a) surface tension
- b) viscosity
- c) contact angle
- d) a combination of all the above

**The corrosivity of a liquid penetrant is usually assessed by:**

- a) actual component testing
- b) the manufacturer of the penetrant
- c) samples of material left in contact for 24 hours and examined
- d) samples of material left in contact for 16 hours and examined

**Water washable penetrants require longer dwell times than solvent removable versions because of the presence of:**

- a) emulsifier
- b) stabiliser
- c) penetrant remover
- d) contaminants

## **Level 2 Sector Specific Theory of the Application of the Liquid Penetrant Method to General Engineering Products**

**If fluorescent penetrant is applied after an acid precleaning treatment:**

- a) the penetrant should dwell for twice the time specified
- b) marking of the test piece may be evident
- c) a decrease in brilliance of the penetrant may occur
- d) an increase in brilliance of the penetrant may occur

**The best preparation of Rusty surfaces for penetrant inspection is:**

- a) shot blasting
- b) grinding
- c) wire brushing



- d) pickling

**The British Standard to be referred to for penetrant flaw detection is:**

- a) BS 6072
- b) BS 4069
- c) BS 4489
- d) BS EN 571-1

**To avoid the risk of fire, penetrants in cans should:**

- a) be stored away from direct sunlight
- b) not be sprayed near or onto hot components
- c) be kept away from incandescent surfaces
- d) be handled so as to avoid all of the above situations

### **Level 3 General Theory of the Liquid Penetrant Method**

**Colour contrast penetrants are best viewed in:**

- a) a minimum of 500 lux white light
- b) a minimum of 800 lux white light
- c) a minimum of 10 lux white light
- d) a minimum 800 microwatts per square centimetre white light

**When using a post emulsifier penetrant, the emulsifier time should be:**

- a) as long as the penetrant dwell time
- b) one half of the penetrant dwell time
- c) the same as the developer time
- d) minimised whilst ensuring all excess penetrant has been removed

### **Level 3 Sector Specific Theory of the Application of the Liquid Penetrant Method to General Engineering Products**

**The corrosivity of a liquid penetrant is usually assessed by:**

- a) actual component testing
- b) the manufacturer
- c) the penetrant is left in contact with a test piece for 24 hours, followed by examination
- d) the penetrant is left in contact with a test piece for 16 hours, followed by examination

**To reduce the corrosive effect of a penetrant, which chemical group should be maintained at a low level?**

- a) aqueous
- b) halogens
- c) thixotropics
- d) volatiles

**Which of the following flaws is most likely to be missed due to improper rinse techniques?**

- a) forging lap
- b) deep pitting
- c) shallow and broad flaws
- d) the rinse techniques will not affect the detection of flaws

# MAGNETIC PARTICLE TESTING

## Level 1 General Theory of the Magnetic Particle Method

**A fundamental requirement of magnetic particle flaw detection is that the material tested:**

- a) can be any type
- b) must be diamagnetic
- c) must be ferromagnetic
- d) must be paramagnetic

**A part should normally be tested with a magnetic field in at least:**

- a) four directions
- b) one direction
- c) two directions
- d) three directions

**Indicate the unit used in the measurement of flux density:**

- a) amp
- b) tesla
- c) volt
- d) watt

## Level 1 Sector Specific Theory of the Application of the Magnetic Particle Method

**Consumables of a toxic nature may:**

- a) not be used at any time
- b) be used on site work only
- c) be used in accordance with the manufacturer's instructions
- d) be used in small amounts

**All surfaces to be examined using magnetic particle flaw detection should be initially:**

- a) welded
- b) painted
- c) clean
- d) sandblasted

**Which of the following items of equipment would be used to determine that ambient lighting conditions are suitable for magnetic testing?**

- a) radiometer
- b) lux meter
- c) magnetometer
- d) spectrometer

## Level 2 General Theory of the Magnetic Particle Method

The technique which involves the application of the detecting medium after magnetisation has ceased is the:

- a) re-applying technique
- b) residual technique
- c) continuous technique
- d) collective technique

When applying a magnetic field to an item, the term flux density refers to the:

- a) concentration of flux per unit area
- b) magnitude of flux leakage detected
- c) observable magnetic furring that occurs
- d) concentration of flux adjacent to the defect

When testing a component using a coil, the magnetic field is:

- a) transverse
- b) circular
- c) diametrical
- d) longitudinal

The most effective method of de-magnetising a low carbon steel is:

- a) AC aperture coil
- b) reversing and decreasing DC
- c) stroking with AC yokes
- d) hammering along the length of the part

For fine, surface breaking cracks the best magnetic particle inspection medium is:

- a) dry powder, black
- b) dry powder, fluorescent
- c) magnetic ink, black
- d) magnetic ink, fluorescent

## Level 2 Sector Specific Theory of the Application of the Magnetic Particle Method

Indications caused by magnetic leakage fields which result from the geometry of the component, i.e., keyways, splines etc., are referred to as:

- a) magnetic writing
- b) non-relevant indications
- c) boundary zones
- d) relevant indications

According to BS EN 9934, which of the following methods of measuring current form the basis for calculating magnetic field intensity?

- a) average
- b) mean
- c) median
- d) peak

**When using the threading bar technique to test a bolt hole, the direction of the magnetic field will be:**

- a) longitudinal
- b) transverse
- c) circular
- d) at 45° to the axis of the bar

**The field strength of an electro-magnetic yoke will be dependent on:**

- a) pole spacing
- b) contact of the poles with the test surface
- c) the number of windings in the coil
- d) all the above

### **Level 3 General Theory of the Magnetic Particle Method**

**The BS 4069 test piece used for magnetic flow resembles:**

- a) a square bar with a transverse hole
- b) a test sample with a visible surface hole
- c) a cylindrical disc with many drilled holes
- d) an insulated rod, supporting a ring with three sub-surface holes

**Detecting media particles must possess:**

- a) high residual magnetism
- b) high permeability
- c) high retentivity
- d) high coercivity

**A five turn rigid coil is used to test a 180 mm long by 30 mm diameter bar. If the 'K' value is 22000, the minimum current is:**

- a) 73.3 amps rms
- b) 58.67 amps rms
- c) 733 amps rms
- d) 586.7 amps rms

### **Level 3 Sector Specific Theory of the Application of the Magnetic Particle Method**

**When calibrating a fixed bench unit ammeter in accordance with BS 9934, which of the following standards apply?**

- a) calibration ammeter scale 60 mm. Accuracy + or - 5%
- b) calibration ammeter scale 80 mm. Accuracy + or - 15%
- c) calibration ammeter scale 80 mm. Accuracy + or - 5%
- d) calibration ammeter scale 60 mm. Accuracy + or - 10%

# RADIOGRAPHIC TESTING

## Level 1 General Theory of the Radiographic Method

The amount of X radiation or Gamma radiation is often spoken of as the:

- a) wave length
- b) energy
- c) intensity
- d) frequency

Unsharpness ( $U_g$ ) resulting from using a large source size can be compensated for by:

- a) increasing source to specimen distance
- b) addition of lead screens
- c) increasing specimen to film distance
- d) using a fast film

The emulsion or image layer of the unexposed film contains grains of:

- a) black silver
- b) hypo
- c) alkali
- d) silver halides

What is the one requirement that every radiographic film base must have?

- a) flexibility
- b) transparency
- c) toughness
- d) fine grain

If radiation energy is increased, with all other conditions remaining constant, the resulting radiograph will have:

- a) greatly improved contrast
- b) greatly improved definition
- c) less contrast
- d) a much lower density

## Level 1 Sector Specific Theory of the Application of the Radiographic Method in the Testing of Castings

Generally the range of densities acceptable on a casting radiograph are greater than on a weld radiograph, to allow for:

- a) density differences in the material
- b) different materials on the same radiograph
- c) greater thickness variation in castings than welds
- d) clearer images of the internal discontinuities

In order to locate the depth of a discontinuity within the thickness of a cast section a technique involving \_\_\_\_\_ could be used.

- a) tube shift
- b) image enlargement

- c) double film loading
- d) focal spot size

**Screens would not be used below 120 kV, because at these levels:**

- a) the radiation is hard enough not to scatter
- b) more intensification than absorption occurs
- c) more absorption than intensification occurs
- d) only aluminium alloys are radiographed at this level

**If the smallest wire visible on the radiograph of a 35 mm aluminium section is 0.63 mm, (number 14) then the sensitivity is:**

- a) 1.8%
- b) 0.55%
- c) 0.055%
- d) 0.018%

## **Level 1 Sector Specific Theory of the Application of the Radiographic Method in the Testing of Welds**

**Which of the following will cause artefacts on radiographs?**

- a) cracked lead screens
- b) static electricity
- c) pressure after exposure
- d) all of the above

**An IQI is used to determine the:**

- a) size of a discontinuity in the part
- b) density of the film
- c) radiographic contrast
- d) quality of the radiographic image

**An exposure chart is used to:**

- a) assess the current strength of gamma ray
- b) determine the radiographic exposure
- c) calculate the thickness of shielding
- d) all of the above

**Collimators should be selected:**

- a) by the quality control manager only
- b) for gamma ray sources only
- c) based on the film speed used
- d) to be of the size and shape to limit the beam only to the area of interest

## **Level 2 General Theory of the Radiographic Method**

**Thin sheets of lead foil in intimate contact with radiographic film increase film density because they:**

- a) fluoresce and emit visible light which helps expose the film
- b) absorb the scattered radiation
- c) prevent back-scattered radiation from fogging the film

- d) emit electrons which help darken the film

**The fact that gases, when bombarded with radiation, ionise and become electrically conducting make them useful in:**

- a) X-ray transformers
- b) X-ray tubes
- c) masks
- d) monitoring equipment

**Developer preferentially reduces:**

- a) bromide ions over silver ions
- b) silver ions over bromide ions
- c) exposed silver ions over unexposed silver ions
- d) unexposed silver ions over exposed silver ions

**Many modern X-ray units utilise \_\_\_\_\_ circuits to provide smooth high voltage supplies to the X-ray tube.**

- a) diode
- b) triode
- c) Villard
- d) thyristor based

**A beam of radiation consisting of a single wavelength is known as:**

- a) microscopic radiation
- b) monochromatic radiation
- c) heterogeneous radiation
- d) fluoroscopic radiation

## **Level 2 Sector Specific Theory of the Application of the Radiographic Method in the Testing of Castings**

**The range of densities permitted by BS M34, to appear on a single radiograph is:**

- a) 1 - 4
- b) 2 - 4
- c) 2 - 3
- d) 1 - 3

**A radiographic image which appears near to a change of section and is wavy, ragged and linear, although usually discontinuous, would most likely be caused by:**

- a) static
- b) shrinkage
- c) hot tear
- d) segregation

**In castings radiography the IQIs will be placed:**

- a) at the ends of the area being radiographed
- b) directly below the centre of the radiation beam
- c) on the film side of the casting
- d) on the thickest section of the casting

**The most appropriate radiation source for the examination of a 250 mm thick section of a steel casting would be:**

- a) 1000 Ci Ir192
- b) 50 Ci Co60
- c) 35 MeV betatron
- d) 2 MeV Linac

## **Level 2 Sector Specific Theory of the Application of the Radiographic Method in the Testing of Welds**

**The end result of filtering an X-ray beam is to:**

- a) increase net contrast
- b) decrease net contrast
- c) increase or decrease contrast depending on the nature of the part radiographed
- d) have no effect on radiographic contrast

**Which has a higher radiographic equivalence factor than steel?**

- a) magnesium
- b) aluminium
- c) titanium
- d) brass

**A film being manually processed was tapped gently to remove bubbles but clear streaks still occurred. This is because:**

- a) developer was spilled on the film prior to development
- b) developer contaminated the fixer
- c) the film was not agitated sufficiently during development
- d) water splashed on the film prior to development

**The focal spot should be small (as conditions will allow) in order to obtain the:**

- a) density required
- b) sharpest image
- c) sharpest contrast
- d) required kilovoltage

## **Level 3 General Theory of the Radiographic Method**

**Annihilation is a reaction between:**

- a) X-rays and Gamma rays
- b) electrons and protons
- c) protons and positrons
- d) electrons and positrons

**If a nucleus is in an excited state, it can return to its ground state by emission of:**

- a) an electron
- b) a gamma photon
- c) a neutron
- d) an alpha particle



**X-ray film is most sensitive to light in the \_\_\_\_\_ spectrum.**

- a) UV
- b) blue
- c) yellow/green
- d) red

**Heat dissipation characteristics of X-ray tubes are expressed in relation to the product of kV potential and mAs. These products are known as:**

- a) watts
- b) calories
- c) heat units
- d) erg

**Pair production occurs when electromagnetic radiation consists of photons in the energy range:**

- a) 0.025 to 0.1 MeV
- b) 30 to 50 eV
- c) 1.02 or greater MeV
- d) 0.1 to 1.0 MeV

**In a Betatron, electrons are accelerated by:**

- a) field emission
- b) changing magnetic field
- c) high frequency electrical wave
- d) accelerating magnets

**X-ray photons differ from gamma photons of the same energy only in their:**

- a) biological effect
- b) origin
- c) interaction
- d) wavelength

**Focusing of the electron beam onto the target is controlled by:**

- a) shape and size of filament
- b) shape and size of focusing cup
- c) position of filament within the focusing cup
- d) all of the above

### **Level 3 Sector Specific Theory of the Application of the Radiographic Method in the Testing of Castings**

**In the tube shift method of defect location, the most accurate method of determining the depth of the defect is:**

- a) calculation from measurement of ffd, ofd, etc.
- b) a scale drawing of the set up used in tube shift
- c) graphical presentation of tube shift vs. image shift
- d) by using markers and taking data from the radiograph only

**A radiographic image of a casting which appears as small areas of differing density could be due to grain structure effects or segregation. To determine which, a second shot would be taken:**

- a) at lower kilovoltage
- b) at higher kilovoltage
- c) with thicker back screens
- d) after the casting has been annealed

**Small, isolated indications, of high density and irregular, angular form, on a radiograph of a sand cast aluminium component are most likely due to:**

- a) porosity or gas pores
- b) shrinkage sponge
- c) hot tears
- d) inclusion

**Dark crescent-shaped marks on the radiograph of a casting could be caused by:**

- a) pressure after processing or an unfused chaplet
- b) pressure before processing or shrinkage sponge
- c) developer splashes before developments or static
- d) fixer splashes before development or mottling

**A trial shot on a casting of varying thickness shows that the range of densities produced are too great for satisfactory interpretation. In selecting the films for a 'two film' technique, the single exposure is best determined from:**

- a) an exposure chart for each film
- b) characteristic curves for the films
- c) a 'two film' trial shot
- d) two films of the same grain size

### **Level 3 Sector Specific Theory of the Application of the Radiographic Method in the Testing of Welds**

**X-radiography and neutron radiography can be considered:**

- a) equivalent NDT techniques
- b) competitive NDT techniques
- c) complimentary NDT techniques
- d) unsuitable for testing welds

**Which of the following could cause non-repeatability of film contrast when producing a radiograph of the same weld?**

- a) supply voltage
- b) supply current
- c) screen thickness
- d) all of the above variables

**Real-time radiographic systems using an image intensifier and a vidicon camera or a fluorescent screen and isocon camera combination can perform at \_\_\_\_\_ sensitivity.**

- a) less than 1%
- b) between 1.5% and 2%
- c) not better than 5%
- d) not better than 10%

## Digital Radiographic Testing Level 1

**Profile Radiography is also known as;**

- a) Computed Radiography
- b) Tangential Radiography
- c) Comparative Radiography
- d) Stereo Radiography

**Geometric unsharpness can be caused by which of the following factors**

- a) Too small a Source to film Distance (SFD)
- b) Too large a physical source size
- c) Too large an Object to Film Distance (OFD)
- d) All of the above

**In Profile Radiography, the Object to Film Distance (OFD) is measured as;**

- a) The pipe diameter
- b) The distance between the front of the pipe and the film
- c) The distance from the centreline of the pipe to the film
- d) The pipe wall thickness

**Comparators are used to provide;**

- a) A contrast comparison
- b) A measure of the geometric unsharpness present
- c) A density comparison between the inside and outside of the pipe
- d) A reference of a known size that is projected on to the image plate

**The image that is stored on the computer, but has not been enhanced or manipulated is known as;**

- a) The Latent image
- b) The Primary image
- c) The Unprocessed image
- d) The Raw image

## Digital Radiographic Testing Level 2

**C0<sub>2</sub> corrosion is characterised by.**

- a) A very smooth surface
- b) Heavy localised pitting
- c) Heavy general pitting
- d) Heavy pitting with a Sulphide film

**Bimetallic / Galvanic corrosion is associated with which of the following.**

- a) Vibration and general movement between 2 load bearing surfaces
- b) Two dissimilar metals in contact/close proximity
- c) A highly corrosive environment
- d) Two similar metals in a dielectric solution where an electrical current passes between them

**Fretting corrosion is characterised by**

- a) Deep heavy pitting
- b) Material loss caused by the rubbing action of solid particle

- c) Smooth surface with material loss
- d) A scab like appearance with heavy corrosive products beneath

**Micro-biological corrosion will normally be found in areas of**

- a) High velocity and high particulate content
- b) Dead legs and stagnant areas
- c) Under fibreglass insulation
- d) High temperatures

**When CO<sub>2</sub> mixes with water, an aggressive acid is formed that will gradually eat away at the parent material. This acid is called.**

- a) Concentrated Hydrochloric acid
- b) Sulfuric acid
- c) Carbonated Hydrochloric acid
- d) Carbonic acid

**The most common form of corrosion found on unprotected pipe supports and clamps is**

- a) Bi-metallic
- b) Crevice
- c) Galvanic
- d) Micro-biological

**Hydrogen Induced Cracking (HIC) and hydrogen blisters are associated with which process environments**

- a) Hydrocarbon
- b) Water processing
- c) Acid
- d) Caustic

**Smoothing of the enhanced image is carried out by**

- a) Using high pass filters
- b) Using low pass filters
- c) Reducing the edge contrast effect
- d) Blurring of the pixel

**Blow-up of the image is defined as**

- a) The increase in the apparent size of an object when its shadow is projected onto a surface
- b) The percentage distortion or geometric enlargement of an image when projected onto the screen
- c) When a three dimensional object is projected onto a two dimensional plane, blow-up is the amount of distortion present
- d) None of the above

**What is meant by the term "Burn-off"**

- a) That part of the image that is too dark to see
- b) The apparent thinning of the pipe OD due to overexposure
- c) The blurring and distortion seen at the edges of the image
- d) Damage to the screen caused by heat, resulting in an area of blackness in the image.

# ULTRASONIC TESTING

## Level 1 General Theory of the Ultrasonic Method

**When a compressional wave is incident on a boundary between two media, the following type of waves may be generated:**

- a) shear wave
- b) compressional wave
- c) surface wave
- d) all of the above

**The equation describing wavelength in terms of velocity and frequency is:**

- a) wavelength = velocity - frequency
- b) wavelength = velocity x frequency
- c) wavelength = velocity + frequency
- d) wavelength = velocity/frequency

**Sound waves above the human hearing range are referred to as ultrasonic waves and this term embraces all vibrational waves above frequency of approximately:**

- a) 20 kHz
- b) 2 MHz
- c) 2 kHz
- d) 200 kHz

**In ultrasonic testing, the display in which pulse amplitude is represented as a displacement along one axis and time as a displacement along another is known as:**

- a) A-scan
- b) B-scan
- c) C-scan
- d) isometric projection

**If the difference in echo height between two signals is 50%, this represents a dB difference of:**

- a) 20
- b) 14
- c) 6
- d) 2

**The depth of a discontinuity cannot be determined when using the:**

- a) straight beam testing method
- b) through transmission method
- c) angle beam testing
- d) paint brush testing

**A term used to describe the ability of ultrasonic testing equipment to detect discontinuities close to the scanning surface of the material is:**

- a) sensitivity
- b) penetration
- c) segregation
- d) resolution

**Which of the following wave forms has the greatest velocity?**

- a) shear wave
- b) transverse wave
- c) surface wave
- d) longitudinal wave

**The process of comparing an instrument with a standard is called:**

- a) angulation
- b) calibration
- c) attenuation
- d) correlation

**When the motion of the particles of a medium are parallel to the direction of motion of the wave, the transmitted wave is called:**

- a) longitudinal
- b) shear
- c) surface
- d) Lamb

### **Level 1 Sector Specific Theory of the Application of the Ultrasonic Method in the Testing of Castings**

**What is the maximum permitted difference between successive backwall echoes when testing castings?**

- a) 5 dB
- b) 10 dB
- c) 15 dB
- d) 20 dB

**Reduction in backwall echo, whilst scanning a casting with a compression wave probe, may be caused by:**

- a) rough surfaces
- b) coarse grain structure
- c) fine porosity
- d) all of the above

**Before testing a large steel casting, attenuation should be assessed:**

- a) at a single point
- b) on the thinnest section
- c) at a number of points
- d) on the thickest section

### **Level 1 Sector Specific Theory of the Application of the Ultrasonic Method in the Thickness Measurement of Metals and Composite Engineering Materials.**

**Corroded materials typically exhibit high levels of ultrasonic energy loss. Identify the principle cause for the acoustic energy reduction?**

- a) scatter
- b) absorption

- c) beam spread
- d) couplant

**A couplant is required in ultrasonic testing to:**

- a) protect the test material
- b) protect the probe shoe
- c) protect the tester's hands
- d) enable sound energy to pass into the test material

**Probes used in ultrasonic thickness measurement vary in design for specific applications. Which of the following probes is not suitable for thickness measurement?**

- a) delay tip probe
- b) surface wave probe
- c) dual element normal beam probe
- d) captive water column probe

**Thickness measurement through coated surfaces is preferably conducted utilising the:**

- a) initial pulse to first backwall echo
- b) maximum Amplitude technique
- c) echo to echo measurement method
- d) 1st backwall and 3rd backwall echo to eliminate the coating

## **Level 1 Sector Specific Theory of the Application of the Ultrasonic Method to Wrought & Weld Products**

**Which of the following causes the greatest attenuation of ultrasound?**

- a) a hand forging
- b) a coarse grained casting
- c) an extrusion
- d) all materials have the same attenuation

**The most appropriate wave mode for locating lamination in thin plate would be:**

- a) Lamb
- b) shear
- c) surface
- d) longitudinal

**Which of the following is not a method of flaw sizing?**

- a) 20 dB drop
- b) 6 dB drop
- c) B-Scan
- d) maximum amplitude

**A couplant is required in ultrasonic testing to:**

- a) protect the test material
- b) protect the probe shoe
- c) protect the tester's hands
- d) enable sound energy to pass into the test material

**Probes used in ultrasonic contact testing are checked periodically for performance when in regular use. Which characteristic would not be checked daily?**

- a) probe index
- b) beam angle
- c) beam profile
- d) overall system gain

**In weld inspection, transverse cracks are best located by:**

- a) scanning at right angles to the weld axis
- b) scanning parallel to the weld axis
- c) using a compressional probe
- d) immersion testing

### **Level 1 Sector Specific Theory of the Application of the Ultrasonic Method in the Testing of Solid Axles**

**In ultrasonic testing, a liquid layer between the axle end face and the ultrasonic probe is necessary because:**

- a) a lubricant is required to minimise wear of the probe contact surface
- b) an air interface between the probe and axle end face would almost completely reflect the ultrasonic waves
- c) the crystal will not vibrate if the probe surface is in direct contact with the axle end face
- d) the liquid is necessary to complete an electrical circuit between the probe and test piece

**The primary purpose of the calibration block is to:**

- a) aid the operator in obtaining maximum back reflections
- b) obtain the greatest possible sensitivity from the instrument
- c) obtain a reproducible signal
- d) none of the above

**Moving a probe around the axle end is referred to as:**

- a) scanning
- b) attenuating
- c) angulating
- d) resonating

**In a basic ultrasonic test pattern the initial pulse (assume no trace delay) is:**

- a) the first indication on the left side of the CRT screen representing the near surface of the test object
- b) the last indication on the CRT screen representing the far surface of the test object
- c) an indication that appears and disappears during scanning
- d) always the second pulse on the CRT screen

**The angle of incidence is:**

- a) greater than the angle of reflection
- b) less than the angle of reflection
- c) equal to the angle of reflection
- d) not related to the angle of reflection



## **Level 1 Sector Specific Theory of the Application of the Ultrasonic Method in the Testing of Rail**

**A possible reason for a total loss of back-wall echo when measuring rail depth using a zero degree compression wave probe with the beam passing between holes 1 and 2 is:**

- a) an S & T hole
- b) a horizontal flaw
- c) a bonding hole
- d) piping

**The primary purpose of the calibration block is to:**

- a) aid the operator in obtaining maximum back reflections
- b) obtain the greatest possible sensitivity from the instrument
- c) obtain a reproducible signal
- d) none of the above

**The process of comparing an instrument with a standard is called:**

- a) angulation
- b) calibration
- c) attenuation
- d) correlation

## **Level 2 General Theory of the Ultrasonic Method**

**The angle at which the shear component of an incident beam is refracted at 90 degrees to the normal is called:**

- a) the normal angle of incidence
- b) the first critical angle
- c) the angle of maximum reflection
- d) the second critical angle

**As frequency increases in ultrasonic testing the angle of beam divergence of a given diameter crystal:**

- a) decreases
- b) remains constant
- c) increases
- d) varies uniformly through each wavelength

**The fundamental frequency of a piezo-electric crystal used in ultrasonic probes is a function of:**

- a) its thickness
- b) the velocity of sound in the crystal material
- c) both A and B above
- d) its diameter

**Shear waves are generally more sensitive to fine discontinuities for a given frequency than longitudinal waves because:**

- a) the wavelength is shorter
- b) shear waves are not as easily dispersed in the material
- c) the direction of particle vibration of shear is more sensitive
- d) the wavelength of shear waves is longer

**A linear time base is achieved when the electron beam in the CRT:**

- a) is deflected with constant velocity
- b) is deflected with constant acceleration
- c) is deflected with the same velocity as the probe movement
- d) produces four echoes on the screen

## **Level 2 Sector Specific Theory of the Application of the Ultrasonic Method in the Thickness Measurement of Metals and Composite Engineering Materials**

**Which of the following are factors that affect acoustic velocity in composites and polymers?**

- a) percentage resin content
- b) chemicals used to produce a polymer
- c) stage of material cure
- d) all of the above

## **Level 2 Sector Specific Theory of the Application of the Ultrasonic Method in the Testing of Castings**

**Given that the velocity of a compression wave in steel is 6000 m/s, how long does it take a wave to travel from one side to the other of a 30 mm thick section of a steel casting?**

- a) 5 microseconds
- b) 5 milliseconds
- c) 2 microseconds
- d) 2 milliseconds

**The vertical axis of the DGS diagram represents:**

- a) probe diameter
- b) flat-bottomed hole size
- c) gain
- d) reflector depth

**Defect assessment to BS EN 12680-1 for castings examination is based on:**

- a) zoning
- b) reference reflectors
- c) 20 dB drop
- d) all of the above

**Which of the following methods will quickly assess the size of large areas of shrinkage?**

- a) 20 dB drop
- b) 6 dB drop
- c) DGS
- d) DAC

## **Level 2 Sector Specific Theory of the Application of the Ultrasonic Method to Wrought & Weld Products**

**DGS diagrams compare flaw signal amplitudes to:**

- a) reference blocks

- b) flat bottomed holes
- c) a theoretical maximum
- d) DAC

**The most appropriate method for sizing lamination in rolled plate would be:**

- a) DGS
- b) DAC
- c) 20 dB
- d) 6 dB

**The best probe for inspecting a two metre long, 200 mm diameter, forged shaft, working from one end, down the length of the shaft would be:**

- a) 10 mm, 5 MHz single crystal
- b) 25 mm, 2 MHz single crystal
- c) 10 mm, 4 MHz twin crystal
- d) 25 mm, 5 MHz twin crystal

**When scanning towards a welded joint, the ultrasonic 'A' scan presentation displays an echo dynamic pattern in which the signal amplitude rises smoothly to a plateau, which is held with minor variations, before falling smoothly to zero. This describes the typical echodynamic pattern of:**

- a) a smooth planar reflector at oblique incidence
- b) a point reflector
- c) a smooth planar reflector at normal incidence
- d) an irregular reflector at normal incidence

## **Level 2 Sector Specific Theory of the Application of the Ultrasonic Method in the Testing of Solid Axles**

**Given that the velocity of a compression wave in steel is 6000 m/s, how long does it take a wave to travel from one side to the other of a 2.5m axle?**

- a) 0.0417 seconds
- b) 4.17 microseconds
- c) 4.17 milliseconds
- d) none of the above

**The best probe for inspecting a two metre long, 200mm diameter, forged shaft, working from one end, down the length of the shaft would be:**

- a) 10mm, 5MHz single crystal
- b) 25mm, 2MHz single crystal
- c) 10mm, 4MHz twin crystal
- d) 25mm, 5MHz twin crystal

**Longitudinal and transverse ultrasonic scanning on an un-machined axle shall take place:**

- a) after final heat treatment
- b) before heat treatment
- c) immediately after forging
- d) any time

## Level 2 Sector Specific Theory of the Application of the Ultrasonic Method in the Testing of Rail

When testing number 1 bolt hole for a 'D' flaw, a signal appears on the time base at a short range. You would suspect:

- a) a miss-shapen bolt hole
- b) a horizontal reflector
- c) half a hole
- d) a bonding hole

In the ultrasonic testing of thermit welds, what flaw in the weld can the tandem rig readily identify?

- a) lack of fusion
- b) porosity
- c) horizontal inclusion
- d) isolated pores

When scanning towards a welded rail joint, the ultrasonic 'A' scan presentation displays an echo-dynamic pattern in which the signal amplitude rises smoothly to a plateau, which is held with minor variations, before falling smoothly to zero. This describes the typical echo-dynamic pattern of:

- a) a smooth planar reflector at oblique incidence
- b) a point reflector
- c) a smooth planar reflector at normal incidence
- d) an irregular reflector at normal incidence

## Level 3 General Theory of the Ultrasonic Test Method

For piezo-electric transducers, the general relationship between frequency and transducer thickness states:

- a) frequency and transducer thickness are independent
- b) thicker transducers generate lower ultrasonic frequencies
- c) thinner transducers generate lower ultrasonic frequencies
- d) none of the above

The half-angle calculation of beam spread to one tenth of the beam centre-line intensity is calculated from:

- a)  $\sin\theta/2 = 1.08v/Df$
- b)  $\sin\theta = 1.08D/vf$
- c)  $\sin\theta/2 = 0.56v/Df$
- d)  $\sin\theta/v = 1.22v/fD$

The principal reason for damping the transducer in an ultrasonic probe is to:

- a) reduce the applied voltage
- b) enhance resolving power
- c) modify sensitivity
- d) reduce bandwidth

When using focused probes, non-symmetry in a propagated sound beam may be caused by:

- a) backing material variations
- b) lens centering or misalignment

- c) porosity in lenses
- d) all of the above

**The 6 dB drop sizing technique should only be applied to which of the following types of discontinuity?**

- a) those which are larger than the ultrasonic beam width
- b) those of similar dimensions to the ultrasonic beam width
- c) those which are smaller than the ultrasonic beam width
- d) any size of discontinuity

**Which of the following displays can be used to produce a plan view of a defect?**

- a) A-scan
- b) B-scan
- c) C-scan
- d) D-scan

### **Level 3 Sector Specific Theory of the Application of the Ultrasonic Method in the Testing of Castings & welds**

**A through-wall welded repair in a 30 mm thick casting is tested using a 60 degree shear wave probe and is found to contain a flaw. If the sound path to the flaw is 85 mm, the flaw is approximately:**

- a) 17.5 mm from the test surface
- b) 12.5 mm from the test surface
- c) 1.5 mm from the opposite surface
- d) 26 mm from the opposite surface

### **Level 3 Sector Specific Theory of the Application of the Ultrasonic Method in the Testing of Wrought Products**

**A plot of the variation of beam intensity along the beam axis for a given target size is:**

- a) a distance amplitude curve
- b) used for determining the vertical extent of the beam
- c) used for determining the horizontal extent of the beam
- d) not useful

### **Level 3 Sector Specific Theory of the Application of the Ultrasonic Method in the Testing of Railway Axles**

**When setting the sensitivity for a high angle axle scan, the probe must be positioned:**

- a) on the stand-off line
- b) as far into the wheel seat as possible
- c) on the calibration block
- d) facing away from the wheel

**When producing a near-end trace pattern for a roller bearing axle, the siting of the probe is taken to be:**

- a) at the extreme of the axle end
- b) 15mm below the turning centre

- c) equi-distant between the turning centre and the axle edge
- d) adjacent to the turning centre

### **Level 3 Sector Specific Theory of the Application of the Ultrasonic Method in the Testing of Rail**

**When balancing the 070 system, the signal from the zero degree probe is set to FSH, and the signal from the seventy degree probe is set at:**

- a) 20% FSH
- b) 40% FSH
- c) 50% FSH
- d) 60% FSH

**When testing jointed rail, an echo signal may not be received from one of the fish-plate holes because:**

- a) it is not round
- b) the bolt is an interference fit
- c) the hole has been 'burnt in'
- d) the bolt is missing

### **ULTRASONIC TESTING USING TIME OF FLIGHT DIFFRACTION (TOFD)**

#### **Level 1 Sector Specific Theory of the Application of the Ultrasonic Time of Flight Diffraction Method for Testing of Welds**

**Why is capturing the information as a D- scan preferable to looking at individual A-scans during a TOFD inspection?**

- a) gives less attenuation of the sound
- b) gives more efficient tip diffraction
- c) enables weak signals to be recognised
- d) provides only longitudinal wave patterns

**What angle will give a poor tip diffraction response?**

- a) 38 degrees
- b) 45 degrees
- c) 50 degrees
- d) 60 degrees

**Does the lateral wave:**

- a) follow the surface contour
- b) changes mode and travels as a shear wave
- c) follows the path which takes the minimum time
- d) reflect from the back wall

**What is the lateral wave time of a PCS of 25mm focus with 60 degree wedges?**

- a) 6.745 µsecs
- b) 14.671 µsecs
- c) 7.336 µsecs
- d) 5.902 µsecs

**Why are the shear wave signals collected during TOFD inspection?**

- a) they are useful for seeing off-axis reflectors
- b) spreads out the signals in time more
- c) provides a different wavelength
- d) all the above

**Level 2 Sector Specific Theory of the Application of the Ultrasonic Time of Flight Diffraction Method for Testing of Welds**

**Which of the following probe pairs would give best time/depth resolution?**

- a) 38°
- b) 45°
- c) 60°
- d) 70°

**Which of the following probe pairs would give greatest material volume coverage in one scan, assume identical crystal diameters and frequencies?**

- a) 38°
- b) 45°
- c) 60°
- d) 70°

**Poorest sensitivity to detection of bottom edge diffraction is at a refracted angle of approximately:**

- a) 38°
- b) 47°
- c) 55°
- d) 63°

**Level 3 Sector Specific Theory of the Application of the Ultrasonic Time of Flight Diffraction Method in the Testing of Welds**

**Calculate the overall timing of a bottom diffracted signal given the following information:**

Material Velocity: 5960 m/s

Tx 9.2 μs (pulse echo measured)

Rx 8.2 μs (pulse echo measured)

PCS 58mm (at probe shoe index)

Depth from scan surface to bottom of flaw 37mm

- a) 24.5 μs
- b) 33 μs
- c) Insufficient information is given to calculate
- d) This defect tip is not detectable with these parameters

**What is the recognised tolerance for overall depth error when initially sizing a resolvable flaw?**

- a) +/- 0.3mm
- b) +/- 0.5mm
- c) +/- 1mm
- d) +/- 4mm

**Derive the material depth encompassed by a lateral wave given the following:**

Velocity 5960 m/s Longitudinal; 3230 m/s Transverse

Probe Frequency 7 MHz

PCS 70mm

Pulse Duration 2.5 cycles

Wedge Angle 60°

- a) 2.12mm
- b) 8.7mm
- c) 11.7mm
- d) Not enough information given

## **ULTRASONIC TESTING USING PHASED ARRAYS (UTPA)**

### **Level 1 Specific questions on the application of UT Phased Arrays**

**Calibration of any Phased Array Beam to be code compliant shall include:**

- a) Adjusting angular sweep after sensitivity calibration
- b) Use of Thixotropic couplant
- c) Adjustment of screen display format
- d) Ensuring uniform sensitivity across the range of focal laws

**Phased Array indications can best be described as:**

- a) Images collated from stacked 'A' scans
- b) Actual reproductions of flaw shape and size
- c) An artistic impression of the scanned test piece
- d) Finitely precise

**Which of the following affect data collection speed:**

- a) PRF
- b) Collection step
- c) Number of focal laws
- d) All of the above

### **Level 2 Specific questions on the application of UT Phased Arrays**

**When using sectorial swept angle scans the image quality and resolution in the direction of the sweep can be improved by:**

- a) Increasing the array frequency
- b) Reducing the increment between the angular steps
- c) Increasing the array aperture
- d) Using dynamic depth focussing

**Sizing principles of phased array data rely upon:**

- a) Changes in amplitude
- b) Colour palette selection
- c) FFT analysis
- d) Orientation of the echo-dynamic envelope



**Which of the following factors affect the extent of beam steering?**

- a) Pitch between elements
- b) Width of elements
- c) Number of elements excited
- d) All of the above

### **Level 3 Specific questions on the application of UT Phased Arrays**

**Which of the following features is principally attributed to the pitch between elements in an array design?**

- a) Sensitivity at the point of focus
- b) Far surface resolution
- c) Position and magnitude of grating lobes
- d) Focal law calculations

**What does the principle of 'DDF' rely upon?**

- a) Sequentially scanning the component at different depths followed by file merging to synchronise the peak responses.
- b) Electronic adjustment of the received impulse delays computed to account for changes in acoustic range.
- c) Use of low power focussing to increase the depth of field over which focus can be maintained.
- d) Multiplexing the array with the PRF firing at exponential timing sequences.

**Calculate the maximum focal depth in the active plane for an array with the following characteristics:**

32 elements excited; 0.5mm element width; 1mm pitch; 5MHz; No wedge; Material velocity 5.9mm/μs

- a) 217mm
- b) 478mm
- c) 488mm
- d) 625mm

## **VISUAL TESTING**

### **Level 1 General Theory of Visual Testing**

**Fibre Optic systems work on which of the following principles?**

- a) reflection
- b) diffraction
- c) refraction
- d) reticulation

**Resolution is the ability to see which of the following?**

- a) the smallest flaw possible
- b) two flaws adjacent to each other as one
- c) two flaws adjacent to each other as separate flaws
- d) a large flaw at a distance of over 3 metres

**What is the minimum angle in relation to the test surface that visual examination can be carried out at?**

- a) 60 degrees
- b) 90 degrees
- c) 0 degrees
- d) 30 degrees

**Stereoscopic vision is limited to magnification factors less than \_\_\_\_\_ when using singular magnification lenses.**

- a) none
- b) X2
- c) X5
- d) X10

### **Level 1 Sector Specific Theory of the Application of Visual Testing to General Engineering Products**

**A measured amount of undercut is detected that is allowable when referenced to an acceptance criteria. This undercut is therefore described as:**

- a) a defect
- b) an indication
- c) a flaw
- d) none of the above

**Which of the following weld defects would be visually detectable on a completed weld?**

- a) lack of interrun fusion
- b) sub surface porosity
- c) lack of side wall fusion
- d) undercut

**Visual inspectors shall be capable of reading a Jaeger type standard chart of a certain number and a set distance, which of the following is correct?**

- a) type No. 1 at 60 cm
- b) type No. 2 at 30 cm
- c) type No. 1 at 30 cm
- d) type No. 2 at 60 cm

### **Level 2 General Theory of Visual Testing**

**If objects are viewed with both eyes then it is termed:**

- a) dual vision
- b) monocular vision
- c) binocular vision
- d) twin field of view vision

**The area at the back of the eyeball on the retina where the optic nerve terminates is known as the:**

- a) fovea centralis
- b) blind spot
- c) rod
- d) cone

**As magnification increases the focal distance will:**

- a) increase
- b) stay the same
- c) decrease
- d) either A or C

**Direct visual examinations may be carried out using which of the following?**

- a) boroscope
- b) mirrors
- c) fibrescope
- d) all of the above

## **Level 2 Sector Specific Theory of the Application of Visual Testing to General Engineering Products**

**Direct visual examination may be carried out when the eye can be placed within \_\_\_\_\_ of the surface and at an angle not less than \_\_\_\_\_.**

- a) 60 cm 45 degrees
- b) 60 cm 30 degrees
- c) 30 cm 45 degrees
- d) 30 cm 30 degrees

**A convex mirror may be used to:**

- a) magnify the object
- b) increase the field of view
- c) decrease the field of view
- d) converge the image

**A complex pipe system is to be examined for internal corrosion. Which of the following items will be most effective?**

- a) light source and mirror
- b) rigid boroscope
- c) fibroscope
- d) pit gauge

## **Level 3 General Theory of Visual Testing**

**To what wavelength of radiation is the human eye most sensitive?**

- a) 320 nm
- b) 5750 angstroms
- c) 4200 angstroms
- d) 400 nm

## Level 3 Sector Specific Theory of the Application of Visual Testing to General Engineering Products

Which of the following systems offers the best resolution?

- a) CCD camera
- b) CCTV
- c) video scope
- d) photography

## RADIATION SAFETY & RADIATION PROTECTION

To avoid confusion any source activities or dose rates are given in dual units on the paper. e.g.:

740 GBq  $^{60}\text{Co}$  (20 Ci  $^{60}\text{Co}$ )

185 GBq  $^{192}\text{Ir}$  (5 Ci  $^{192}\text{Ir}$ )

In order to offer a variety of questions, various sources will be referenced and various shielding materials e.g. concrete, steel or lead and the relevant half or tenth value thickness given.

### Basic Radiation Safety

Atoms of a single element which have different numbers of neutrons in the nucleus are:

- a) radioactive
- b) unstable
- c) isotopes
- d) beta emitters

The Quality Factor of different forms of ionising radiation is a measure of their relative:

- a) wavelength
- b) biological effect
- c) electrical charge
- d) penetrating ability

The radiation intensity 1 metre from a source is 10  $\mu\text{Sv}/\text{hour}$ . The distance required to reduce this to 2.5  $\mu\text{Sv}/\text{hr}$  is:

- a) 2 metres
- b) 5 metres
- c) 10 metres
- d) 20 metres

The thickness of a specified material necessary to reduce the exposure rate to 25% of the initial value is the:

- a) two half value thicknesses
- b) tenth value layer
- c) attenuation coefficient
- d) inverse square law factor

**A controlled area is an area where workers are likely to receive an effective dose rate greater than:**

- a) 50 mSv/yr
- b) 15 mSv/yr
- c) 6 mSv/yr
- d) 20 mSv/Yr

**A 370 GBq (10 Ci) source of Iridium is being used on a panoramic shot inside an open-ended pipe with a wall thickness of 39mm and outside diameter of 2 metres. If the barrier is only 25 metres away from the source at the open end of the pipe, how far back must the barrier be moved to achieve a dose rate at the barrier of 7.5  $\mu$ Sv/hr?**

- a) 80 metres
- b) 55 metres
- c) 8.0 metres
- d) 3.28 metres

### Radiation Protection (To Supervisor Level)

**The following data will be used with all calculation questions:**

Half value thicknesses:		Dose rates at 1 metre:		
Steel (Iridium)	= 13 mm	Iridium	$\mu$ Sv/hr/GBq	= 130
Steel (Cobalt)	= 20 mm	Iridium	rem/hr/Ci	= 0.48
Steel (250 kV x-rays)	= 12 mm	Cobalt	$\mu$ Sv/hr/GBq	= 357
Steel (200 kV x-rays)	= 6 mm	Cobalt	rem/hr/Ci	= 1.32
Lead (Cobalt)	= 11 mm	Ytterbium	$\mu$ Sv/hr/GBq	= 33.8
Lead (Iridium)	= 5.5 mm	Ytterbium	rem/hr/Ci	= 0.125
Concrete (Iridium)	= 43 mm	Thulium	$\mu$ Sv/hr/GBq	= 0.676
Concrete (Cobalt)	= 63 mm	Thulium	rem/hr/Ci	= 0.0025
Lead (Selenium)	= 1.5 mm	Selenium	$\mu$ Sv/hr/GBq	= 55

**Every employer shall designate as a controlled area, any area under his control which has been identified as an area in which:**

- a) special procedures have to be adopted to restrict significant exposure
- b) any person working in the area is likely to receive an effective dose greater than 6 mSv per year
- c) any person working in the area is likely to receive an equivalent dose greater than three tenths of any relevant dose limit
- d) both A and C

**Every employer shall ensure that an investigation is carried out when the effective dose of ionising radiation received by any of his employees for the first time in any calendar year exceeds:**

- a) 1 mSv
- b) 2 mSv
- c) 6 mSv
- d) 15 mSv

### **Radiation Protection narrative answer questions**

**You are required to carry out on-site radiography from the centre of a 20 metre long x 4 metre diameter 45 mm WT steel pipe using a panoramic technique with an Iridium 192 isotope of 700 GBq (19 Curie). At what distance from the pipe would you need to set barriers for a maximum dose rate of 7.5 $\mu$ Sv/hr? (Source output = 130  $\mu$ Sv/hr/GBq)**

**List the requirements of LOCAL RULES and state how they should be controlled.**

**Detail the procedure to be followed when an employee of a company reports that he has reasonable cause to believe he has received excessive exposure to radiation.**