# PCN24/GEN/Appendix Z2

## Compendium of specimen examination questions

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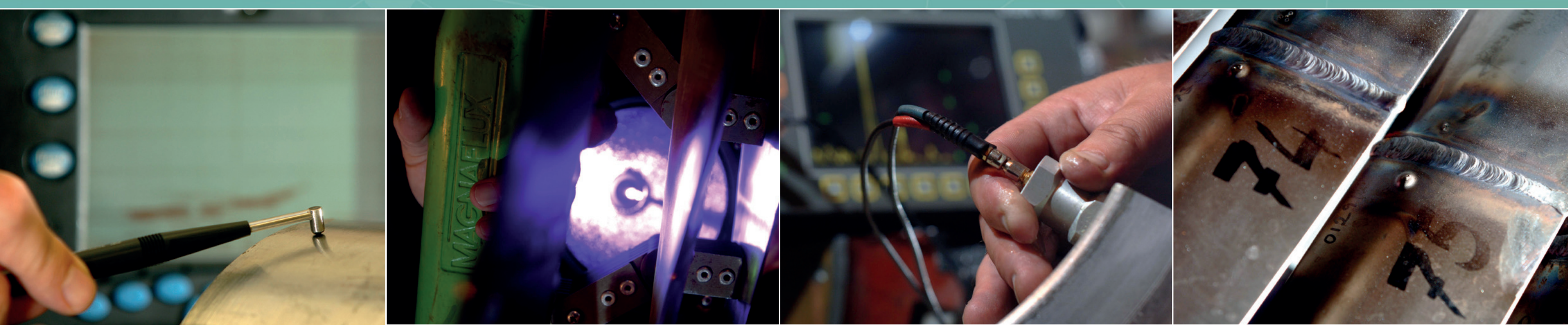

## Contents

# Scope

The purpose of this document is to provide a structured collection of sample examination questions intended to support training, assessment and certification of personnel in non-destructive testing (NDT). The questions are designed to examine knowledge at various levels of competency, including Level 1, Level 2 and Level 3, and cover both theoretical and practical aspects of various NDT inspection methods. Sample questions for various NDT methods are included in this document, covering methods such as eddy current testing (ET), magnetic testing (MT), penetrant testing (PT) radiographic testing (RT), ultrasonic testing (UT) and visual testing (VT), amongst others.

The questions included in this document are for practice, guidance and educational purposes only and may not exactly reflect PCN official certification examinations. The purpose of this document is to provide candidates with a brief overview of the questions they may encounter during their certification process and is not exhaustive of the examination content that a candidate may experience. For further information on the full PCN syllabi for all NDT methods, please refer to PCN24/GEN Appendix Z1, titled: 'NDT examination syllabi'.

**Product technology theory**

| Castings | |
|---|---|
| **A large cavity at the centre of a cast section is most likely to be:** | (a) A gas hole<br>(b) A cold shut<br>(c) Shrinkage<br>(d) Hot tearing |
| **Large smooth voids or porosity in a casting result from:** | (a) Turbulent flow of metal during pouring<br>(b) Segregation of alloy constituents<br>(c) Gas evolved before and during solidification<br>(d) Hot tearing in the thick sections of the casting |
| **Discontinuities that originate in the cast ingot can often be reduced by a process that closes and welds the voids, as well as breaking up inclusions. This process is:** | (a) Machining<br>(b) Welding<br>(c) Forging<br>(d) Cold extrusion |
| **A uniform rounded cavity in a cast section is most likely to be:** | (a) A gas hole<br>(b) A cold shut<br>(c) Shrinkage<br>(d) Hot tearing |
| **A casting discontinuity that is caused by gas release or the evaporation of moisture during solidification is:** | (a) Micro shrinkage<br>(b) Porosity<br>(c) Porous segregation<br>(d) Hydrogen-induced porosity |
| **Composite materials** | |
| **Anechoic polymers are used for:** | (a) Impact resistance<br>(b) Rigidity<br>(c) Acoustic reflectivity<br>(d) Acoustic absorption |
| **Lack of bond between two layers of carbon fibre is generally termed as:** | (a) Lamination<br>(b) Delamination<br>(c) Roving<br>(d) Marcelling |
| **Which of the following is a common internal defect found in composite materials?** | (a) Undercut<br>(b) Fibre misalignment<br>(c) Incomplete fusion<br>(d) Weld porosity |

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| **Porosity in composite materials is typically caused by:** | (a) Excessive resin hardener<br>(b) Trapped air or volatiles during curing<br>(c) Fibre misalignment<br>(d) Resin-rich areas |
| **Matrix cracking in a composite laminate is typically the result of:** | (a) Over-curing the resin<br>(b) Impact or thermal stress causing cracks in the resin matrix<br>(c) Fibre corrosion<br>(d) Misaligned plies |
| **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<br>(b) Tungsten inert gas (TIG) welding<br>(c) Metal inert gas (MIG)/metal active gas (MAG)<br>(d) Oxy-acetylene welding |
| **Which of the following is a weld defect?** | (a) Porosity<br>(b) Hot tear<br>(c) Lamination<br>(d) Burst |
| **Gross wormhole porosity that breaks the surface of a submerged arc weld is most likely caused by:** | (a) Damp flux<br>(b) Poor current connection<br>(c) Work oxide films<br>(d) Variation in joint fit-up |
| **Which of the following will not be found in a TIG welded joint?** | (a) Porosity<br>(b) Slag<br>(c) Crater cracking<br>(d) Incomplete penetration |
| **The heat treatment process that is employed to give a soft ductile product, by recrystallisation of the material, is termed:** | (a) Tempering<br>(b) Hardening<br>(c) Stress relieving<br>(d) Annealing |
| **Wrought products** | |
| **In open die forging, the top and bottom dies are called, respectively, the:** | (a) Tup and anvil<br>(b) Cope and drag<br>(c) Head and foot<br>(d) Hammer and anvil |
| **An example of wrought products could be:** | (a) A casting<br>(b) A forged section<br>(c) A weld<br>(d) None of the answers listed above |
| **Discontinuities that originate in the cast ingot can often be reduced by a process that closes and welds the voids, as well as breaking up inclusions. This process is:** | (a) Machining<br>(b) Welding<br>(c) Forging<br>(d) Cold extrusion |
| **Pipelines carrying fluids containing sand and mineral particles are susceptible to:** | (a) Cavitation<br>(b) Weld root erosion<br>(c) Stress corrosion cracking<br>(d) Hydrogen embrittlement |

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| **Poor forging temperature or too great a reduction in section can give rise to rupturing of the material; this is called a:** | (a) Lap<br>(b) Seam<br>(c) Burst<br>(d) Inclusion |
| **Solid railway axles** | |
| **Longitudinal defects on the surface that are less than 0.5 mm deep may be removed by polishing in a longitudinal direction. The maximum number of defects that can be removed during rectification is:** | (a) Two<br>(b) Five<br>(c) Eight<br>(d) Ten |
| **Axles are made from steel and are produced by:** | (a) An electric process<br>(b) A basic oxygen process<br>(c) Both (a) and (b) above<br>(d) The Bessemer process |
| **Discontinuities that originate in the cast ingot can often be reduced by a process that closes and welds the voids, as well as breaking up inclusions, this process is:** | (a) Machining<br>(b) Welding<br>(c) Forging<br>(d) Cold extrusion |
| **Forging of axles is not done at temperatures above:** | (a) 1260°C<br>(b) 1500°C<br>(c) 1750°C<br>(d) 2000°C |
| **The minimum height of scroll or block stamps on axle ends shall be:** | (a) 4 mm<br>(b) 6 mm<br>(c) 8 mm<br>(d) 10 mm |
| **Running rail** | |
| **Rails are made from steel and are produced by:** | (a) Forging<br>(b) Extrusion<br>(c) Pultrusion<br>(d) Rolling |
| **The height of the branding marks on the web of a rail must be at least:** | (a) 5 mm<br>(b) 10 mm<br>(c) 15 mm<br>(d) 20 mm |
| **During the manufacture of rail, what forms the nucleus of a tache ovale?** | (a) Water entrapment<br>(b) Hydrogen flakes<br>(c) Shatter cracks<br>(d) Stress |
| **What is the primary reason for applying corrosion-resistant coatings on running rails?** | (a) To improve aesthetic appeal<br>(b) To prevent rust and degradation in harsh environments<br>(c) To reduce manufacturing cost<br>(d) To increase weight |
| **What defect in running rails is characterised by small cracks appearing along the surface due to repeated stress?** | (a) Corrosion<br>(b) Surface spalling<br>(c) Fatigue cracking<br>(d) Warping |

**Level 3 knowledge of the PCN24 requirements for PCN certification**

| Basic examination – Part B | |
|---|---|
| **The minimum additional period of industrial experience required for the holder of a PCN Level 1 eddy current testing certificate to be eligible for Level 2 eddy current testing certification is:** | (a) 45 days<br>(b) 105 days<br>(c) 135 days<br>(d) 155 days |
| **In accordance with PCN24/GEN, the Level 3 basic examination – Part A (covering materials technology and science) shall include a minimum of how many questions?** | (a) 20 questions<br>(b) 25 questions<br>(c) 30 questions<br>(d) 40 questions |
| **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<br>(b) Jaeger number 1 letters at not more than 30 cm<br>(c) Jaeger number 1 letters at 400 mm<br>(d) Jaeger number 2 letters at 30 cm |
| **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<br>(b) Between eight and four months prior to expiry<br>(c) At least 56 days prior to expiry<br>(d) On the expiry date |
| **For PCN specific theory multiple-choice examination questions, what time is permitted per question?** | (a) 1 minute per question<br>(b) 2 minutes per question<br>(c) 3 minutes per question<br>(d) Specific theory questions are not timed |

**Eddy current testing**

| Level 1 – General theory eddy current testing | |
|---|---|
| **The depth of eddy current penetration is dependent on the:** | (a) Shape of the probe being used<br>(b) Area of the item under inspection<br>(c) Thickness of the item under inspection<br>(d) Test frequency |
| **The inductive reactance of a coil is measured in:** | (a) Volts<br>(b) Ohms<br>(c) Mhos<br>(d) Henrys |
| **Conductivity of a material is affected by:** | (a) The couplant used between probe and specimen<br>(b) Its chemical composition<br>(c) Equipment sensitivity settings<br>(d) All of the answers listed |
| **The total opposition to flow of AC is called:** | (a) Reluctance<br>(b) Inductance<br>(c) Impedance<br>(d) Resistance |
| **What happens to the strength of eddy currents when the frequency of the magnetic field increases?** | (a) They decrease due to damping<br>(b) They remain constant<br>(c) They increase<br>(d) They disappear completely |

| **Level 1 – Specific theory eddy current testing – Welds** | |
|---|---|
| **To lessen the effects of the proximity of a material of different permeability:** | (a) A couplant should be used<br>(b) Wrap a layer of masking tape around the probe coil<br>(c) Use a shielded probe<br>(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<br>(b) Ensure paint is in good condition and make allowance for lift-off<br>(c) Only high-frequency probes can be used with lift-off compensation<br>(d) Only low-frequency ring probes are suitable |
| **Variations in probe speed:** | (a) Have no deleterious effect on results<br>(b) Will cause changes in signal amplitude<br>(c) May result in incorrect defect assessment<br>(d) Both (b) and (c) are correct |
| **A high-frequency pencil probe will only locate defects that:** | (a) Have measurable depth<br>(b) Are surface breaking<br>(c) Are in materials of very high permeability<br>(d) Are close to changes of geometry |
| **Which of the following weld defects can be effectively detected using eddy current testing?** | (a) Internal porosity at 10 mm depth<br>(b) Surface cracks and lack of fusion<br>(c) Undercut visible to the naked eye<br>(d) Misalignment of the weld joint |
| **Level 1 – Specific theory eddy current testing – Wrought products** | |
| **To lessen the effects of the proximity of a material of different permeability:** | (a) A couplant should be used<br>(b) Wrap a layer of masking tape around the probe coil<br>(c) Use a shielded probe<br>(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<br>(b) Ensure paint is in good condition and make allowance for lift-off<br>(c) Only high-frequency probes can be used with lift-off compensation<br>(d) Only low-frequency ring probes are suitable |
| **Variations in probe speed:** | (a) Have no deleterious effect on results<br>(b) Will cause changes in signal amplitude<br>(c) May result in incorrect defect assessment<br>(d) Both (b) and (c) are correct |
| **A high-frequency pencil probe will only locate defects that:** | (a) Have measurable depth<br>(b) Are surface breaking<br>(c) In materials of a very high permeability<br>(d) Are close to changes of geometry |
| **What is the main limitation of eddy current testing when inspecting wrought products?** | (a) Cannot detect metallic inclusions<br>(b) Not applicable to high-volume inspections<br>(c) Limited to conductive materials and shallow penetration<br>(d) Requires destructive cutting of samples |

| Level 2 – General theory eddy current testing | |
|---|---|
| **When the applied voltage and current through a circuit are in phase, the:** | (a) Current leads voltage by 90°<br>(b) Current and voltage have the same value<br>(c) Voltage leads current by 90°<br>(d) None of the answers listed are correct |
| **In eddy current test systems where encircling coils are used, coupling efficiency is referred to as:** | (a) Lift-off<br>(b) Edge factor<br>(c) Fill factor<br>(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<br>(b) Magnetising force<br>(c) Back EMF<br>(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<br>(b) In phase<br>(c) Regenerate<br>(d) Out of phase |
| **In eddy current testing, which material property combination results in the shallowest penetration depth?** | (a) High conductivity, high permeability<br>(b) Low conductivity, low permeability<br>(c) High conductivity, low permeability<br>(d) Low conductivity, high permeability |

| Level 2 – Specific theory eddy current testing – Welds | |
|---|---|
| **Which of the following conditions are most 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<br>(b) The specimen should have the same heat treatment as the piece to be inspected<br>(c) The surface finish of the specimen should be the same as the piece to be tested<br>(d) If the material is aluminium, the surface should be anodised |
| **One main advantage of phase analysis displays over meter reading equipment is that:** | (a) It can be pocket sized<br>(b) It allows separation of many test variables<br>(c) It is simple to use<br>(d) Test variables cannot be separated |
| **It is possible to use phase analysis equipment for:** | (a) The location of internal or external flaws<br>(b) The location of internal defects only<br>(c) The location of support plates<br>(d) Both answers (a) and (c) are impossible |
| **The impedance of an AC system used for eddy current testing is a combination of:** | (a) Inductive reactance and resistance<br>(b) Inductive reactance and capacitive reactance only<br>(c) Resistance and capacitive reactance only<br>(d) None of the answers listed are correct |
| **Before performing eddy current testing on a weld, which step is essential?** | (a) Applying a magnetic field<br>(b) Painting the weld area<br>(c) Cleaning the surface to remove oxidation and contaminants<br>(d) None of the answers listed |

| Level 2 – Specific theory eddy current testing – Wrought products | |
|---|---|
| **Which of the following conditions are most 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<br>(b) The specimen should have the same heat treatment as the piece to be inspected<br>(c) The surface finish of the specimen should be the same as the piece to be tested<br>(d) If the material is aluminium, the surface should be anodised |
| **One main advantage of phase analysis displays over meter reading equipment is that:** | (a) It can be pocket sized<br>(b) It allows separation of many test variables<br>(c) It is simple to use<br>(d) Test variables cannot be separated |
| **It is possible to use phase analysis equipment for:** | (a) The location of internal or external flaws<br>(b) The location of internal defects only<br>(c) The location of support plates<br>(d) Both answers (a) and (c) are impossible |
| **The impedance of an AC system used for eddy current testing is a combination of:** | (a) Inductive reactance and resistance<br>(b) Inductive reactance and capacitive reactance only<br>(c) Resistance and capacitive reactance only<br>(d) None of the answers listed are correct |
| **Which type of defect would be least likely to be detected by eddy current testing in a wrought aluminium bar?** | (a) Longitudinal surface crack<br>(b) Deep internal void<br>(c) Surface lap<br>(d) Subsurface inclusions near the surface |
| **Level 3 – General theory eddy current testing** | |
| **Commercial eddy current equipment may be designed to detect changes in:** | (a) Specific gravity<br>(b) Subsurface cavities<br>(c) Grain direction<br>(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<br>(b) Deep but very narrow<br>(c) Full length and uniform<br>(d) Short and wide |
| **Impedance of an AC system used for eddy current testing is a combination of:** | (a) Inductive reactance and resistance<br>(b) Inductive reactance and capacitive reactance only<br>(c) Resistance and capacitive reactance only<br>(d) Frequency and phase |
| **The effect of lift-off on the impedance of a test coil is used principally when designing:** | (a) Crack detectors<br>(b) Coating thickness meters<br>(c) Conductivity meters<br>(d) AC crack depth instruments |
| **In multi-frequency eddy current testing, the primary purpose of using multiple frequencies is to:** | (a) Increase penetration uniformly<br>(b) Eliminate the need for calibration<br>(c) Separate and characterise different flaw types and material properties<br>(d) Increase scanning speed |

| Level 3 – Specific theory eddy current testing – Welds | |
|---|---|
| **During eddy current testing of welds on austenitic stainless steel, phase discrimination is especially useful for:** | (a) Measuring weld hardness<br>(b) Determining crack orientation<br>(c) Differentiating between surface defects and lift-off variations<br>(d) Locating porosity clusters |
| **In weld inspection using eddy current testing, non-relevant indications are most likely caused by:** | (a) Subsurface porosity<br>(b) Base metal inclusions<br>(c) Surface geometry changes, spatter and oxide scale<br>(d) Magnetic permeability changes in aluminium |
| **Which of the following coil configurations is most suitable for manual scanning along irregular weld geometry?** | (a) Encircling coil<br>(b) Differential coil<br>(c) Shielded pencil probe<br>(d) Large-area absolute coil |
| **Which eddy current technique provides the most reliable detection of small, surface-breaking cracks in the weld toe area of a non-ferromagnetic material?** | (a) Remote field eddy current<br>(b) Pencil probe with high-frequency absolute coil<br>(c) Magnetic flux leakage<br>(d) Low-frequency encircling coil |
| **When scanning a butt weld with a differential probe, a consistent noise signal appears near both edges of the weld. This is most likely due to:** | (a) Subsurface porosity<br>(b) Weld spatter<br>(c) Geometry changes at the weld toe<br>(d) Signal saturation |

| Level 3 – Specific theory eddy current testing – Wrought products | |
|---|---|
| **During testing, the secondary magnetic field developed by the eddy currents:** | (a) Totally cancels the coil's magnetic field<br>(b) Totally reinforces the coil's magnetic field<br>(c) Partially reinforces the coil's magnetic field<br>(d) Partially cancels the coil's magnetic field |
| **The impedance of a test coil can usually be represented by the vector sum of:** | (a) Inductive reactance and resistance<br>(b) Capacitive reactance and resistance<br>(c) Inductive reactance and capacitive reactance<br>(d) Inductance and capacitance |
| **The inductive reactance of a test coil depends upon which of the following?** | (a) Frequency, coil inductance, coil resistance<br>(b) Coil inductance<br>(c) Coil resistance and inductance<br>(d) Frequency and coil inductance |
| **How does cold working of a wrought metal influence eddy current test results?** | (a) Cause changes in electrical conductivity<br>(b) Decreases electrical conductivity and changes magnetic permeability<br>(c) Has no effect on eddy current response<br>(d) Only affects ultrasonic testing and not eddy currents |
| **When testing wrought products made from ferromagnetic materials, which additional complication arises in eddy current testing compared to non-magnetic materials?** | (a) No difference in testing technique<br>(b) Magnetic permeability variations significantly affect impedance readings<br>(c) Reduced signal due to low electrical conductivity<br>(d) Coating thickness has no effect |

## Alternating current field measurement (ACFM)

| Level 1 – Specific theory ACFM – Welds | |
|---|---|
| **Variations in probe speed:** | (a) Have no deleterious effects on results<br>(b) May cause changes in signal amplitude<br>(c) May result in incorrect flaw detection and assessment<br>(d) Both answers (b) and (c) are correct |
| **Which of the following would result from a linear flaw parallel to the scanning direction, when scanned in an 'A' direction?** | (a) $B_x$: trough $B_z$: trough-peak pair<br>(b) $B_x$: trough $B_z$: peak-trough pair<br>(c) $B_x$: peak $B_z$: trough-peak pair<br>(d) $B_x$: trough $B_z$: trough only |
| **What is the standard operating frequency of the ACFM equipment when deployed on carbon steel?** | (a) 5 kHz<br>(b) 5 MHz<br>(c) 5 Hz<br>(d) None of the answers listed are correct |
| **Which of the following best describes the surface condition requirements for ACFM testing?** | (a) Highly polished surface only<br>(b) Surface free from heavy rust, scale or thick coatings<br>(c) Surface must be bare metal with no paint<br>(d) Any surface condition is acceptable |
| **ACFM is primarily used for detecting:** | (a) Subsurface corrosion<br>(b) Surface-breaking cracks<br>(c) Laminar defects inside welds<br>(d) Porosity |
| **Level 2 – Specific theory ACFM – 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<br>(b) The surface finish and material specification should conform to the component under test<br>(c) The backwall of the specimen should be at least 50 mm in depth<br>(d) None of the answers listed |
| **By using smaller sensing coils, you would expect:** | (a) No measurable difference<br>(b) Larger signals<br>(c) Improved discrimination of defect features<br>(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<br>(b) Greater than the uniform field<br>(c) The same as the uniform field<br>(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<br>(b) Multiple cracking<br>(c) Geometry signals<br>(d) Material changes |
| **Which of the following would result from a linear flaw perpendicular to the scanning direction, when scanned in an 'A' direction?** | (a) $B_x$: peak $B_z$: trough, peak or no signal<br>(b) $B_x$: trough $B_z$: peak-trough pair<br>(c) $B_x$: peak $B_z$: peak-trough pair<br>(d) $B_x$: trough $B_z$: trough only |

| Level 3 – Specific theory ACFM – Welds | |
|---|---|
| **ACFM signal interpretation becomes unreliable when:** | (a) The flaw is surface breaking<br>(b) Scanning is performed over weld spatter or poor surface geometry without compensation<br>(c) The surface is painted<br>(d) Detecting transverse flaws |
| **Which factor has the least influence on ACFM's ability to detect a crack in a weld?** | (a) Surface coating up to 5 mm thick<br>(b) Flaw orientation perpendicular to the probe scan direction<br>(c) Weld heat-affected zone hardness<br>(d) Accurate probe positioning and calibration |
| **In ACFM, the $B_z$ component of the magnetic field is used to:** | (a) Calculate the flaw depth<br>(b) Determine conductivity of the material<br>(c) Measure coating thickness<br>(d) Indicate flaw orientation |
| **Which ACFM parameter correlates most directly with crack length?** | (a) Peak-to-peak amplitude of the $B_x$ signal<br>(b) Width of the $B_z$ signal at the baseline<br>(c) Phase shift of the excitation waveform<br>(d) Lift-off variation |
| **For which of the following would you normally need to create a new configuration?** | (a) When the material differs from carbon steel<br>(b) When a non-conductive surface coating is present<br>(c) Both answers (a) and (b) would normally require a new configuration<br>(d) There is no need to create new configurations with ACFM |

## Magnetic testing (MT)

| Level 1 – General theory magnetic testing | |
|---|---|
| **A fundamental requirement of magnetic particle flaw detection is that the material tested:** | (a) Can be any type<br>(b) Must be diamagnetic<br>(c) Must be ferromagnetic<br>(d) Must be paramagnetic |
| **A part should normally be tested with a magnetic field in at least:** | (a) Four directions<br>(b) One direction<br>(c) Two directions<br>(d) Three directions |
| **Indicate the unit used in the measurement of flux density:** | (a) Amp<br>(b) Tesla<br>(c) Volt<br>(d) Watt |
| **A yoke is typically used to create:** | (a) A circular magnetic field<br>(b) A longitudinal magnetic field<br>(c) An ultrasonic wave<br>(d) A radiographic exposure |
| **Demagnetisation is required after magnetic particle inspection to:** | (a) Increase test sensitivity<br>(b) Prevent residual magnetism from interfering with future use or machining<br>(c) Improve image quality<br>(d) Remove test indications |

| **Level 1 – Specific theory magnetic testing** | |
|---|---|
| **Consumables of a toxic nature may:** | (a) Not be used at any time<br>(b) Be used on site work only<br>(c) Be used in accordance with the manufacturer's instructions<br>(d) Be used in small amounts |
| **All surfaces to be examined using magnetic particle flaw detection should be initially:** | (a) Welded<br>(b) Painted<br>(c) Cleaned<br>(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<br>(b) Photometer<br>(c) Magnetometer<br>(d) Spectrometer |
| **Which of the following weld defects is most likely to be detected using MT?** | (a) Lack of inter-run fusion<br>(b) Internal slag inclusions<br>(c) Surface-breaking cracks at the toe of the weld<br>(d) Cold shuts in aluminium |
| **Which type of current is most suitable for detecting surface defects in castings during MT?** | (a) Direct current (DC)<br>(b) Alternating current (AC)<br>(c) Half-wave DC only<br>(d) Pulsed ultrasonic current |
| **Level 2– General theory magnetic testing** | |
| **The technique that involves the application of the detecting medium after magnetisation has ceased is the:** | (a) Reapplying technique<br>(b) Residual technique<br>(c) Continuous technique<br>(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<br>(b) Magnitude of flux leakage detected<br>(c) Observable magnetic furring that occurs<br>(d) Concentration of flux adjacent to the defect |
| **When testing a component using a rigid coil, the magnetic field is:** | (a) Transverse<br>(b) Circular<br>(c) Diametrical<br>(d) Longitudinal |
| **The most effective method of demagnetising a low-carbon steel is:** | (a) AC aperture coil<br>(b) Reversing and decreasing DC<br>(c) Stroking with AC yokes<br>(d) Hammering along the length of the part |
| **For fine surface-breaking cracks, the most sensitive magnetic particle inspection medium is:** | (a) Dry powder, black<br>(b) Dry powder, fluorescent<br>(c) Magnetic ink, black<br>(d) Magnetic ink, fluorescent |

| **Level 2 – Specific theory magnetic testing** | |
|---|---|
| **Indications caused by magnetic flux leakage fields that result from the geometry of the component, *ie* keyways, splines, etc, are referred to as:** | (a) Magnetic writing<br>(b) Non-relevant indications<br>(c) Boundary zones<br>(d) Relevant indications |
| **According to BS EN 9934, which of the following methods of measuring current forms the basis for calculating magnetic field intensity?** | (a) Average<br>(b) Root mean square<br>(c) Median<br>(d) Peak |
| **When using the threading bar technique to test a bolt hole, the direction of the magnetic field will be:** | (a) Longitudinal<br>(b) Transverse<br>(c) Circular<br>(d) At 45° to the axis of the bar |
| **The field strength of an electromagnetic yoke will be dependent on:** | (a) Pole spacing<br>(b) Contact of the poles with the test surface<br>(c) The number of windings in the coil<br>(d) All of the answers listed |
| **During in-service inspection using MT, one of the most critical considerations is:** | (a) Part conductivity<br>(b) Residual stress level in the component<br>(c) Surface temperature and accessibility<br>(d) Colour of the magnetic particles |
| **Level 3 – General theory magnetic testing** | |
| **Which of the following is a commonly used test-piece, used for magnetic flow and rigid coil control checks:** | (a) A square bar with a transverse hole<br>(b) A test sample with a visible surface hole<br>(c) A cylindrical disc with many drilled holes<br>(d) An insulated rod, supporting a ring with three subsurface holes |
| **Detecting media particles must possess:** | (a) High residual magnetism<br>(b) High permeability<br>(c) High retentivity<br>(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<br>(b) 58.67 amps RMS<br>(c) 733 amps RMS<br>(d) 586.7 amps RMS |
| **Magnetic saturation occurs when:** | (a) No more magnetic lines of force can be induced in the material<br>(b) The applied current is reversed<br>(c) The field is perpendicular to the discontinuity<br>(d) The magnetic field begins to oscillate |
| **Why is AC current preferred for detecting surface-breaking discontinuities only?** | (a) It penetrates deeply into the part<br>(b) It produces a strong residual field<br>(c) It concentrates magnetic flux at the surface due to the skin effect<br>(d) It causes permanent magnetisation |

| Level 3 – Specific theory magnetic testing | |
|---|---|
| **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 ± 5%<br>(b) Calibration ammeter scale 80 mm, accuracy ± 15%<br>(c) Calibration ammeter scale 80 mm, accuracy ± 5%<br>(d) Calibration ammeter scale 60 mm, accuracy ± 10% |
| **When performing MT on a complex casting with varying cross-sectional thickness, the best practice for ensuring consistent magnetisation is:** | (a) Use a fixed current regardless of thickness<br>(b) Adjust magnetising current according to local thickness variations<br>(c) Only magnetise the thickest sections<br>(d) Use AC current exclusively |
| **When selecting magnetic particles for a specific application, what is the primary reason for choosing wet fluorescent over dry visible particles?** | (a) Wet fluorescent particles are less expensive<br>(b) Wet fluorescent particles offer higher sensitivity, especially on fine cracks<br>(c) Dry particles are only used for non-ferromagnetic materials<br>(d) Dry particles are preferred under ultraviolet (UV) light |
| **An indication produced at contact points between test items that are magnetised prior to testing is referred to as:** | (a) A false indication<br>(b) A true relevant indication<br>(c) Magnetic writing<br>(d) Furring/bearding |
| **In developing an MT procedure, the concept of 'magnetising force' (*H*) is critical. It is expressed in:** | (a) amperes per meter (A/m)<br>(b) Gauss (G)<br>(c) Tesla (T)<br>(d) Volts (V) |

## Penetrant testing (PT)

| Level 1 – General theory penetrant testing | |
|---|---|
| **Which of the following would assist the penetrant to enter subsurface cracks in a component?** | (a) The material's surface finish<br>(b) The penetrant viscosity<br>(c) The inherent surface tension<br>(d) None of the answers listed |
| **The only discontinuities that penetrant testing can detect are:** | (a) Subsurface<br>(b) Surface breaking<br>(c) The inherent surface tension<br>(d) None of the answers listed |
| **The term used to define the period of time that a developer has been applied is:** | (a) Attraction time<br>(b) Development time<br>(c) Dwell time<br>(d) Drain time |
| **What is the function of a developer in penetrant testing?** | (a) Clean the surface before testing<br>(b) Act as a drying agent<br>(c) Draw penetrant out of defects and make them visible<br>(d) Prevent surface corrosion |
| **Which penetrant type requires the application of an emulsifier before developer?** | (a) Solvent-removable<br>(b) Water-washable<br>(c) Post-emulsifiable<br>(d) None of the answers listed |

| Level 1 – Specific theory penetrant testing | |
|---|---|
| **Consumables of a toxic nature may:** | (a) Not be used at any time<br>(b) Be used on site work only<br>(c) Be used in accordance with the manufacturer's instructions<br>(d) Be used in small amounts |
| **All surfaces to be examined using penetrant flaw detection should be initially:** | (a) Welded<br>(b) Painted<br>(c) Cleaned<br>(d) Sandblasted |
| **A radiometer would be used in conjunction with which of the following?** | (a) Colour-contrast penetrants<br>(b) Fluorescent penetrants<br>(c) Both colour contrast and fluorescent penetrants<br>(d) Neither colour contrast nor fluorescent penetrants |
| **Which cleaning method is most suitable before penetrant testing on stainless steel welds?** | (a) Wire brushing with a carbon steel brush<br>(b) Shot blasting<br>(c) Solvent cleaning<br>(d) Using an oil-based degreaser |
| **Which developer type is most effective for rough or porous casting surfaces?** | (a) Non-aqueous wet developer (NAWD)<br>(b) Dry powder developer<br>(c) Water-soluble developer<br>(d) Oil-based developer |
| **Level 2 – General theory penetrant testing** | |
| **The property of a liquid that affects the speed of flow is:** | (a) Surface tension<br>(b) Viscosity<br>(c) Contact angle<br>(d) A combination of all the answers listed |
| **The corrosivity of a liquid penetrant is usually assessed by:** | (a) Actual component testing<br>(b) The manufacturer of the penetrant<br>(c) Samples of material left in contact for a defined period and examined<br>(d) Corrosivity is not applicable to penetrant consumables |
| **Which of the following is considered the most sensitive penetrant testing technique?** | (a) Colour contrast, solvent removable<br>(b) Fluorescent, solvent removable<br>(c) Fluorescent, water washable<br>(d) Fluorescent, post-emulsifiable |
| **In fluorescent penetrant testing, the required UV-A (black light) intensity, in accordance with BS EN ISO 3059, at the component surface shall be at least:** | (a) 100 $\mu W/cm^2$<br>(b) 1000 $\mu W/cm^2$<br>(c) 5000 $\mu W/cm^2$<br>(d) 10,000 $\mu W/cm^2$ |
| **What is the main reason for using solvent-removable penetrant?** | (a) It is the most sensitive technique<br>(b) It can be used on site where water is not available<br>(c) It is safer under UV light<br>(d) It requires no cleaning before use |

| Level 2 – Specific theory penetrant testing | |
|---|---|
| **If fluorescent penetrant is applied after an acid precleaning treatment:** | (a) The penetrant should dwell for twice the time specified<br>(b) Marking of the test-piece may be evident<br>(c) A decrease in brilliance of the penetrant may occur<br>(d) An increase in brilliance of the penetrant may occur |
| **The best preparation of rusty surfaces for penetrant inspection is:** | (a) Shot blasting<br>(b) Grinding<br>(c) Wire brushing<br>(d) Pickling |
| **The international standard to be referred to for penetrant flaw detection is:** | (a) BS 6072<br>(b) BS EN ISO 9934<br>(c) BS 4489<br>(d) BS EN ISO 3452 |
| **To avoid the risk of fire, penetrants in cans should:** | (a) Be stored away from direct sunlight<br>(b) Not be sprayed near or onto hot components<br>(c) Be kept away from incandescent surfaces<br>(d) Be handled so as to avoid all of the listed situations |
| **How should mill scale on wrought steel products be handled before PT inspection?** | (a) No action is required<br>(b) Remove by mechanical means such as wire brushing or grinding<br>(c) Conducting a mild acid etch<br>(d) Clean with water only |

| Level 3 – General theory penetrant testing | |
|---|---|
| **In accordance with BS EN ISO 3059, colour contrast penetrants must be viewed in:** | (a) A minimum of 500 lux white light<br>(b) A minimum of 800 lux white light<br>(c) A minimum of 10 lux white light<br>(d) A minimum of 800 microwatts per square centimetre white light |
| **When using a post-emulsifiable penetrant, the emulsification time should be:** | (a) As long as the penetrant dwell time<br>(b) One half of the penetrant dwell time<br>(c) The same as the developer time<br>(d) Minimised whilst ensuring all excess penetrant has been removed |
| **Which of the following best describes a 'bleed out' effect in penetrant testing?** | (a) Penetrant drying on the surface before developer action<br>(b) Penetrant leaking from discontinuities causing indistinct or smeared indications<br>(c) Excess developer diluting penetrant indications<br>(d) The formation of a flaw indication through blotting action |
| **When inspecting a component using colour contrast penetrant, the inspector notices faint red indications on a dark background. What is the most appropriate action?** | (a) Immediately reject the part without further analysis<br>(b) Adjust lighting to enhance visibility and verify indications carefully<br>(c) Increase the dwell time of the penetrant<br>(d) Clean and reprocess the component |
| **Which type of developer cannot be used under visible light conditions?** | (a) Dry powder<br>(b) Water-suspendable<br>(c) Water-soluble<br>(d) Non-aqueous wet developer |

| Level 3 – Specific theory penetrant testing | |
|---|---|
| The corrosivity of a liquid penetrant is usually assessed by: | (a) Actual component testing<br>(b) The manufacturer<br>(c) Samples of material left in contact for a defined period and examined<br>(d) Corrosivity is not applicable to penetrant consumables |
| To reduce the corrosive effect of a penetrant, which chemical group should be maintained at a low level? | (a) Aqueous<br>(b) Halogens<br>(c) Thixotropics<br>(d) Volatiles |
| Which of the following flaws is most likely to be missed due to improper rinse techniques? | (a) Forging lap<br>(b) Deep pitting<br>(c) Shallow and broad flaws<br>(d) The rinse techniques will not affect the detection of flaws |
| Which penetrant technique would be preferable for the testing of large batches of complex castings with a critical use? | (a) Colour contrast, post-emulsifiable<br>(b) Fluorescent, post-emulsifiable<br>(c) Fluorescent, water-washable<br>(d) Colour contrast, solvent-removable |
| When PT indications on a weld are smeared or unclear after developer application, the most likely cause is: | (a) Incomplete penetrant removal<br>(b) Excess dwell time<br>(c) Excess developer thickness<br>(d) Developer applied before removal of excess penetrant |

## Radiographic testing (RT) – Film

| Level 1 – General theory radiographic testing | |
|---|---|
| The amount of X-radiation or gamma radiation is often spoken of as the: | (a) wavelength<br>(b) energy<br>(c) intensity<br>(d) frequency |
| Unsharpness (Ug) resulting from using a large source size can be compensated for by: | (a) increasing source-to-specimen distance<br>(b) addition of lead screens<br>(c) increasing specimen-to-film distance<br>(d) using a fast film |
| The emulsion or image layer of the unexposed film contains grains of: | (a) black silver<br>(b) hypo<br>(c) alkali<br>(d) silver halides |
| What is the one requirement that every radiographic film base must have? | (a) flexibility<br>(b) transparency<br>(c) toughness<br>(d) fine grain |
| If radiation energy is increased, with all other conditions remaining constant, the resulting radiograph will have: | (a) greatly improved contrast<br>(b) greatly improved definition<br>(c) less contrast<br>(d) a much lower density |

| Level 1 – Specific theory radiographic testing (film) – 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<br>(b) Different materials on the same radiograph<br>(c) Greater thickness variation in castings than welds<br>(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<br>(b) Image enlargement<br>(c) Double film loading<br>(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<br>(b) More intensification than absorption occurs<br>(c) More attenuation than intensification occurs<br>(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%<br>(b) 0.55%<br>(c) 0.055%<br>(d) 0.018% |
| **Which casting defect would most likely appear as an irregular dark shape with fuzzy edges on a radiograph?** | (a) Shrinkage cavity<br>(b) Machining mark<br>(c) Cold shut<br>(d) Slag inclusions |
| **Level 1 – Specific theory radiographic testing (film) – Welds** | |
| **Which of the following will cause artefacts on radiographs?** | (a) Cracked lead screens<br>(b) Static electricity<br>(c) Pressure after exposure<br>(d) All of the answers listed |
| **An image quality indicator (IQI) is used to determine the:** | (a) Size of a discontinuity<br>(b) Density of the film<br>(c) Radiographic contrast<br>(d) Quality of the radiographic image |
| **An exposure chart is used to:** | (a) Assess the current strength of gamma rays<br>(b) Determine the radiographic exposure<br>(c) Calculate the thickness of shielding<br>(d) All of the answers listed |
| **Collimators should be selected:** | (a) By the quality control manager only<br>(b) For gamma ray sources only<br>(c) Based on the film speed used<br>(d) To be of the size and shape to limit the beam only to the area of interest |
| **When using film radiography to inspect welded joints, which of the following discontinuities is not commonly identified?** | (a) Improper weld bead appearance<br>(b) Lack of fusion, slag inclusions and internal cracks<br>(c) Excessive spatter on the weld surface<br>(d) Incorrect electrode type used during welding |

| Level 2 – General theory radiographic testing | |
|---|---|
| **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<br>(b) Absorb the scattered radiation<br>(c) Prevent back-scattered radiation from fogging the film<br>(d) Emit electrons, which help darken the film |
| **The fact that gases, when bombarded with radiation, ionise and become electrically conducting makes them useful in:** | (a) X-ray transformers<br>(b) X-ray tubes<br>(c) Masks<br>(d) Monitoring equipment |
| **Developer preferentially reduces:** | (a) Bromide ions over silver ions<br>(b) Silver ions over bromide ions<br>(c) Exposed silver ions over unexposed silver ions<br>(d) Unexposed silver ions over exposed silver ions |
| **Many modern X-ray units utilise _______________ circuits to provide smooth high-voltage supplies to X-ray tubes** | (a) Diode<br>(b) Greinacher<br>(c) Villard<br>(d) Thyristor-based |
| **A beam of radiation consisting of a single wavelength is known as:** | (a) Microscopic radiation<br>(b) Monochromatic radiation<br>(c) Heterogeneous radiation<br>(d) Fluoroscopic radiation |
| **Level 2 – Specific theory radiographic testing (film) – Castings** | |
| **The range of densities permitted by BS M34, to appear on a single radiograph is:** | (a) 1-4<br>(b) 2-4<br>(c) 2-3<br>(d) 1-3 |
| **A radiographic image that appears near to a change of section and is wavy, ragged and linear, although usually discontinuous, would most likely be caused by:** | (a) Static<br>(b) Shrinkage<br>(c) Hot tear<br>(d) Segregation |
| **In castings radiography, the IQIs will be placed:** | (a) At the ends of the area being radiographed<br>(b) Directly below the centre of the radiation beam<br>(c) On the film side of the casting<br>(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<br>(b) 50 Ci Co60<br>(c) 35 MeV betatron<br>(d) 2 MeV linac |
| **Which of the following best describes the primary purpose of using film radiography in the inspection of castings?** | (a) To measure the surface roughness of the casting<br>(b) To detect internal discontinuities, such as porosity, shrinkage or cracks<br>(c) To determine the exact chemical composition of the casting material<br>(d) To verify the dimensional accuracy of the casting |

| Level 2 – Specific theory radiographic testing (film) – Welds | |
|---|---|
| **The end result of filtering an X-ray beam is to:** | (a) Increase net contrast<br>(b) Decrease net contrast<br>(c) Increase or decrease contrast depending on the nature of the part radiographed<br>(d) Have no effect on radiographic contrast |
| **Which has a higher radiographic equivalence factor than steel?** | (a) Magnesium<br>(b) Aluminium<br>(c) Titanium<br>(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<br>(b) Developer contaminated the fixer<br>(c) The film was not agitated sufficiently during development<br>(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<br>(b) Sharpest image<br>(c) Sharpest contrast<br>(d) Required kilovoltage |
| **Which of the following types of defect can be best detected using radiographic testing with film?** | (a) Lack of sidewall fusion<br>(b) Porosity and slag inclusions<br>(c) Surface cracks<br>(d) Undercut |
| **Level 3 – General theory radiographic testing** | |
| **Annihilation is a reaction between:** | (a) X-rays and gamma rays<br>(b) Electrons and protons<br>(c) Protons and positrons<br>(d) Electrons and positrons |
| **If a nucleus is in an excited state, it can return to its ground state by emission of:** | (a) A gamma photon<br>(b) A neutron<br>(c) An alpha particle<br>(d) All of the answers listed |
| **Focusing of the electron beam onto the target is controlled by:** | (a) Shape and size of filament<br>(b) Shape and size of focusing cup<br>(c) Position of filament within the focusing cup<br>(d) All of the above |
| **Pair production occurs when electromagnetic radiation consists of photons in the energy range:** | (a) 0.025 to 0.1 MeV<br>(b) 30 to 50 eV<br>(c) 1.02 or greater MeV<br>(d) 0.1 to 1.0 MeV |
| **In a Betatron, electrons are accelerated by:** | (a) Field emission<br>(b) A changing magnetic field<br>(c) A high-frequency electrical wave<br>(d) Accelerating magnets |

| Level 3 – Specific theory radiographic testing (film) – 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<br>(b) A scale drawing of the set-up used in tube shift<br>(c) Graphical presentation of tube shift *versus* image shift<br>(d) By using markers and taking data from the radiograph only |
| **A radiographic image of a casting that 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<br>(b) At high kilovoltage<br>(c) With thicker back screens<br>(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<br>(b) Shrinkage sponge<br>(c) Hot tears<br>(d) Inclusion |
| **Dark crescent-shaped marks on the radiograph of a casting could be caused by:** | (a) Pressure after development or unfused chaplet<br>(b) Pressure before development or shrinkage sponge<br>(c) Developer splashes before development or static<br>(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 sandwich technique, the single exposure is best determined from:** | (a) An exposure chart for each film<br>(b) Characteristic curves for the films<br>(c) A 'two film' trial shot<br>(d) Two films of the same grain size |
| **Level 3 – Specific theory radiographic testing (film) – Welds** | |
| **X-radiography and neutron radiography can be considered:** | (a) Equivalent NDT techniques<br>(b) Competitive NDT techniques<br>(c) Complementary NDT techniques<br>(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) A change in supply voltage<br>(b) A change in supply current<br>(c) A change in screen thickness<br>(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%<br>(b) Between 1.5% and 2%<br>(c) Not better than 5%<br>(d) Not better than 10% |
| **When reinspecting a weld using a 300 Kv X-ray tube that was previously exposed using a 150 Kv X-ray tube, which of the following would be expected?** | (a) An increase in contrast and a decrease in latitude<br>(b) An increase in contrast and an increase in latitude<br>(c) A decrease in contrast and a decrease in latitude<br>(d) A decrease in contrast and an increase in latitude |
| **Which film radiographic technique offers the lowest distortion and greatest productivity when inspecting butt welds in thick-walled pipe?** | (a) Double wall, single image<br>(b) Panoramic technique<br>(c) Elliptical exposure<br>(d) Single wall, single image |

## Radiographic testing (RT) – Digital

| | |
|---|---|
| **Level 1 – Specific theory radiographic testing (digital) – Welds** | |
| **Profile radiography is also known as:** | (a) Computed radiography<br>(b) Tangential radiography<br>(c) Comparative radiography<br>(d) Stereo radiography |
| **Geometric unsharpness can be caused by which of the following factors:** | (a) Too small a source-to-film distance (SFD)<br>(b) Too large a physical source size<br>(c) Too large an object-to-film distance (OFD)<br>(d) All of the answers listed |
| **In profile radiography, the object-to-film distance is measured as:** | (a) The pipe diameter<br>(b) The distance between the front of the pipe and the film<br>(c) The distance from the centreline of the pipe to the film<br>(d) The pipe wall thickness |
| **Comparators are used to provide:** | (a) A contrast comparison<br>(b) A measure of the geometric unsharpness present<br>(c) A density comparison between the inside and outside of the pipe<br>(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<br>(b) The primary image<br>(c) The unprocessed image<br>(d) The raw image |
| **Level 2 – Specific theory radiographic testing (digital) – Welds** | |
| **$CO_2$ corrosion is characterised by:** | (a) A very smooth surface<br>(b) Heavy localised pitting<br>(c) Heavy general pitting<br>(d) Heavy pitting with a sulphide film |
| **Bimetallic/galvanic corrosion is associated with which of the following:** | (a) Vibration and general movement between two load-bearing surfaces<br>(b) Two dissimilar metals in contact or close proximity<br>(c) A highly corrosive environment<br>(d) Two similar metals in a dielectric solution where an electrical current passes between them |
| **Fretting corrosion is characterised by:** | (a) Deep heavy pitting<br>(b) Material loss caused by the rubbing action of solid particles<br>(c) Smooth surface with material loss<br>(d) A scab like appearance with heavy corrosive products beneath |
| **What is the role of the digital detector array (DDA) in digital radiography?** | (a) Amplifies sound waves<br>(b) Detects light from the screen<br>(c) Converts radiation into a digital signal<br>(d) Produces visible dye indications |
| **Which of the following is not an advantage of digital radiography compared to conventional film radiography?** | (a) No chemical processing<br>(b) Digital storage and easy sharing<br>(c) Reduced inspection time<br>(d) Reduced need for radiation shielding |

| Level 3 – Specific theory radiographic testing (digital) – Welds | |
|---|---|
| What is the primary reason for applying geometric unsharpness ($U_g$) limits in digital radiographic testing? | (a) To reduce radiation scatter<br>(b) To ensure compliance with pixel resolution<br>(c) To maintain image interpretability and defect detection<br>(d) To limit X-ray exposure to operators |
| Which of the following image artefacts in RT-D could indicate a defect in the detector system rather than the weld? | (a) Clustered porosity<br>(b) Irregular shape indication with variable contrast<br>(c) Consistent linear lines across multiple images<br>(d) Lack of fusion with sharp boundary |
| What technique may be used to optimise contrast sensitivity for a thick weld with varying geometry? | (a) Increase tube current without adjusting exposure time<br>(b) Apply multi-energy exposure (dual-energy technique)<br>(c) Use a larger focal spot to cover the entire weld<br>(d) Reduce detector gain settings |
| In digital radiographic testing of multi-pass welds, which of the following is a key concern for accurate flaw characterisation? | (a) Filtering images with high saturation<br>(b) Detection of subsurface corrosion<br>(c) Image lag and ghosting in the detector<br>(d) Overlapping indications from multiple passes |
| For critical welds, why is geometric unsharpness ($U_g$) especially important in DRT? | (a) It reduces radiation dose<br>(b) It determines the sharpness and visibility of fine defects<br>(c) It improves detector calibration<br>(d) It enhances image brightness |

## Radiation safety and radiation protection

| Basic Radiation Safety (BRS) – X-ray | |
|---|---|
| Which unit is commonly used to measure radiation dose to personnel? | (a) Gray (Gy)<br>(b) Becquerel (Bq)<br>(c) Sievert (Sv)<br>(d) Curie (Ci) |
| What is the primary purpose of a dosimeter? | (a) Detect leaks in piping systems<br>(b) Measure radiation exposure of a worker over time<br>(c) Control radiation source output<br>(d) Enhance image quality in radiography |
| Which of the following materials is commonly used for radiation shielding? | (a) Glass<br>(b) Ceramic<br>(c) Lead<br>(d) Stainless steel |
| X-rays are a form of which type of energy? | (a) Non-ionising radiation<br>(b) Ionising electromagnetic radiation<br>(c) Alpha particle radiation<br>(d) Thermal radiation |
| Why should X-ray equipment be regularly calibrated and maintained? | (a) To improve image brightness<br>(b) To reduce the need for shielding<br>(c) To ensure accurate dose output and safety compliance<br>(d) To ensure maximum radiation output |

| Basic Radiation Safety (BRS) – X-ray and gamma ray | |
|---|---|
| **What does a controlled area in radiation safety refer to:** | (a) An area where radiation is not used<br>(b) An area where radiation exposure is monitored and restricted<br>(c) A zone for equipment storage only<br>(d) An area where heat energy is monitored |
| **Prolonged radiation exposure below permissible dose limits can still be harmful because:** | (a) It improves eyesight<br>(b) Accumulated doses over time can lead to chronic effects<br>(c) It builds radiation immunity<br>(d) It only affects skin cells, which can regenerate |
| **If an X-ray unit fails to shut off after exposure, what is the first action the operator should take?** | (a) Restart the unit<br>(b) Enter the room and inspect the unit<br>(c) Evacuate the area and notify the Radiation Safety Officer<br>(d) Call maintenance after finishing the inspection |
| **The half-life of iridium-192 is approximately?** | (a) 3 days<br>(b) 74 days<br>(c) 264 days<br>(d) 1 year |
| **The ALARA principle means you should keep your radiation exposure:** | (a) As long as radiation allows<br>(b) As low as reasonably achievable<br>(c) At legal and required amount<br>(d) Always legal and readily available |

| Advanced Radiation Safety (ARS) – X-ray | |
|---|---|
| **A mobile X-ray unit used in field radiography must meet which of the following control and safety interlock requirements?** | (a) Manual override to bypass all alarms<br>(b) No restriction on key access<br>(c) Activation of visual and audible warning signals during exposure<br>(d) Separate power supply and back-up system |
| **In a fixed X-ray installation, which factor most significantly affects scatter radiation levels in adjacent rooms?** | (a) Tube cooling system<br>(b) Distance from generator<br>(c) Wall composition and shielding effectiveness<br>(d) Age of the X-ray unit |
| **The effectiveness of lead shielding is best described by its:** | (a) Colour and density<br>(b) Ability to reflect radiation<br>(c) Half-value layer (HVL) for a specific X-ray energy<br>(d) Thickness in centimetres only |
| **What is the primary biological effect of repeated low-dose exposure to X-rays over time?** | (a) Heat burns or blisters<br>(b) Cataract formation and increased cancer risk<br>(c) Muscle atrophy<br>(d) Bone hardening |
| **A controlled area must be designated when:** | (a) Access needs to be restricted for security reasons<br>(b) The dose rate could exceed 7.5 µSv/h<br>(c) Radiation exposure could exceed 6 mSv/year for workers<br>(d) Any source of radiation is used |

| Advanced Radiation Safety (ARS) – X-ray and gamma ray | |
|---|---|
| What is the primary responsibility of the Radiation Protection Supervisor (RPS) when a gamma source is used on site? | (a) Ensure the image quality is high<br>(b) Approve all radiographic techniques<br>(c) Ensure radiation safety procedures and local rules are followed<br>(d) Ensure gamma source is stored securely after use |
| What does the trefoil radiation warning symbol on a gamma source container indicate? | (a) Chemical hazard<br>(b) Source age<br>(c) Presence of ionising radiation<br>(d) Thermal hazard |
| What is the required response if the transport container for a gamma source is damaged during transit? | (a) Patch the container with tape as a precaution<br>(b) Continue work and replace the container later<br>(c) Notify the regulatory authority and isolate the container<br>(d) Notify the regulatory authority but continue with the inspection using the gamma source |
| A radiographer spends 30 minutes in an area with a dose rate of 2 mSv/h. What total radiation dose does the radiographer receive? | (a) 0.5 mSv<br>(b) 1 mSv<br>(c) 2 mSv<br>(d) 4 mSv |
| The dose rate from a gamma source at a certain distance is 4 mSv/h. What will the dose rate be if you double the distance? | (a) 8 mSv/h<br>(b) 2 mSv/h<br>(c) 1 mSv/h<br>(d) 0.5 mSv/h |

## Ultrasonic testing (UT)

| Level 1 – General theory ultrasonic testing | |
|---|---|
| When a compressional wave is incident on a boundary between two media, the following type of waves may be generated: | (a) Shear wave<br>(b) Compressional wave<br>(c) Surface wave<br>(d) All of the answer listed |
| The equation describing wavelength in terms of velocity and frequency is: | (a) Wavelength = velocity – frequency<br>(b) Wavelength = velocity × frequency<br>(c) Wavelength = velocity + frequency<br>(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<br>(b) 2 MHz<br>(c) 2 kHz<br>(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<br>(b) B-scan<br>(c) C-scan<br>(d) Isometric projection |
| If the difference in echo height between two signals is 50%, this represents a dB difference of: | (a) 20<br>(b) 14<br>(c) 6<br>(d) 2 |

| Level 1 – Specific theory ultrasonic testing – Castings | |
|---|---|
| **What is the maximum permitted difference between successive backwall echoes when testing castings?** | (a) 5 dB<br>(b) 10 dB<br>(c) 15 dB<br>(d) 20 dB |
| **Reduction in backwall echo whilst scanning a casting with a compression wave probe may be caused by:** | (a) Rough surfaces<br>(b) Coarse grain structure<br>(c) Fine porosity<br>(d) All of the answers listed |
| **Before testing a large steel casting, attenuation should be assessed:** | (a) At a single point<br>(b) On the thinnest section<br>(c) At a number of points<br>(d) On the thickest section |
| **What is the most common type of defect found in castings using ultrasonic testing?** | (a) Cracks only<br>(b) Lack of fusion<br>(c) Porosity and shrinkage cavities<br>(d) Lamination |
| **What is the typical frequency range used for UT inspection of castings?** | (a) 0.1-0.5 MHz<br>(b) 0.5-1.0 MHz<br>(c) 2-5 MHz<br>(d) 10-20 MHz |

| Level 1 – Specific theory ultrasonic testing – Welds | |
|---|---|
| **In weld inspection, transverse cracks are best located by:** | (a) Scanning at right angles to the weld axis<br>(b) Scanning parallel to the weld axis<br>(c) Using a compressional probe<br>(d) Immersion testing |
| **A couplant is required in ultrasonic testing to:** | (a) Protect the test material<br>(b) Protect the probe shoe<br>(c) Protect the tester's hands<br>(d) Enable sound energy to pass into the test material |
| **Which part of the ultrasonic equipment produces high-frequency sound waves?** | (a) Display screen<br>(b) Battery<br>(c) Transducer (probe)<br>(d) Couplant |
| **Which wave type is typically used for weld inspection using angle beam testing?** | (a) Longitudinal wave<br>(b) Shear wave<br>(c) Surface wave<br>(d) Lamb wave |
| **In ultrasonic testing, a skip distance refers to:** | (a) Distance the probe must move per scan<br>(b) Distance from probe to backwall<br>(c) Distance between probe position and where beam reflects off the bottom and hits the surface<br>(d) Distance from the defect to weld cap |

| Level 1 – Specific theory ultrasonic testing – Wrought products | |
|---|---|
| **A lack of backwall echo in a wrought plate inspection could indicate:** | (a) Clean, defect-free metal<br>(b) A fine grain structure<br>(c) A large lamination or discontinuity<br>(d) Proper couplant use |
| **Which of the following affects ultrasonic wave speed in wrought materials?** | (a) Colour of material<br>(b) Shape of product<br>(c) Material density and elastic properties<br>(d) Surface coating |
| **A forging with uneven grain structure may affect ultrasonic testing by:** | (a) Increasing surface reflectivity<br>(b) Improving the signal<br>(c) Causing scattering and attenuation of sound waves<br>(d) Preventing defect formation |
| **Which testing technique is best suited for inspecting flat rolled products for laminar flaws?** | (a) Angle beam inspection<br>(b) Surface wave inspection<br>(c) Straight beam inspection<br>(d) Eddy current inspection |
| **In ultrasonic inspection, the term attenuation refers to:** | (a) The angle of wave entry<br>(b) The increase in wave speed<br>(c) The loss of sound energy as it travels through a material<br>(d) The amplification of defect signals |
| **Level 1 – Specific theory ultrasonic testing – Rail 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<br>(b) An air interface between the probe and axle end face would almost completely reflect the ultrasonic waves<br>(c) The crystal will not vibrate if the probe surface is in direct contact with the axle end face<br>(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<br>(b) Obtain the greatest possible sensitivity from the instrument<br>(c) Obtain a reproducible signal<br>(d) None of the answers listed |
| **Moving a probe around the axle end is referred to as:** | (a) Scanning<br>(b) Attenuating<br>(c) Angulating<br>(d) Resonating |
| **Why is ultrasonic testing preferred for detecting defects in rail axles?** | (a) It can detect surface defects only<br>(b) It requires no calibration<br>(c) It is less expensive than magnetic testing<br>(d) It can detect internal defects without damaging the axle |
| **The angle of incidence is:** | (a) Greater than the angle of reflection<br>(b) Less than the angle of reflection<br>(c) Equal to the angle of reflection<br>(d) Not related to the angle of reflection |

| Level 1 – Specific theory ultrasonic testing – Rail | |
|---|---|
| **A possible reason for a total loss of backwall 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 and T hole<br>(b) A horizontal flaw<br>(c) A bonding hole<br>(d) Piping |
| **The primary purpose of the calibration block is to:** | (a) Aid the operator in obtaining maximum back reflections<br>(b) Obtain the greatest possible sensitivity from the instrument<br>(c) Obtain a reproducible signal<br>(d) None of the answers listed |
| **What type of wave is most commonly used in angle-beam ultrasonic inspection of railhead cracks?** | (a) Rayleigh wave<br>(b) Shear wave<br>(c) Surface wave<br>(d) Longitudinal wave |
| **What should a Level 1 technician do if an indication is found during ultrasonic testing?** | (a) Ignore it unless it is large<br>(b) Continue testing and erase the signal<br>(c) Mark the location and report it to a Level 2 or Level 3 technician<br>(d) Grind the area to verify the defect |
| **In ultrasonic testing of rail, what angle is typically used to detect transverse defects in the railhead?** | (a) 0°<br>(b) 45°<br>(c) 70°<br>(d) 90° |
| **Level 2 – General theory ultrasonic testing** | |
| **The angle at which the shear component of an incident beam is refracted at 90° to the normal is called:** | (a) The normal angle of incidence<br>(b) The first critical angle<br>(c) The angle of maximum reflection<br>(d) The second critical angle |
| **As frequency increases in ultrasonic testing, the angle of beam divergence of a given diameter crystal:** | (a) Decreases<br>(b) Remains constant<br>(c) Increases<br>(d) Varies uniformly through each wavelength |
| **The fundamental frequency of a piezoelectric crystal used in ultrasonic probes is a function of:** | (a) Its thickness<br>(b) The velocity of sound in the crystal material<br>(c) Its diameter<br>(d) Both answers (a) and (b) above |
| **Shear waves are generally more sensitive to fine discontinuities for a given frequency than longitudinal waves because:** | (a) The wavelength is shorter<br>(b) Shear waves are not as easily dispersed in the material<br>(c) The direction of particle vibration of shear is more sensitive<br>(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<br>(b) Is deflected with constant acceleration<br>(c) Is deflected with the same velocity as the probe movement<br>(d) Produces four echoes on the screen |

| Level 2 – Specific theory ultrasonic testing – 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<br>(b) 5 milliseconds<br>(c) 2 microseconds<br>(d) 2 milliseconds |
| **The vertical axis of the distance-gain-size (DGS) diagram represents:** | (a) Probe diameter<br>(b) Flat-bottomed hole size<br>(c) Gain<br>(d) Reflector depth |
| **Defect assessment to BS EN 12680-1 for castings examination is based on:** | (a) Zoning<br>(b) Reference reflectors<br>(c) 20 dB drop<br>(d) All of the answers listed |
| **Which of the following methods will quickly assess the size of large areas of shrinkage?** | (a) 6 dB drop<br>(b) 20 dB drop<br>(c) DGS<br>(d) DAC |
| **When ultrasonically testing a casting made from aluminium, what key adjustment is required compared to testing steel?** | (a) Use a higher frequency transducer due to lower attenuation<br>(b) Increase gain to compensate for higher attenuation<br>(c) Use a slower scanning speed<br>(d) Reduce couplant viscosity |
| **Level 2 – Specific theory ultrasonic testing – Welds** | |
| **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 echo dynamic pattern of:** | (a) A smooth planar reflector at oblique incidence<br>(b) A point reflector<br>(c) A smooth planar reflector at normal incidence<br>(d) An irregular reflector at normal incidence |
| **DGS diagrams compare flaw signal amplitudes to:** | (a) Reference blocks<br>(b) Flat-bottomed holes<br>(c) A theoretical maximum<br>(d) Distance amplitude correction (DAC) |
| **Why are angled beam probes commonly used in ultrasonic testing of welds?** | (a) They provide higher resolution images<br>(b) They reduce attenuation in the weld metal<br>(c) They eliminate the need for couplant<br>(d) They allow better detection of planar flaws oriented parallel to the surface |
| **How can you distinguish between a real flaw and a geometric reflector (such as a weld toe or root) in ultrasonic testing?** | (a) Geometric reflectors only appear at certain frequencies<br>(b) Real flaws always produce higher amplitude signals<br>(c) Use multiple scanning angles and positions to compare responses<br>(d) Flaws can only be detected using shear waves |
| **Which of the following conditions would most likely result in a false indication during ultrasonic testing of a weld?** | (a) Using a dual-crystal probe<br>(b) Use of a low-frequency probe<br>(c) Coarse grain structure in the heat-affected zone<br>(d) Using DAC for amplitude comparison |

| Level 2 – Specific theory ultrasonic testing – Wrought products | |
|---|---|
| **The most appropriate method for sizing lamination in rolled plate would be:** | (a) DGS<br>(b) DAC<br>(c) 6 dB drop<br>(d) 20 dB drop |
| **The best probe for inspecting a 2 m-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<br>(b) 25 mm, 2 MHz single crystal<br>(c) 10 mm, 4 MHz twin crystal<br>(d) 25 mm, 5 MHz twin crystal |
| **What is the primary ultrasonic wave mode used for volumetric inspection of forged components?** | (a) Surface waves<br>(b) Lamb waves<br>(c) Longitudinal waves<br>(d) Shear waves |
| **A forging is tested using a 5 MHz longitudinal wave probe, but expected defects are not being detected. Switching to a 2.5 MHz probe improves defect visibility, why?** | (a) Lower frequency increases gain<br>(b) Lower frequency increases resolution<br>(c) Lower frequency reduces sensitivity to porosity<br>(d) Lower frequency improves penetration in attenuative materials |
| **A rolled plate is tested ultrasonically using a 5 MHz straight-beam probe. To detect finer near-surface indications, which change would improve sensitivity?** | (a) Increase the probe frequency to 10 MHz<br>(b) Switch to an angle-beam probe<br>(c) Increase couplant viscosity<br>(d) Use a lower-frequency probe with a delay line |
| **Level 2 – Specific theory ultrasonic testing – Thickness measurement** | |
| **What is the primary purpose of ultrasonic thickness measurement?** | (a) To detect surface roughness<br>(b) To measure the hardness of a material<br>(c) To determine internal cracks<br>(d) To measure the remaining wall thickness of a material |
| **Which type of ultrasonic transducer is typically used for thickness measurement?** | (a) Straight-beam contact transducer<br>(b) Dual-element transducer<br>(c) Immersion transducer<br>(d) Angle-beam transducer |
| **What is the typical frequency range used in ultrasonic thickness gauging?** | (a) 0.1-0.5 MHz<br>(b) 0.5-2 MHz<br>(c) 2-10 MHz<br>(d) 10-50 MHz |
| **If a coating is present on the surface of the material, how can it affect ultrasonic thickness measurement?** | (a) It has no effect<br>(b) It increases sound velocity<br>(c) It eliminates the need for a couplant<br>(d) It may cause incorrect thickness readings |
| **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<br>(b) Surface wave probe<br>(c) Dual-element normal beam probe<br>(d) Captive water column probe |

| Level 2 – Specific theory ultrasonic testing – Rail 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 2.5 m axle?** | (a) 0.0417 seconds<br>(b) 4.17 microseconds<br>(c) 4.17 milliseconds<br>(d) None of the answers listed |
| **The best probe for inspecting a 2 m-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<br>(b) 25 mm, 2 MHz single crystal<br>(c) 10 mm, 4 MHz twin crystal<br>(d) 25 mm, 5 MHz twin crystal |
| **Longitudinal and transverse ultrasonic scanning on an unmachined axle shall take place:** | (a) After final heat treatment<br>(b) Before heat treatment<br>(c) Immediately after forging<br>(d) At any time |
| **Which ultrasonic testing method is most commonly used to detect internal transverse defects in rail axles?** | (a) Surface wave testing<br>(b) Longitudinal wave straight-beam testing<br>(c) Angle-beam testing using shear waves<br>(d) Through-transmission testing |
| **When scanning a hollow axle with an internal UT probe using an angle beam, you detect a signal that shifts position significantly when the probe is rotated. This behaviour most likely indicates:** | (a) A flat-bottomed hole used for calibration<br>(b) A defect with radial orientation<br>(c) A laminar discontinuity<br>(d) A reflection from the bore surface |
| **Level 2 – Specific theory ultrasonic testing – Rail** | |
| **When testing the 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<br>(b) A horizontal reflector<br>(c) Half a hole<br>(d) A bonding hole |
| **In the ultrasonic testing of thermit welds, what flaw in the weld can the tandem rig readily detect?** | (a) Lack of fusion<br>(b) Porosity<br>(c) Horizontal inclusion<br>(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<br>(b) A point reflector<br>(c) A smooth planar reflector at normal incidence<br>(d) An irregular reflector at normal incidence |
| **Which defect is most critical to detect in in-service ultrasonic testing of rails?** | (a) Longitudinal surface scoring<br>(b) Transverse cracks at the railhead<br>(c) Minor pitting due to corrosion<br>(d) Bolt hole elongation |
| **Why are lower-frequency transducers (2-4 MHz) preferred for ultrasonic testing of railheads in service?** | (a) They are more portable and cheaper<br>(b) They increase surface sensitivity<br>(c) They offer better penetration in coarse-grained material<br>(d) They eliminate false indications |

| Level 3 – General theory ultrasonic testing | |
|---|---|
| **For piezoelectric transducers, the general relationship between frequency and transducer thickness states:** | (a) Frequency and transducer thickness are independent<br>(b) Thicker transducers generate lower ultrasonic frequencies<br>(c) Thinner transducers generate lower ultrasonic frequencies<br>(d) None of the answers listed are correct |
| **The half-angle calculation of beam spread to one beam centreline intensity is calculated from:** | (a) $\sin\theta/2 = 1.08v/Df$<br>(b) $\sin\theta = 1.08D/vf$<br>(c) $\sin\theta/2 = 0.56v/Df$<br>(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<br>(b) Enhance resolving power<br>(c) Modify sensitivity<br>(d) Reduce bandwidth |
| **When using focused probes, non-symmetry in a propagated sound beam may be caused by:** | (a) Backing material variations<br>(b) Lens centring or misalignment<br>(c) Porosity in lenses<br>(d) All of the answers listed |
| **The 6 dB drop sizing technique should only be applied to which of the following types of discontinuity?** | (a) Those that are larger than the ultrasonic beam width<br>(b) Those of similar dimensions to the ultrasonic beam width<br>(c) Those that are smaller than the ultrasonic beam width<br>(d) Any size of discontinuity |
| **Level 3 – Specific theory ultrasonic testing – Castings** | |
| **A through-wall welded repair in a 30 mm-thick casting is tested using a 60° 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<br>(b) 12.5 mm from the test surface<br>(c) 1.5 mm from the opposite surface<br>(d) 26 mm from the opposite surface |
| **Which of the following is the most significant ultrasonic limitation when inspecting castings made of austenitic stainless steel?** | (a) Lack of sufficient sensitivity to small defects<br>(b) Generation of spurious surface wave indications<br>(c) Highly attenuative and anisotropic grain structure<br>(d) Inability to couple with surface due to oxide layer |
| **When using ultrasonic testing to inspect a large steel casting, you notice a 'snowy' or 'grass-like' A-scan display with no clear flaw or backwall echo. What is the most likely explanation?** | (a) Electrical noise from instrumentation<br>(b) High concentration of micro-shrinkage porosity<br>(c) Probe wedge contamination<br>(d) Incorrect pulse repetition rate |
| **In ultrasonic testing of castings, time-corrected gain (TCG) or distance amplitude correction (DAC) is used to:** | (a) Eliminate surface noise caused by oxide layers<br>(b) Account for material velocity variations across the casting<br>(c) Normalise signal amplitude across varying depths<br>(d) Automatically classify detected indications |
| **In ultrasonic inspection of large castings, which scanning strategy is most effective for detecting centrally located volumetric shrinkage?** | (a) Straight-beam longitudinal wave scanning from multiple surfaces<br>(b) Angle-beam inspection from the casting edge<br>(c) Immersion testing using 70° shear waves<br>(d) Surface wave inspection along casting faces |

| Level 3 – Specific theory ultrasonic testing – Welds | |
|---|---|
| In ultrasonic testing of welds, why might time-corrected gain (TCG) be preferred over distance-amplitude correction (DAC) when evaluating defects over a large depth range? | (a) TCG provides higher-resolution images<br>(b) DAC cannot be used with phased array systems<br>(c) TCG allows real-time amplitude compensation and dynamic sensitivity adjustment<br>(d) DAC is only valid for angle-beam inspections |
| Which condition is most likely to cause a false indication during weld inspection with angle-beam shear waves? | (a) Root concavity<br>(b) Coarse-grain weld cap<br>(c) Sidewall misalignment<br>(d) Mode conversion at a weld bevel |
| A Level 2 UT technician asks for Level 3 input after detecting an unusual signal during weld inspection. The signal appears at the same depth as the weld bevel but shifts with probe angle. How should the Level 3 approach the issue first? | (a) Reject the weld immediately<br>(b) Switch to surface wave technique for confirmation<br>(c) Review calibration and scan plan to rule out geometric reflections<br>(d) Increase gain by 20 dB and rescan the area |
| A technician performs weld inspection using a 60° shear wave and identifies an indication with consistent amplitude but no corre-sponding backwall echo loss. What type of defect is most likely? | (a) Volumetric inclusion<br>(b) Planar root crack<br>(c) Lack of sidewall fusion<br>(d) Slag trapped at the weld cap |
| For angle-beam ultrasonic testing of a weld, the critical angle determines: | (a) The wedge's acoustic impedance<br>(b) The angle at which total internal reflection occurs<br>(c) The separation of longitudinal and shear waves in the material<br>(d) The point where mode conversion begins |
| **Level 3 – Specific theory ultrasonic testing – Wrought products** | |
| In ultrasonic testing of rolled plate, which type of flaw is most likely to be missed if scanning is performed only in the direction of rolling? | (a) Subsurface inclusions<br>(b) Flat-bottom holes<br>(c) Laminar discontinuities aligned with the rolling direction<br>(d) Cracks transverse to the rolling direction |
| A 10 MHz probe produces a noisy, irregular signal when testing a heavy wrought bar. Which of the following actions would best improve signal-to-noise ratio without losing flaw sensitivity? | (a) Increase the test frequency<br>(b) Reduce the damping in the probe<br>(c) Switch to a dual-element probe at a lower frequency<br>(d) Increase gain and use an immersion tank |
| For ultrasonic inspection of wrought aluminium alloys, which flaw type is most challenging to detect due to acoustic impedance mismatch? | (a) Oxide inclusions<br>(b) Delamination<br>(c) Shrinkage cavities<br>(d) Porosity |
| A straight-beam pulse-echo inspection of a wrought steel bar reveals a repeating echo pattern at equal intervals. What should be suspected? | (a) Scattered porosity<br>(b) Backwall reflections from internal lamination<br>(c) Multiple echoes from a flat flaw<br>(d) Sidewall reflections in a round geometry |
| What is the main advantage of using a dual-element transducer when testing near surface regions of wrought products? | (a) Allows use of higher gain without distortion<br>(b) Enables a focused beam without a wedge<br>(c) Minimises near-surface dead zone and improves resolution<br>(d) Produces longitudinal and shear waves simultaneously |

| Level 3 – Specific theory ultrasonic testing – Rail axles | |
|---|---|
| What is the most suitable ultrasonic technique for detecting transverse fatigue cracks in a solid railway axle bore? | (a) 0° longitudinal wave from the axle body<br>(b) Immersion testing using a surface wave probe<br>(c) Angle-beam shear wave introduced from the end face<br>(d) Axial scanning using longitudinal wave with echo technique from inside the bore |
| Which material characteristic of forged steel axles most significantly influences probe frequency? | (a) Thermal conductivity<br>(b) Magnetic permeability<br>(c) Acoustic impedance<br>(d) Grain size and structure |
| 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<br>(b) 15 mm below the turning centre<br>(c) Adjacent to the turning centre<br>(d) Equal distance between the turning centre and the axle edge |
| A UT system designed for in-service axle inspection uses rotating scanning heads. What is the primary reason for rotating the transducer rather than the axle? | (a) To improve signal-to-noise ratio<br>(b) To avoid removing the axle from the bogie<br>(c) To increase scan coverage speed<br>(d) To allow phased array implementation |
| When conducting ultrasonic testing on wheel seat fillets of axles, what is the most common limitation of using fixed-angle probes? | (a) Inability to detect inclusions<br>(b) Oversensitivity to shallow porosity<br>(c) Limited coverage due to complex geometry<br>(d) High energy loss due to acoustic impedance mismatch |
| **Level 3 – Specific theory ultrasonic testing – Rail** | |
| What is the most critical factor in selecting ultrasonic transducer frequency for detecting transverse defects in heavy rail sections? | (a) Surface finish of the railhead<br>(b) Expected flaw orientation and grain structure<br>(c) Rail hardness profile<br>(d) Electrical conductivity of the rail steel |
| In rail ultrasonic testing, a transverse defect in the head is most effectively detected using which technique? | (a) Straight-beam inspection from the rail foot<br>(b) Angle-beam shear wave introduced from the railhead<br>(c) Surface wave propagation along the rail web<br>(d) Longitudinal wave pulse-echo from the rail base |
| A Level 3 inspector is reviewing scan data that shows intermittent signals at the rail foot. What is the first step in evaluating whether these are relevant indications? | (a) Increase gain by 6 dB and rescan<br>(b) Check equipment for electrical interference<br>(c) Verify angle of incidence and probe coupling<br>(d) Discard the data and repeat the inspection |
| 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<br>(b) 40% FSH<br>(c) 50% FSH<br>(d) 60% FSH |
| When testing jointed rail, an echo signal may not be received from one of the fishplate holes because: | (a) It is not round<br>(b) The bolt is an interference fit<br>(c) The hole has been 'burnt in'<br>(d) The bolt is missing |

**Phased array ultrasonic testing (PAUT)**

| Level 1 – Specific theory phased array ultrasonic testing – Welds | |
|---|---|
| **Calibration of any phased array beam to be code compliant shall include:** | (a) Adjusting angular sweep after sensitivity calibration<br>(b) Use of thixotropic couplant<br>(c) Adjustment of screen display format<br>(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<br>(b) Actual reproductions of flaw shape and size<br>(c) An artistic impression of the scanned test-piece<br>(d) Finitely precise |
| **Which of the following effect data collection speed:** | (a) Pulse repetition frequency (PRF)<br>(b) Collection step<br>(c) Number of focal laws<br>(d) All of the answers listed |
| **In phased array testing, the process of changing the angle of the ultrasonic beam electronically is known as:** | (a) Beam focusing<br>(b) Beam steering<br>(c) Beam deflection<br>(d) Beam divergence |
| **The term 'sectorial scan' (S-scan) refers to:** | (a) A scan where the beam angle is varied to cover a range of angles<br>(b) A scan that moves the probe linearly across the surface<br>(c) A scan performed at a fixed angle<br>(d) A scan used only for thickness |
| **Level 2 – Specific theory phased array ultrasonic testing – Welds** | |
| **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<br>(b) Reducing the increment between the angular steps<br>(c) Increasing the array aperture<br>(d) Using dynamic depth focusing |
| **Sizing principles of phased array data rely upon:** | (a) Changes in amplitude<br>(b) Colour palette selection<br>(c) Fast Fourier transform (FFT) analysis<br>(d) Orientation of the echo-dynamic envelope |
| **Which of the following factors affect the extent of beam steering?** | (a) Pitch between elements<br>(b) Width of elements<br>(c) Mumber of elements excited<br>(d) All of the answers listed |
| **When interpreting a PAUT image, a planar indication (for example lack of fusion) will usually appear as:** | (a) A broad, low-amplitude reflection with random orientation<br>(b) A rounded, low-frequency echo<br>(c) A narrow, high-amplitude indication with consistent orientation along the weld fusion line<br>(d) A cluster of scattered signals |
| **The main function of a C-scan in PAUT data presentation is to:** | (a) Display depth *versus* amplitude<br>(b) Provide a top-view plan map of indications<br>(c) Show time-of-flight *versus* distance<br>(d) Represent angle coverage |

| Level 3 – Specific theory phased array ultrasonic testing – Welds | |
|---|---|
| **Which of the following features is principally attributed to the pitch between elements in an array design?** | (a) Sensitivity at the point of focus<br>(b) Far-surface resolution<br>(c) Position and magnitude of grating lobes<br>(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<br>(b) Electronic adjustment of the received impulse delays computed to account for changes in acoustic range<br>(c) Use of low-power focusing to increase the depth of field over which focus can be maintained<br>(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:**<br>• 32 elements excited, 0. 5 mm element width, 1 mm pitch, 5 MHz, no wedge, material velocity 5.9 mm/µs | (a) 217 mm<br>(b) 478 mm<br>(c) 488 mm<br>(d) 625 mm |
| **When interpreting a PAUT image, a creeping wave indication typically appears:** | (a) At the back wall only<br>(b) At the weld root only<br>(c) As a vertical indication in the centre of the weld<br>(d) At shallow depth near the top surface |
| **When developing a phased array inspection procedure, the beam modelling process is used to:** | (a) Create synthetic A-scans for calibration<br>(b) Verify software licensing<br>(c) Predict beam paths, coverage and sensitivity zones within the weld geometry<br>(d) Determine the number of focal laws to store |

## Time-of-flight diffraction (TOFD)

| Level 1 – Specific theory time-of-flight diffraction ultrasonic testing – 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<br>(b) Gives more efficient tip diffraction<br>(c) Enables weak signals to be recognised<br>(d) Provides only longitudinal wave patterns |
| **What angle will give a poor tip diffraction response?** | (a) 38°<br>(b) 45°<br>(c) 50°<br>(d) 60° |
| **Does the lateral wave:** | (a) Follow the surface contour<br>(b) Change mode and travel as a shear wave<br>(c) Follow the path that takes the minimum time<br>(d) Reflect from the back wall |
| **What is the lateral wave time of a PCS of 25 mm focus with 60° wedges?** | (a) 5.902 µsecs<br>(b) 6.745 µsecs<br>(c) 7.336 µsecs<br>(d) 14.671 µsecs |
| **Why are the shear wave signals collected during TOFD inspection?** | (a) They are useful for seeing off-axis reflectors<br>(b) Spreads out the signals in time more<br>(c) Provides a different wavelength<br>(d) All of the answers listed |

| Level 2 – Specific theory time-of-flight diffraction ultrasonic testing – Welds | |
|---|---|
| **Which of the following probe pairs would give greatest material volume coverage in one scan? Assume identical crystal diameters and frequencies.** | (a) 38°<br>(b) 45°<br>(c) 60°<br>(d) 70° |
| **For TOFD inspection of thick welds, lower-frequency probes are used because:** | (a) They improve near-surface resolution<br>(b) They increase penetration and reduce scattering<br>(c) They enhance the lateral wave signal<br>(d) They reduce beam divergence |
| **A root crack in a weld will usually produce:** | (a) A single diffracted signal below the lateral wave<br>(b) Two distinct tip-diffracted signals (upper and lower tip)<br>(c) A reflection from the back wall<br>(d) No signal at all |
| **Poorest sensitivity to detection of bottom edge diffraction is at a refracted angle of approximately:** | (a) 38°<br>(b) 47°<br>(c) 55°<br>(d) 63° |
| **TOFD is least effective for detecting defects:** | (a) Near the surface (close to the lateral wave)<br>(b) In the weld root<br>(c) In the heat-affected zone<br>(d) Oriented perpendicular to the beam |
| **Level 3 – Specific theory time-of-flight diffraction ultrasonic testing – Welds** | |
| **Calculate the overall timing of a bottom-diffracted signal given the following information:**<br>Material velocity: 5960 m/s<br>Tx 9.2 µs (pulse-echo measured)<br>Rx 8.2 µs (pulse-echo measured)<br>PCS 58 mm (at probe shoe index)<br>Depth from scan surface to bottom of flaw: 37 mm | (a) 24.5 µs<br>(b) 33 µs<br>(c) Insufficient information is given to calculate<br>(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) ± 0.3 mm<br>(b) ± 0.5 mm<br>(c) ± 1 mm<br>(d) ± 4 mm |
| **Derive the material depth encompassed by a lateral wave given the following:**<br>Velocity m/s longitudinal; 3230 m/s transverse<br>Probe frequency 7 MHz<br>PCS 70 mm<br>Pulse duration 2.5 cycles<br>Wedge angle 60° | (a) 2.12 mm<br>(b) 8.7 mm<br>(c) 11.7 mm<br>(d) Not enough information given |
| **In TOFD, the sound path geometry is primarily determined by:** | (a) The probe separation and refracted angle<br>(b) The gain and time gate settings<br>(c) The amplitude of the lateral wave<br>(d) The couplant film thickness |
| **If the backwall echo appears curved in the TOFD B-scan image, this most likely indicates:** | (a) Velocity heterogeneity across the weld thickness<br>(b) Incorrect probe alignment relative to the weld centreline<br>(c) Incorrect wedge refracted angle<br>(d) Excessive lateral wave attenuation |

## Visual testing (VT)

| Level 1 – General theory visual testing | |
|---|---|
| **Fibre-optic systems work on which of the following principles?** | (a) Reflection<br>(b) Refraction<br>(c) Diffraction<br>(d) Reticulation |
| **Resolution is the ability to see which of the following?** | (a) The smallest flaw possible<br>(b) Two flaws adjacent to each other as one<br>(c) Two flaws adjacent to each other as separate flaws<br>(d) A large flaw at a distance of over 3 m |
| **What is the minimum angle in relation to the test surface that visual examination can be carried out at?** | (a) 0°<br>(b) 30°<br>(c) 60°<br>(d) 90° |
| **Stereoscopic vision is limited to magnification factors less than ____________ when using singular magnification lenses.** | (a) None<br>(b) × 2<br>(c) × 5<br>(d) × 10 |
| **The most important requirement for performing effective visual testing is:** | (a) Expensive optical equipment<br>(b) Use of X-rays<br>(c) Adequate lighting and clean surface conditions<br>(d) Magnetic fields |
| **Level 1 – Specific theory visual testing** | |
| **A measured amount of undercut is detected that is allowable when referenced to an acceptance criterion. This undercut is therefore described as:** | (a) A defect<br>(b) An indication<br>(c) A flaw<br>(d) None of the answers listed |
| **Which of the following weld defects would be visually detectable on a completed weld?** | (a) Lack of inter-run fusion<br>(b) Subsurface porosity<br>(c) Lack of sidewall fusion<br>(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 30 cm<br>(b) Type No 1 at 60 cm<br>(c) Type No 2 at 30 cm<br>(d) Type No 2 at 60 cm |
| **Before performing a visual inspection on a casting, the surface should be:** | (a) Painted to increase contrast<br>(b) Polished to a mirror finish<br>(c) Cleaned of sand, scale, oil and dirt<br>(d) Left as cast |
| **Which of the following equipment is used to inspect internal surfaces of hollow castings or pipes?** | (a) Flashlight<br>(b) Borescope<br>(c) Magnetic yoke<br>(d) Ruler |

| Level 2 – General theory visual testing | |
|---|---|
| If objects are viewed with both eyes then it is termed: | (a) Dual vision<br>(b) Monocular vision<br>(c) Binocular vision<br>(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<br>(b) Blind spot<br>(c) Rod<br>(d) Cone |
| As magnification increases the focal distance will: | (a) Increase<br>(b) Stay the same<br>(c) Decrease<br>(d) Either increase or decrease |
| Direct visual examinations may be carried out using which of the following: | (a) Borescope<br>(b) Mirrors<br>(c) Fibrescope<br>(d) All of the above |
| Excessive glare from a polished surface can be minimised by: | (a) Using a high-lumen spotlight<br>(b) Direct perpendicular lighting<br>(c) Diffused or angled lighting<br>(d) Increasing magnification |
| **Level 2 – Specific theory visual testing** | |
| 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°<br>(b) 60 cm; 30°<br>(c) 30 cm; 45°<br>(d) 30 cm; 30° |
| A convex mirror may be used to: | (a) Magnify the object<br>(b) Increase the field of view<br>(c) Decrease the field of view<br>(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<br>(b) Rigid borescope<br>(c) Fibrescope<br>(d) Pit gauge |
| The function of the cornea is to: | (a) Refract and focus incoming light<br>(b) Regulate colour perception<br>(c) Control light intensity<br>(d) Allow for contraction of the iris |
| In low light conditions, the human eye loses sensitivity to which colour? | (a) Red<br>(b) Blue<br>(c) Green<br>(d) All of the above |

| **Level 3 – General theory visual testing** | |
|---|---|
| **To what wavelength of radiation is the human eye most sensitive?** | (a) 320 nm<br>(b) 400 nm<br>(c) 4200 angstroms<br>(d) 5750 angstroms |
| **The complete dark adaptation of the human eye typically takes:** | (a) 1-2 minutes<br>(b) 5-10 minutes<br>(c) 20-30 minutes<br>(d) over 60 minutes |
| **Visual acuity is primarily limited by:** | (a) Pupil size alone<br>(b) Lens curvature alone<br>(c) Photoreceptor spacing, illumination and contrast<br>(d) Retinal blood supply |
| **Chromatic aberration occurs because:** | (a) Different wavelengths of light focus at different points<br>(b) Light intensity is too high<br>(c) The object is not aligned properly<br>(d) The light intensity is too low |
| **The numerical aperture (NA) of a lens system affects:** | (a) Only depth perception<br>(b) Colour contrast only<br>(c) Viewing distance<br>(d) Resolution and light-gathering ability |
| **Level 3 – Specific theory visual testing** | |
| **Which of the following systems offers the best resolution?** | (a) Charge-coupled device (CCD) camera<br>(b) CCTV<br>(c) Videoscope<br>(d) Photography |
| **For detecting weld undercut, the most effective method is:** | (a) Viewing at 90° with bright light<br>(b) Using red light only<br>(c) Reducing magnification<br>(d) Oblique angle inspection with side lighting |
| **Which part of the eye is primarily responsible for the fine detail recognition required in visual testing?** | (a) Cornea<br>(b) Lens<br>(c) Fovea centralis<br>(d) Optic nerve |
| **Which type of light is least effective for visual inspection of welds and castings?** | (a) Directional light-emitting diode (LED)<br>(b) Fluorescent angled<br>(c) Diffused UV light<br>(d) Polarised halogen |
| **According to BS EN 13018, what is the minimum illumination level required for general visual testing?** | (a) 50 lux<br>(b) 160 lux<br>(c) 200 lux<br>(d) 500 lux |

## Change control record

| PCN24/GEN/Appendix Z2 – Document issue and review status | | |
|---|---|---|
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