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SYLLABUS COMPENDIUM FOR PCN AEROSPACE SECTOR EXAMINATIONS

CONTENTS

SECTOR SPECIFIC AEROSPACE PRODUCT TECHNOLOGY THEORY

This examination is common to all PCN aerospace Level 2 and Level 3 examinations except for those covering radiography of aerospace welds, which is provided separately under that heading.

The depth of knowledge required is deeper for levels 3, but for all levels is such that the candidate will be capable of understanding the description of potential defects and their likely locations as specified in NDT instructions and procedure; describing unambiguously in NDT reports the nature and location of what has been found such that the non-NDT engineer can gain an accurate appreciation of the condition of the inspected area.

Aerospace Materials and Components

- Basic Casting Production Methods - Finished Products. Sand casting; die casting; investment casting.
- Basic defects associated with cast products and their appearance: shrinkage; sinks; cold shuts; porosity; laps; hot tears; cracks.
- Wrought products forming processes: cold rolling; open forging and press forging; closed die forging; extrusion.
- Defects associated with wrought product forming processes and their appearance: rolling defects; forging bursts; laps; seams; cracks.
- Heat treatment: annealing; normalising; stress relieving.

Aerospace Materials Components and Structures

- All of the above, and in addition candidates will be required to demonstrate a basic understanding of assembly and fastening technology, and defects associated with aerospace structure.
- Assembly of structure. Knowledge of terms: primary and secondary structure; spars; ribs; frames; longerons; stringers; skin; multi-layer assembly; composite assemblies.
- Fastening methods. Knowledge of terms: threaded fasteners: rivets; bonding; brazing; welding.
- Defects. Knowledge of terms. Origins, nature and appearance of defects related to structures: fatigue cracking; stress corrosion cracking; corrosion; intergranular stress corrosion; exfoliation corrosion; surface pitting; differential metal corrosion; fretting.
- The effects of corrosive substances on aircraft materials, eg. mercury.
- Foreign object damage (FOD) and loose articles.

EDDY CURRENT TESTING OF AEROSPACE MATERIALS COMPONENTS & STRUCTURE

LEVEL 2

EDDY CURRENT GENERAL THEORY

- History of Eddy Current Testing
- Terms and Definitions in Eddy Current Testing
- Electrical Theory
- Basic principles of DC and AC theory: Ohms Law, power formulae; alternating current simple circuits, impedance, frequency, phase relationships.
- Basic principles of magnetisation: Magnetic effect of current flow, magnetic field intensity, hysteresis loop, permeability.
- Principles of Eddy Currents
- Simple circuits: Series and parallel resonance, Bridge circuits.
- Coils and coil arrangements. Inducing eddy currents by coil. The effects of frequency. Impedance diagrams.
- Factors affecting the eddy current field
- Effective depth of penetration and factors affecting penetration, test coil information from impedance, coupling and phase change; phase analysis.
- Eddy Current equipment
- Basic types of eddy current instruments. Coil arrangements and types of coil; in-depth principles of probe design; types of circuits including bridge and resonance; construction of eddy current probes.
- Comparison with other NDT methods
- Advantages and disadvantages of the eddy current method. Sensitivity in eddy current testing.

EDDY CURRENT SECTOR SPECIFIC THEORY

Preparation for Testing

- Surface preparation; Methods used for surface preparation; Importance of correct surface preparation.
- Techniques: probe characteristics and selection; factors affecting sensitivity; selection of equipment; lift-off compensation; design and application of test reference standards; selection of frequency; low frequency systems; multi-frequency systems; limitations of the various methods and types of test equipment; examples of when to use various techniques; selection of the appropriate technique to ensure complete coverage.
- Methods of assessing sensitivity of technique.

Test Procedures

- Test Procedure - reasons for NDT instructions and general contents required.
- Correct use of meter and CRT instruments: Impedance change instruments including conductivity measurement, coating thickness measurement and crack detection; phase change instruments including volumetric measurement and crack detection; methods of presenting information.
- Probes and calibration standards. Selection of probes for surface and bolt hole inspection; advantages and disadvantages of differential and absolute probes. Probe handling factors which can affect indications.

Detectability of Defects

- Advantages and limitations of the test method with regard to defect detection.

- Characteristics of indications.
- Basic metallurgical factors that can affect eddy current readings.
- Types of discontinuity and their identification.
- Relevant, non-relevant and false indications and their cause.
- Interpretation of indications.
- Equipment faults, causes and corrective actions. Off scale readings on instrument, reasons and corrective actions.

Presentation and reporting of inspection results

Standards and Specifications

- See essential reading list.

LEVEL 3

- Level 3 personnel are expected to be competent to assume the responsibilities of management of an industrial NDT facility. The PCN level 3 examination will therefore include questions designed to evaluate the candidate's knowledge of the following subjects:
- Allocation of staff with appropriate certification according to customer's requirements. Supervision and maintenance of subordinate's certification and recertification documents and records.
- Compilation of records of equipment performance, repairs and maintenance; the work done and results achieved by supervised staff. The review of reports of work done by subordinates, its periodic validation, and the endorsement of routine reports. Review of current practices, equipment, techniques and instructions. Maintenance of standards and text book libraries. Safe working practices and current legislation.
- The detailed examination syllabus follows.

Eddy Current General Theory

- Candidates will be required to be familiar with all the content of the theoretical and practical syllabi for level 2 and, in addition:

General Theory at Level 2 of Other NDT Methods

- A knowledge of the level 2 General Theory, limitations and applications of the principal alternative methods of NDT to eddy current testing is required. The examination syllabi are detailed in various documents obtainable from PCN.
- In detail, the level 3 candidate will be required to demonstrate a knowledge of the General Theory syllabus for MT, PT, and UT or RT, as well as ET.

Knowledge of PCN Requirements

- Knowledge of the current edition of the PCN Requirements for the certification of Aerospace NDT personnel.

Eddy Current Sector Specific Theory

- All of the combined syllabus for PCN Eddy Current Tester (Aerospace) Level 2, and in addition:
- Flaw sizing systems: Knowledge of the currently used systems for defect sizing.
- Alternative methods of data presentation. Methods of digital data-processing and recording. Paper chart recorders.
- Multi-frequency testing.
- Codes for Testing and Flaw Acceptance Limits.
- Familiarity with the criteria in codes and standards covering the application of eddy current testing in the Aerospace sector. An understanding of the way in which these are applied in practice.

2.6 Sector Specific Practical – Eddy Current Procedure Writing

- Candidates will be required to produce a written procedure for the inspection of a specified component to a provided code or standard. PCN publishes a document, CP25, for information and for use by candidates in this open book examination.

  NOTE: Codes and standards of other national (or international) origins may be proposed by candidates, if appropriate to their job responsibilities, for use in this examination module. Candidates should notify the test centre of their choice on the enrolment form and will be permitted to bring a copy of the chosen code or standard to the test centre for use in this open book examination.

- The procedure must include safety requirements appropriate to the test situation, acceptance levels to specified application standards, NDT personnel approvals, reference documentation, the use of complementary NDT methods, the timing of inspection in relation to manufacture and overhaul, special contractual requirements, action to be taken in case of non-compliance and reporting instructions (implementation of the procedure).

REFERENCE LITERATURE

Essential Reading

- BS EN 1330-1: Non-destructive testing-Terminology – Part 1 List of general terms
- BS EN 1330-2: Non-destructive testing – Terminology – Part 2: Terms common to the non-destructive testing methods
- BS EN ISO 12718: Non-destructive testing. Eddy current testing. Vocabulary
- BS M 38: Guide to compilation of instructions and reports for the in-service Non- Destructive Testing of Aerospace Products.
- Product Technology Classroom Training Handbook. Obtainable from the Certification Services Division, The British Institute of Non-Destructive Testing, Newton Building, St George's Avenue, Northampton NN2 6JB.
- Training Course Notes. PCN requires candidates to have attended an approved course of training. Accredited Training Establishments are required to provide trainees with an up-to-date set of training course notes. These are considered essential reading.

Recommended Reading

- Civil Aviation Airworthiness Inspection Procedures Part 4 leaflet 4.8.
- Basic Metallurgy for Non-Destructive Testing, Edited by J L Taylor: The British Institute of Non-Destructive Testing, Newton Building, St George's Avenue, Northampton NN2 6JB.
- American Society for Metals - 'Non-destructive Inspection and Quality Control : Metals Handbook' Vol II. Metals Park, Ohio.
- Materials and Processes for NDT Technology. ASNT.
- Eddy Current Testing, Classroom Training Handbook (CT-6-5): ASNT.
- Eddy Current Testing, Programmed Instruction Handbook (PI-4-5): ASNT.
- Non-Destructive Testing Handbook, Volume 4 - Electromagnetic Testing. ASNT.
- Non-Destructive Testing (Second Edition 1991) by R Halmshaw. Edward Arnold.
- Non-Destructive Testing Handbook, First edition. Edited by R McMaster.
- ASNT Self Study Handbook (originally published by General Dynamics).
- ASNT Classroom Training Handbook (originally published by General Dynamics).
- ASNT Question and Answer book.
- ASNT Level III Study Guide.
- ASNT Student Package.
- ASNT Instructor Package (overheads for training).

ULTRASONIC TESTING OF AEROSPACE MATERIALS COMPONENTS & STRUCTURE

LEVEL 1

Although there are currently no level 1 examinations available in the aerospace sector, the level 2 examination syllabus includes that for level 1 and the level 1 syllabus is therefore included herein since the depth of knowledge required increases from level 1 through level 2 to level 3.

ULTRASONIC GENERAL THEORY

- Introduction - essential features of ultrasonic testing. Generation of ultrasonic waves.
- Electromagnetic transducers (piezo electric, magnetostrictive and electrodynamic). Properties of the transducer (nominal and working frequency, bandwidth). Effect of different transducer materials.
- Wave properties - types of wave, vibration, waves, sound waves, continuous wave, pulse. Units, relationship between frequency, velocity and wavelength.
- Principles of reflection and transmission of sound waves at perpendicular incidence. Effect of coupling media on transmission. Acoustic impedance.
- Principles of reflection and refraction of sound waves at inclined incidence. Factors affecting angles of reflection, refraction and mode conversion.
- Effect of reflector on echo response. Sound field - influence of frequency, sound velocity and size of transducer. Estimate of near field, far field and beam divergence.
- Influence of properties of test object on sound propagation, sound velocity and attenuation. Definition and use of decibel.
- Equipment construction and mode of operation.
- Block diagram of an ultrasonic instrument with single and double transducer, controls and functions of ultrasonic instrument. Signal presentation - A, B, C scans.
- Types of probe - normal beam, single and twin crystal, angle beam. Construction and mode of operation. Probe index. Beam angle. Squint.
- Scanning techniques - manual, semi-automatic, automatic.
- Testing Techniques (basic principles): Pulse-echo technique, measured values (transmit time, echo amplitude), advantages and limitations; Contact scanning - couplant, protective layer; Gap scanning; Immersion testing; Through-transmission technique, measured value (intensity), advantages and limitations. Application of compression and shear waves.
- Calibration of Testing Systems: Timebase calibration - normal, single and twin crystal and angle beam probes.
- Calibration blocks and reference blocks. Calibration checks. Effect of different sound velocities in calibration block and test piece.
- Measurement of wall thickness and flaw position using normal and angle beam probes.
- Sensitivity setting - simple methods, BWE, DAC. Sensitivity and signal to noise ratio; sensitivity and pulse duration.
- Effect of surface finish, geometry and attenuation in specimen.

ULTRASONIC SECTOR SPECIFIC THEORY

- Detectability of Defects; advantages and limitations of the test method with regard to defect detection.
- Factors Affecting the Performance of the Ultrasonic Test. Mechanical properties of the material, attenuation. Geometry of the specimen. Surface condition.
- Codes of Practice and Standards (See essential reading list).

- Conducting and Recording the Test.
- Routine calibration of equipment. Procedure to be adopted to carry out the test. Information to be recorded on the report. Flaw assessment, sizing techniques and reporting.

LEVEL 2

ULTRASONIC GENERAL THEORY

All of the general theory for level 1 and, in addition:

Physical Principles of Ultrasonic Testing

- Behaviour of sound wave for perpendicular incidence. Acoustic impedance. Reflection and transmission factors. Calculations of reflected and transmitted energy.
- Behaviour of sound wave for inclined incidence. Snell's Law concerning reflection, refraction and mode conversion. Critical angles. Calculations.
- Interpretation and prediction of boundary echoes. Time base position of mode converted echoes under known conditions.
- Influence on sound waves of reflector size (reflection, scatter, refraction, interference).
- Reflection at defined reflectors. Laws concerning distance and size of backwall echo, side drilled hole and disc reflectors. Comparison with real flaws.
- Sound field. Calculation and estimation of near field, far field and beam spread.
- Influence of properties of specimen on sound propagation, attenuation, cause, effect and measurement, attenuation coefficient. Surface shape and condition. Sound velocity, cause, effect and measurement.

Equipment

- Probe construction and mode of operation. Special probes, double crystal angle probes, focused probes, probes with different damping.
- Measurement of resolving power of angle probes. Correlation between resolution, frequency, penetrating power and damping.
- Amplifier characteristics, broad and narrow band, logarithmic, saturation, linearity, suppression, DAC correction.
- Signal presentation. Deeper knowledge of automatic test systems.

ULTRASONIC SECTOR SPECIFIC THEORY

Calibration of Testing Systems

- Timebase calibration - projected distance, shortened projected distance. Thin wall, curved surfaces, effect of different materials.
- Construction of reference lines and calibration of sensitivity with reference to backwall echo, side drilled hole, flat bottomed hole. Reference block and DGS methods.
- Measurement of the differences for surface condition and attenuation between test piece and reference block. Correction for transfer (coupling, attenuation) correction for attenuation depending on path length, correction for near surface defects.

Detectability of Defects

- Advantages and limitations of the test method with regard to defect detection.
- Tandem techniques, transmission techniques, causes of spurious indications and other signals not associated with defects, selection of method for accurate sizing of defects.
- Types of signal from typical flaws. Errors in defect size/measurement.
- Influence on techniques of geometry, size, surface condition, metal composition, structure. Influence of surface coatings, heat treatments and repairs.

Factors Affecting the Performance of the Ultrasonic Test

- Relationship between properties of the material, condition, attenuation and sound velocity. Testing of materials with differing attenuation characteristics, including austenitic steels. Selection of probe type, frequency and angle.
- Preparation of test surface. Selection of couplant and method.
- Influence of defect type, position and orientation on detection, eg. size, geometry, distance from surface, orientation, reflectivity and opacity.

Codes of Practice and Standards

- See essential reading list.
- Establishing of testing instructions considering application, equipment, technique, probes, calibration, operation of test, recording of test results.

Conducting and Recording the Test

- Procedure to be adopted to carry out the test. Information to be recorded on the report including sensitivity levels. Flaw assessment and reporting.

Interpretation of Test Results

- Interpretation of test results to acceptance standards.

LEVEL 3

- Level 3 personnel are expected to be competent to assume the responsibilities of management of an industrial NDT facility. The PCN level 3 examination will therefore evaluate the candidate's knowledge of the following:
- Allocation of staff with appropriate certification according to customer's requirements. Supervision and maintenance of subordinate's certification and recertification documents and records.
- Compilation of records of equipment performance, repairs and maintenance; the work done and results achieved by supervised staff. The review of reports of work done by subordinates, its periodic validation, and the endorsement of routine reports.
- Review of current practices, equipment, techniques and instructions. Maintenance of standards and text book libraries. Safe working practices and current legislation.

ULTRASONIC GENERAL THEORY

- Candidates will be required to be familiar with all the content of the theoretical and practical syllabi for level 2 and, in addition:

Alternative methods of data presentation

- current examples include B, C and D scan systems, and Time of Flight Diffraction (TOFD), and methods of digital data-processing.

Alternative probe arrangements

- The purpose, construction and performance of twin crystal probes. Special arrays for detection of near surface defects. Probes with focused crystals. Probes with wide band frequency reception.
- The effective range of the above probes, comparative sensitivity to given reflectors and establishment of principal characteristics of beam spread, distance amplitude response curves and sensitivity settings to achieve standard reflector equivalents.

General Theory at Level 2 of Other NDT Methods

- The level 3 candidate is required to have a knowledge of level 2 general theory, including the limitations and applications of the principal and alternative methods of NDT.
- The examination syllabi are detailed in various documents obtainable from PCN.

- In detail, the level 3 candidate will be required to demonstrate a knowledge of the general theory syllabus for PCN Ultrasonic Tester Level 2, and three other NDT methods chosen by the candidate from:
- PCN Radiographic Tester Level 2 (which may include the interpretation of radiographs to a code or defect acceptance standard),
- PCN Magnetic Particle Tester Level 2,
- PCN Penetrant Tester Level 2, and
- PCN Eddy Current Tester Level 2.

Knowledge of PCN Requirements

A thorough understanding of the requirements for certification of all levels of NDT personnel as detailed in the PCN Requirements for qualification and certification of Aerospace NDT personnel.

ULTRASONIC SECTOR SPECIFIC THEORY

All of the combined syllabus for PCN Ultrasonic Tester (Aerospace) Level 2, and in addition:

Flaw sizing systems

- Knowledge of the currently used systems for defect sizing dependent upon geometry and material properties. The application of the systems for cross-sectional defect dimensions and for length of defects.

Flaw recording systems

Knowledge of current systems for flaw recording. Recording echo height comparisons from actual defects and their equivalent reflectors from the test block used.

Sensitivity

Methods of setting sensitivity for normal probes. Methods of setting sensitivity for angle probes to obtain 'grain interference level' (or 'grass') and the recording of the equivalent calibration block echoes, and comparison with a standard calibration block.

Methods of setting sensitivity using predetermined calibration block echoes and making allowances for transfer loss and attenuation in the material.

Accuracy and Limitation

A thorough knowledge of the effective range of all types of probe beams, both of maximum and minimum path distances. Determination of the repeatability and accuracy of the cross section of simulated defects and of their length. Tabulation of the results achieved.

Codes for Testing and Flaw Acceptance Limits

Familiarity with the criteria in codes and standards covering the application of ultrasonics in the aerospace sector. An understanding of the way in which these are applied in practice.

Materials Technology and Science

The level 3 examination will require the candidate to have a technical knowledge in materials science and technology, including production and in-service defects in a wide range of products, including castings, welds and wrought products.

Procedure Writing

Candidates will be required to produce a written procedure for the inspection of a specified component to a provided code or standard. PCN publishes a document, reference CP25, for information and for use by candidates in this open book examination.

NOTE: Codes and standards of other national (or international) origins may be proposed by candidates, if appropriate to their job responsibilities, for use in this examination module. Candidates should notify the test centre of their choice on the enrolment form and will be permitted to bring a copy of the chosen code or standard to the test centre for use in this open book examination.

The procedure must include safety requirements appropriate to the test situation, acceptance levels to specified application standards, NDT personnel approvals, reference documentation, the use of complementary NDT methods, the timing of inspection in relation to manufacture and overhaul,

special contractual requirements, action to be taken in case of non-compliance and reporting instructions (implementation of the procedure).

REFERENCE LITERATURE

Essential Reading

- BS M 36: Method for ultrasonic testing of special forgings by an immersion technique using flat-bottomed holes as a reference standard.
- BS M 38: Guide to compilation of instructions and reports for the in-service Non-Destructive Testing of Aerospace Products.
- BS EN 1330-4: Non-Destructive Testing – Terminology. Terms used in ultrasonic testing
- BS EN 12668-3: Non-Destructive Testing – Characterisation and verification of equipment: Part 3 Combined equipment.
- BS EN 583-1: Non-destructive testing –Ultrasonic examination – Part 1: General principles
- BS EN 583-3 : Non-destructive testing –Ultrasonic examination – Part 3: Transmission technique
- BS EN 583-5: Non-destructive testing –Ultrasonic examination – Part 5: Characterisation and sizing of discontinuities
- BS EN 12223: Calibration block No.1 for ultrasonic examination
- BS EN ISO 17635: Non-destructive examination of welds – General rules for metallic materials
- BS EN ISO 7963: Non-destructive testing. Ultrasonic testing. Specification for calibration block No. 2
- MIL-STD-2154: Inspection, Ultrasonic, Wrought Metals, Process
- MIL-STD-2175A: Castings - classification and inspection of.
- Product Technology Classroom Training Handbook. Obtainable from the Certification Services Division, The British Institute of Non-Destructive Testing, Newton Building, St George's Avenue, Northampton NN2 6JB.
- Training Course Notes. Candidates may have attended an approved course of training. Accredited Training Establishments are required to provide trainees with an up to date set of training course notes. These are considered essential reading.

Recommended Reading

- Civil Aviation Airworthiness Inspection Procedures Part 4 leaflet 4.8.
- Basic Metallurgy for Non-Destructive Testing, Edited by J L Taylor: The British Institute of Non-Destructive Testing, Newton Building, St George's Avenue, Northampton NN2 6JB.
- American Society for Metals - 'Non destructive Inspection and Quality Control : Metals Handbook' Vol II. Metals Park, Ohio.
- Materials and Processes for NDT Technology. ASNT.
- Non-Destructive Testing (Second Edition 1991) by R Halmshaw. Edward Arnold.
- Non-Destructive Testing Handbook, First edition. Edited by R McMaster.
- ASNT Self Study Handbook (originally published by General Dynamics)
- ASNT Classroom Training Handbook (originally published by General Dynamics)
- ASNT Question and Answer book.
- ASNT Level III Study Guide.
- ASNT Student Package.
- ASNT Instructor Package (overheads for training).

RADIOGRAPHIC TESTING OF AEROSPACE MATERIALS COMPONENTS & STRUCTURE

This Appendix to PCN General Requirements for Qualification and Certification of NDT Personnel covers the examination syllabus for PCN certification of personnel engaged in Radiographic Non-Destructive Testing of Aerospace Materials, Components and Structures.

Certification issued as a result of success in an examination defined herein complies with European standard EN 473, international standard ISO 9712, and may be used by employers of NDT personnel to satisfy the qualification requirements of European Standard EN 4179.

Any person requiring information concerning the content of PCN documents should address queries to the PCN Scheme Manager at the above address.

LEVEL 1

Although there are currently no level 1 examinations available in the aerospace sector, the level 2 examination syllabus includes that for level 1 and the level 1 syllabus is therefore included herein since the depth of knowledge required increases from level 1 through level 2 to level 3.

RADIOGRAPHIC GENERAL THEORY

- Introduction - brief history of the development of industrial radiography. Philosophy of non-destructive testing. Radiographic capabilities in relation to other NDT methods.
- Principles of Radiography. Electromagnetic spectrum, significance of wavelength. Sources of X-rays and gamma rays, their characteristics and key properties. Interaction between radiation and matter, absorption and scatter.
- Image Formation. Rectilinear propagation of rays, factors affecting penumbra, inverse square law. Types and choice of film used in industrial radiography. Types and uses of screens.
- Films and Processing. Photographic emulsion chemistry, development, fixation, washing and drying of film. Temperature control. Automatic and manual processing and handling faults including adventitious images.
- Fundamental Aspects of Radiographic Quality.
- Cause, effect and control of scattered radiation and factors that affect:
- Sensitivity
- Density and density measurement
- Contrast, speed and definition

RADIOGRAPHIC SECTOR SPECIFIC THEORY

- Exposure Factors. Radiation quality; effect of changing kV; significance and effect of type of gamma or X-ray source. Effect of time, milliamperage and ffd on exposure. Use of exposure charts. Identification, marking out and setting up.
- Techniques. Factors influencing radiographic techniques including masking, blocking media, screens, filters and film type. The use of IQI. Determination of focal spot size.
- Radiographic Quality Assessment. Judging quality of processed radiographs for subsequent interpretation. Calculation of IQI sensitivity, use of densitometers, determination of film density. Radiographic appearance of discontinuities including adventitious images, their causes and effects. Viewing Conditions. Illuminator requirements, optimum viewing conditions, masking, reduction of external lighting, viewing angle.
- Standards, Codes and Specifications (See essential reading list).

LEVEL 2

RADIOGRAPHIC GENERAL THEORY

All of the general theory for level 1 and, in addition:

Principles of Radiation

- Types and sources of radiation, electromagnetic spectrum.

Nature and Properties of Ionising Radiation

All types briefly, X and gamma in depth. Particles, wave properties, electromagnetic waves, electrical theory of matter, fundamentals of radiation physics. Interaction between penetrating radiation and matter, absorption, scatter, pair production, photoelectric effect, other secondary emission, ionising effects. Glossary of terms and units of measurement.

Sources of Radiation for Radiography

Characteristics and selection of X and gamma, basic types of X-ray generator, tube selection and uses; isotope types, spectra, activity including self absorption, half lives.

Principles of Radiographic Image Formation

Geometry of shadow projection. Use of formulae.

Radiographic Sensitometry

Characteristic curves, gradient density curves, gamma for typical films, effect of development conditions on characteristic curve. Types and choice of film used in industrial radiography. Effect of intensifying screens (metallic, fluorometallic, salt) on exposure conditions and image quality.

Relative merits of X and gamma rays.

Basic Radiation Safety

Candidates for the Basic Radiation Safety (BRS) examination should have a general knowledge of the subjects listed in PCN/GEN Appendix E3.2 and an awareness of the contents of the documents indicated as applicable to industrial radiography. The same syllabus is applicable regardless of the level of certification sought.

Radiation Protection (to supervisor level)

Candidates for the optional Radiation Protection (to supervisor level) examination are expected to have an in depth knowledge of the subjects listed in PCN/GEN Appendix E3.2 covering all aspects of radiation safety. The same syllabus is applicable regardless of the level of certification sought.

RADIOGRAPHIC SECTOR SPECIFIC THEORY

All of the sector specific theory for level 1 plus:

Exposure Factors

Radiographic calculations.

Techniques

Multi-film and panoramic techniques. Assessment of depth of known defects. Causes of diffraction effects and their minimisation. An awareness of the principles of real time systems.

Radiographic Interpretation

Judging quality of processed radiographs, taking into account codes, standards, specifications, procedures and techniques. Calculation of IQI sensitivity. Methods of Reporting.

2.5 Sector Specific Aerospace Product Technology Theory

The depth of knowledge required will be such that the candidate will be capable of understanding the description of potential defects and their likely locations as specified in NDT instructions and procedures; describing unambiguously in NDT reports the nature and location of what has been found such that the non-NDT engineer can gain an accurate appreciation of the condition of the inspected area.

LEVEL 3

Level 3 personnel are expected to be competent to assume the responsibilities of management of an industrial NDT facility. The PCN level 3 examination will therefore evaluate the candidate's knowledge of the following:

Allocation of staff with appropriate certification according to customer's requirements. Supervision and maintenance of subordinate's certification and recertification documents and records.

Compilation of records of equipment performance, repairs and maintenance; the work done and results achieved by supervised staff. The review of reports of work done by subordinates, its periodic validation, and the endorsement of routine reports. Review of current practices, equipment, techniques and instructions. Maintenance of standards and text book libraries. Safe working practices and current legislation.

RADIOGRAPHIC GENERAL THEORY

Candidates will be required to be familiar with all the content of the general theory for level 1 and level 2 inclusive and, in addition:

Alternative Forms of Imaging

Fluoroscopy; screen, image intensification, cine techniques; direct TV viewing; solid state, xeroradiography, iconography; advantages and limitations.

Trends and Developments

Micro focus X-ray equipment; real time radiography and associated instrumentation systems, advantages and limitations, linear accelerators, neutron radiography. Uncommon gamma sources and their application. Computerised radiographic enhancement.

GENERAL THEORY AT LEVEL 2 OF OTHER NDT METHODS

- A knowledge of the level 2 general theory, limitations and applications of the principal alternative methods of NDT to ultrasonic testing is required. The examination syllabi are detailed in various documents obtainable from PCN.
- In detail, the level 3 candidate will be required to demonstrate a knowledge of the general theory syllabus for:
- PCN Ultrasonic Tester Level 2
- PCN Magnetic Particle Tester Level 2
- PCN Penetrant Tester Level 2
- PCN Eddy Current Tester Level 2

Knowledge of PCN Requirements

A thorough understanding of the PCN criteria for certification of all levels of personnel as applied in PCN requirements for the qualification and certification of NDT personnel in the aerospace sector

RADIOGRAPHIC SECTOR SPECIFIC THEORY

This examination part will cover the syllabus given earlier for level 2 sector specific theory examination, but will generally require a greater understanding of the application of the NDT method and, in addition:

Techniques and Sensitivity

- Detailed consideration of factors affecting image quality. X and gamma techniques for products of varying thickness and varying geometry.
- Radiographic sensitivity, IQI sensitivity, flaw sensitivity, planar and volumetric defects, defect measurements.
- The preparation of sensitometric data. The application of codes and standards, the selection or development of techniques in relation to the application of radiography in the absence of codes and standards. Capabilities and limitations of radiography compared to other NDT methods.

Care of Equipment and Consumables

Observance of equipment rating, use and care of screens, use and care of cassettes, darkroom cleanliness, disposal of obsolete films and solutions, silver recovery.

Accuracy and Limitation

A thorough knowledge of source and equipment capability, film types and performance, influence of product type and geometry, influence of factory and site conditions.

Codes for Testing and Flaw Acceptance Limits

Familiarity with the criteria in codes and standards covering the application of radiography and flaw limits. An understanding of the way in which these are applied in practice.

Procedure Writing

- Candidates will be required to produce a written procedure for the radiographic examination of a specified component or structure to a provided code or standard. PCN publishes a document, PCN document CP25, for information and for use by candidates in this open book examination.

  NOTE: Codes and standards of other national (or international) origins may be proposed by candidates, if appropriate to their job responsibilities, for use in this examination module. Candidates should notify the test centre of their choice on the enrolment form and will be permitted to bring a copy of the chosen code or standard to the test centre for use in this open book examination.

- The procedure must include safety requirements appropriate to the test situation, acceptance levels to specified application standards, radiographic personnel approvals, exposure techniques, equipment and its setting up, surface condition, identification and marking out, alignment of radiation source, sensitivity and location of IQI, intensifying screens and film cassettes, films and film quality, density, processing of film and film quality, viewing facilities, interpretation, protection and care of unprocessed film, reference documentation, the use of complementary NDT methods, the timing of radiographic inspection in relation to manufacture and overhaul, special contractual requirements, action to be taken in case of non-compliance and reporting instructions (implementation of the procedure).

REFERENCE LITERATURE

Essential Reading

- BS M 34: Method of preparation and use of radiographic techniques.
- BS M 38: Guide to compilation of instructions and reports for the in-service Non- Destructive Testing of Aerospace Products.
- BS EN 444: Industrial Radiography-General principles for radiographic examination of metallic materials using X and Gamma rays
- BS EN 584-1: Industrial Radiographic Film - Part 1: Classification of films systems for industrial radiography
- BS EN 462-1: NDT Image Quality of Radiographs - Part 1 Image quality indicators (wire type) determination of image quality value
- BS EN 462-2: NDT Image Quality of Radiographs – Part 2 Image quality indicators (step/hole type) – Determination of image quality value
- BS EN 462-3: NDT Image Quality of Radiographs - Part 3 : Image quality classes for ferrous metals
- BS EN 462-5: NDT Image Quality of Radiographs - Part 5 Image quality indicators (Duplex wire type) determination of total image unsharpness value.
- BS EN 1330-1: Non-destructive testing-Terminology – Part 1 List of general terms
- BS EN 1330-2: Non-destructive testing-Terminology – Part 2 Terms common to the non-destructive testing methods
- BS EN1330-3: Non-destructive testing-Terminology - Part 3 Terms used in industrial radiographic testing.
- BS EN 25580: Minimum requirements for industrial radiographic illuminators for non-destructive testing

- BS 3455: Glossary of terms used in nuclear science and technology.
- BS EN 462 Series: Non-destructive testing - Image quality of radiographs:
- ISO 3999: Radiation protection -- Apparatus for industrial gamma radiography -- Specifications for performance, design and tests.
- MIL-STD-453C: Inspection, Radiographic.
- MIL-STD-2175A: Castings, classification and inspection of.
- Product Technology Classroom Training Handbook. Obtainable from the Certification Services Division, The British Institute of Non-Destructive Testing, Newton Building, St George's Avenue, Northampton NN2 6JB.
- Training Course Notes. PCN requires candidates to have attended an approved course of training. Accredited Training Establishments are required to provide trainees with an up to date set of training course notes. These are considered essential reading.

RADIOGRAPHIC TESTING OF AEROSPACE WELDS

LEVEL 1

Although there are currently no level 1 examinations available in the aerospace sector, the level 2 examination syllabus includes that for level 1 and the level 1 syllabus is therefore included herein since the depth of knowledge required increases from level 1 through level 2 to level 3.

RADIOGRAPHIC GENERAL THEORY

- Introduction - brief history of the development of industrial radiography. Philosophy of non-destructive testing. Radiographic capabilities in relation to other NDT methods.
- Principles of Radiography. Electromagnetic spectrum, significance of wavelength. Sources of X-rays and gamma rays, their characteristics and key properties. Interaction between radiation and matter, absorption and scatter.
- Image Formation. Rectilinear propagation of rays, factors affecting penumbra, inverse square law. Types and choice of film used in industrial radiography. Types and uses of screens.
- Films and Processing. Photographic emulsion chemistry, development, fixation, washing and drying of film. Temperature control. Automatic and manual processing and handling faults including adventitious images.
- Fundamental Aspects of Radiographic Quality.
- Cause, effect and control of scattered radiation and factors that affect:
    - Sensitivity
    - Density and density measurement
    - Contrast, speed and definition

1.2 Sector Specific Theory

- Exposure Factors. Radiation quality; effect of changing kV; significance and effect of type of gamma or X-ray source. Effect of time, milliamperage and ffd on exposure. Use of exposure charts. Identification, marking out and setting up.
- Techniques. Factors influencing radiographic techniques including masking, blocking media, screens, filters and film type. The use of IQI. Determination of focal spot size.
- Radiographic Quality Assessment. Judging quality of processed radiographs for subsequent interpretation. Calculation of IQI sensitivity, use of densitometers, determination of film density. Radiographic appearance of discontinuities including adventitious images, their causes and effects. Viewing Conditions. Illuminator requirements, optimum viewing conditions, masking, reduction of external lighting, viewing angle.
- Standards, Codes and Specifications (See essential reading list).

LEVEL 2

RADIOGRAPHIC GENERAL THEORY

All of the general theory for level 1 and, in addition:

Principles of Radiation

Types and sources of radiation, electromagnetic spectrum.

Nature and Properties of Ionising Radiation

All types briefly, X and gamma in depth. Particles, wave properties, electromagnetic waves, electrical theory of matter, fundamentals of radiation physics. Interaction between penetrating radiation and matter, absorption, scatter, pair production, photoelectric effect, other secondary emission, ionising effects. Glossary of terms and units of measurement.

Sources of Radiation for Radiography

Characteristics and selection of X and gamma, basic types of X-ray generator, tube selection and uses; isotope types, spectra, activity including self absorption, half lives.

Principles of Radiographic Image Formation

Geometry of shadow projection. Use of formulae.

Radiographic Sensitometry

Characteristic curves, gradient density curves, gamma for typical films, effect of development conditions on characteristic curve. Types and choice of film used in industrial radiography. Effect of intensifying screens (metallic, fluorometallic, salt) on exposure conditions and image quality.

Relative merits of X and gamma rays

Basic Radiation Safety

Candidates for the Basic Radiation Safety (BRS) examination should have a general knowledge of the subjects listed in PCN/GEN Appendix E3.2 and an awareness of the contents of the documents indicated as applicable to industrial radiography. The same syllabus is applicable regardless of the level of certification sought.

Radiation Protection (to supervisor level)

Candidates for the optional Radiation Protection (to supervisor level) examination are expected to have an in depth knowledge of the subjects listed in PCN/GEN Appendix E3.2 covering all aspects of radiation safety. The same syllabus is applicable regardless of the level of certification sought.

RADIOGRAPHIC SECTOR SPECIFIC THEORY

All of the sector specific theory for level 1 plus:

Exposure Factors

Radiographic calculations.

Techniques

Multi-film and panoramic techniques. Assessment of depth of known defects. Causes of diffraction effects and their minimisation. An awareness of the principles of real time systems.

Radiographic Interpretation

Judging quality of processed radiographs, taking into account codes, standards, specifications, procedures and techniques. Calculation of IQI sensitivity. Methods of Reporting.

SECTOR SPECIFIC AEROSPACE WELDS - PRODUCT TECHNOLOGY THEORY

The depth of knowledge required will be such that the candidate will be capable of understanding the description of potential defects and their likely locations as specified in NDT instructions and procedures; describing unambiguously in NDT reports the nature and location of what has been found such that the non-NDT engineer can gain an accurate appreciation of the condition of the inspected area.

Welding Processes

For producing spot welds, seam welds and butt welds in plate and pipe – MMA; TIG; MIG/MAG; resistance welding.

Welding Process Defects

Lack of fusion (all types); porosity; cracks; visual defects including weld mismatch etc.; lack of penetration; inclusions; grinding cracks.

LEVEL 3

Level 3 personnel are expected to be competent to assume the responsibilities of management of an industrial NDT facility. The PCN level 3 examination will therefore evaluate the candidate's knowledge of the following:

Allocation of staff with appropriate certification according to customer's requirements. Supervision and maintenance of subordinate's certification and recertification documents and records.

Compilation of records of equipment performance, repairs and maintenance; the work done and results achieved by supervised staff. The review of reports of work done by subordinates, its periodic validation, and the endorsement of routine reports. Review of current practices, equipment, techniques and instructions. Maintenance of standards and text book libraries. Safe working practices and current legislation.

The level 3 examination syllabus is as follows:

RADIOGRAPHIC GENERAL THEORY

Candidates will be required to be familiar with all of the content of the general theory for level 1 and level 2 inclusive and, in addition:

Alternative Forms of Imaging

Fluoroscopy; screen, image intensification, cine techniques; direct TV viewing; solid state, xeroradiography, ionography; advantages and limitations.

Trends and Developments

Micro focus X-ray equipment; real time radiography and associated instrumentation systems, advantages and limitations, linear accelerators, neutron radiography. Uncommon gamma sources and their application. Computerised radiographic enhancement.

Basic Radiation Safety

Candidates for the Basic Radiation Safety (BRS) examination should have a general knowledge of the subjects listed in PCN/GEN Appendix E3.2 and an awareness of the contents of the documents indicated as applicable to industrial radiography. The same syllabus is applicable regardless of the level of certification sought.

Radiation Protection (to supervisor level)

Candidates for the optional Radiation Protection (to supervisor level) examination are expected to have an in depth knowledge of the subjects listed in PCN/GEN Appendix E3.2 covering all aspects of radiation safety. The same syllabus is applicable regardless of the level of certification sought.

GENERAL THEORY AT LEVEL 2 OF OTHER NDT METHODS

A knowledge of the level 2 general theory, limitations and applications of the principal alternative methods of NDT to ultrasonic testing is required. The examination syllabi are detailed in various documents obtainable from PCN.

In detail, the level 3 candidate will be required to demonstrate a knowledge of the general theory syllabus for:

- PCN Ultrasonic Tester Level 2
- PCN Magnetic Particle Tester Level 2
- PCN Penetrant Tester Level 2
- PCN Eddy Current Tester Level 2

Knowledge Of PCN Requirements

A thorough understanding of the PCN criteria for certification of all levels of personnel as applied in PCN qualification of NDT personnel in the aerospace sector

RADIOGRAPHIC SECTOR SPECIFIC THEORY

This examination part will cover the syllabus given earlier for level 2 sector specific theory examination, but the level 3 will generally require a greater understanding of the application of the NDT method and, in addition:

Techniques and Sensitivity

- Detailed consideration of factors affecting image quality. X and gamma techniques for products of varying thickness and varying geometry.
- Radiographic sensitivity, IQI sensitivity, flaw sensitivity, planar and volumetric defects, defect measurements.

- The preparation of sensitometric data. The application of codes and standards, the selection or development of techniques in relation to the application of radiography in the absence of codes and standards. Capabilities and limitations of radiography compared to other NDT methods.

Care of Equipment and Consumables

Observance of equipment rating, use and care of screens, use and care of cassettes, darkroom cleanliness, disposal of obsolete films and solutions, silver recovery.

Accuracy and Limitation

A thorough knowledge of source and equipment capability, film types and performance, influence of product type and geometry, influence of factory and site conditions.

Codes for Testing and Flaw Acceptance Limits

Familiarity with the criteria in codes and standards covering the application of radiography and flaw limits. An understanding of the way in which these are applied in practice.

Materials Technology and Science

The level 3 examination will require the candidate to have a technical knowledge in materials science and technology, including production and in-service defects in a wide range of products, including castings, welds and wrought products.

Procedure Writing

- Candidates will be required to produce a written procedure for the radiographic examination of a specified welded component to a provided code or standard. PCN publishes a document, PCN document CP25, for information and for use by candidates in this open book examination.

  NOTE: Codes and standards of other national (or international) origins may be proposed by candidates, if appropriate to their job responsibilities, for use in this examination module. Candidates should notify the test centre of their choice on the enrolment form and will be permitted to bring a copy of the chosen code or standard to the test centre for use in this examination.

- The procedure must include safety requirements appropriate to the test situation, acceptance levels to specified application standards, radiographic personnel approvals, exposure techniques, equipment and its setting up, surface condition, identification and marking out, alignment of radiation source, sensitivity and location of IQI, intensifying screens and film cassettes, films and film quality, density, processing of film and film quality, viewing facilities, interpretation, protection and care of unprocessed film, reference documentation, the use of complementary NDT methods, the timing of radiographic inspection in relation to fabrication and testing procedures, special contractual requirements, action to be taken in case of non-compliance and reporting instructions implementation of the procedure).

REFERENCE LITERATURE

Essential Reading

- BS 499-1: Welding terms and symbols. Glossary for welding, brazing and thermal cutting
- BS 2633: Specification for Class I arc welding of ferritic steel pipework for carrying fluids
- BS 3451: Methods of testing fusion welds in aluminium and aluminium alloys.
- BS EN 1320: Destructive tests on welds in metallic materials. Fracture tests
- BS EN 1321: Destructive test on welds in metallic materials. Macroscopic and microscopic examination of welds
- BS EN 895: Destructive tests on welds in metallic materials. Transverse tensile test
- BS EN ISO 5173: Destructive tests on welds in metallic materials. Bend tests
- BS EN 1330-1: Non-destructive testing-Terminology – Part 1 List of general terms
- BS EN 1330-2: Non-destructive testing-Terminology – Part 2 Terms common to the non-destructive testing methods

- BS EN 1330-3: Non-destructive testing - Terminology. Terms used in industrial radiographic testing.
- BS EN 1435: Non-destructive examination of welds. Radiographic examination of welded joints.
- BS EN 444: Industrial Radiography-General principles for radiographic examination of metallic materials using X and Gamma rays
- BS EN 584-1: Industrial Radiographic Film - Part 1: Classification of films systems for industrial radiography
- BS EN 462-1: NDT Image Quality of Radiographs - Image quality indicators (wire type) determination of image quality value
- BS EN 462-2: NDT Image Quality of Radiographs –Image quality indicators (step/hole type) – Determination of image quality value
- BS EN 462-3: NDT Image Quality of Radiographs - Image quality classes for ferrous metals
- BS EN 462-5: NDT Image Quality of Radiographs - Image quality indicators (Duplex wire type) determination of total image unsharpness value.
- BS EN 25580: Minimum requirements for industrial radiographic illuminators for non-destructive testing
- ISO 3999: Radiation protection -- Apparatus for industrial gamma radiography -- Specifications for performance, design and tests.
- BS EN ISO 9000 Series (for level 3 candidates only).
- BS AERO M 34: Method of preparation and use of radiographic techniques.
- BS M 38: Guide to compilation of instructions and reports for the inspection of butt joints in steel pipe by radiography.
- MIL-STD-453C: Inspection, Radiographic.
- Product Technology Classroom Training Handbook. Obtainable from the Certification Services Division, The British Institute of Non-Destructive Testing, Newton Building, St George's Avenue, Northampton NN2 6JB.
- Training Course Notes. PCN requires candidates to have attended an approved course of training. Accredited Training Establishments are required to provide trainees with an up to date set of training course notes. These are considered essential reading.
- Essential Reading - Safety aspects (A full reading list is published in PCN/GEN Appendix E3.2)

MAGNETIC PARTICLE TESTING OF AEROSPACE PRODUCTS

LEVEL 2

MAGNETIC PARTICLE GENERAL THEORY

Principles of Magnetic Particle Inspection

- Basic principle - magnetisation, leakage field, attraction of ferromagnetic particles, production of indication.
- Requirements for MPI - component, field, defect orientation and detecting media etc.
- Terms and definitions - field, flux, field strength, flux density, poles.
- Magnetic fields - bar magnet, horseshoe magnet, fields produced by straight conductor and coil.
- Magnetic materials - recognise terms i.e. permeability, soft and hard, brief description of hysteresis.
- Magnetising currents - description of AC, DC, HWR, FWR.

Methods of Magnetisation

- General - description of methods showing directions of current, field and flaw, calculation of magnetising current.
- Contact current flow.
- Ridged Coil (flexible cables for Level 2).
- Threading bar.
- Magnets and electromagnets.
- Magnetic flow.

Inspection and Detection of Indications

- Detecting media - types and standard requirements.
- Illumination - white light, UV(A), viewing conditions.

Checks and Calibrations

- General - reasons for checks, frequency and recording.
- Sensitivity - portable flux indicators, field strength meter, brief descriptions.
- Functional tests - CCF and flux flow test pieces.
- Equipment checks - ammeter, illumination, detecting media, electromagnet.

Equipment

Types of equipment - description and correct use of portable and fixed units, electromagnets, coils, contact heads.

MAGNETIC PARTICLE SECTOR SPECIFIC THEORY

Preparation for Testing

Surface preparation, cleaning methods, effect of surface finish and contaminants. Contrast aid paint. Compatibility of materials.

Safety Precautions

Fire hazards, electrical safety, ventilation, toxic materials and safe use of UV(A) radiation.

Test Procedures

- Correct application of field and detecting media.
- Preparation and selection of magnetisation techniques to provide complete coverage with respect to geometry of specimen.

- Selection of current or flux values and methods of assessing sensitivity of technique.

Detectability of Defects

- General - advantages and limitations of the test method with regard to defect detection.
- Characteristics of indications.
- Factors affecting indications - surface preparation, detecting medium and application, magnetising current.

Interpretation and Reporting

- Types of discontinuity and their identification (surface and sub-surface indications).
- Relevant, non-relevant and false indications and their causes.
- Preservation of indications: transparent tape transfer and after coating transfers, magnetic silicone rubber, photographic (fluorescent and non-fluorescent).

Post Test Procedures

- Demagnetisation - reasons for, when and methods.
- Post test cleaning and the need for restoration of preservation coatings.

Standards and Specifications (See essential reading list).

LEVEL 3

Level 3 personnel are expected to be competent to assume the responsibilities of management of an industrial NDT facility. The PCN Level 3 examination will therefore evaluate the candidate's knowledge of the following:

Allocation of staff with appropriate certification according to customer's requirements. Supervision and maintenance of subordinate's certification and recertification documents and records.

Compilation of records of equipment performance, repairs and maintenance; the work done and results achieved by supervised staff. The review of reports of work done by subordinates, its periodic validation, and the endorsement of routine reports. Review of current practices, equipment, techniques and instructions. Maintenance of standards and text book libraries. Safe working practices and current legislation.

The examination syllabus is as follows:

MAGNETIC PARTICLE GENERAL THEORY

Candidates will be required to be familiar with all the content of the General Theory syllabus for Level 2.

General Theory at Level 2 of Other NDT Methods

A knowledge of the Level 2 General Theory, limitations and applications of the principal alternative methods of NDT to Magnetic Particle testing is required. The examination syllabi are detailed in various documents obtainable from PCN.

In detail, the Level 3 candidate will be required to demonstrate a knowledge of the General Theory syllabus for:

- PCN Radiographic Testing Level 2 (which may include the interpretation of radiographs to a code or defect acceptance standard)
- PCN Ultrasonic Testing Level 2
- PCN Penetrant Testing Level 2
- PCN Eddy Current Testing Level 2

Knowledge of PCN Requirements

A thorough understanding of the PCN criteria for certification of all Levels of aerospace sector NDT personnel as applied in PCN requirements for the qualification and certification of personnel in the aerospace sector.

MAGNETIC PARTICLE SECTOR SPECIFIC THEORY

This examination part will cover the syllabus given earlier for the Level 2 examination, but the Level 3 will generally require a greater understanding of the application of the NDT method in the Aerospace sector.

Materials Technology and Science

The Level 3 examination will require the candidate to have a technical knowledge in materials science and technology, including production and in-service defects in a wide range of products, including castings, welds and wrought products.

Procedure Writing

- Candidates will be required to produce a written procedure for the inspection of a specified component to a provided code or standard. PCN publishes a document, PCN document CP25, for information and for use by candidates in this open book examination.

  NOTE: Codes and standards of other national (or international) origins may be proposed by candidates, if appropriate to their job responsibilities, for use in this examination module. Candidates should notify the test centre of their choice on the enrolment form and will be permitted to bring a copy of the chosen code or standard to the test centre for use in this examination.

- The procedure must include safety requirements appropriate to the test situation, acceptance levels to specified application standards, NDT personnel approvals, reference documentation, the use of complementary NDT methods, the timing of inspection in relation to manufacture and overhaul, special contractual requirements, action to be taken in case of non-compliance and reporting instructions (implementation of the procedure).

REFERENCE LITERATURE

Essential Reading

- BS EN 1330-2: Non-destructive testing – Terminology – Part 2: Terms common to the non-destructive testing methods
- BS EN 1330-1: Non-destructive testing-Terminology – Part 1 List of general terms
- BS EN ISO 17638: Non-destructive examination of welds – Magnetic particle testing
- BS EN ISO 23278: Non-destructive examination of welds – Magnetic particle testing of welds. Acceptance levels
- M 38: Guide to compilation of instructions and reports for the in-service Non-Destructive Testing of Aerospace products.
- BS EN ISO 3059: Non-destructive testing. Penetrant testing and magnetic particle testing. Viewing conditions
- BS EN 1330-7: Non-destructive testing. Terminology. Terms used in magnetic particle testing
- BS 4069: Magnetic Flaw Detection inks and powders.
- BS EN ISO 9934-1: Non-destructive testing, Magnetic particle testing. General principles
- BS EN ISO 9934-2: Non-destructive testing, Magnetic particle testing. Detection media
- BS EN ISO 9934-3: Non-destructive testing, Magnetic particle testing. Equipment
- ASTM E1444: Standard practice for Magnetic Particle Examination.
- Product Technology Classroom Training Handbook. Obtainable from the Certification Services Division, The British Institute of Non-Destructive Testing, Newton Building, St George's Avenue, Northampton NN2 6JB.
- Training Course Notes. PCN requires candidates to have attended an approved course of training. Accredited Training Establishments are required to provide trainees with an up to date set of training course notes. These are considered essential reading.

Recommended Reading

- Civil Aviation Airworthiness Inspection Procedures Part 4 Leaflet 4.7

- Basic Metallurgy for Non-Destructive Testing, Edited by J L Taylor. British Institute of Non-Destructive Testing.
- Materials Processes for NDT Technology. ASNT.
- Non-Destructive Testing (second edition, 1991) by R Halmshaw, Edward Arnold.
- Non-Destructive Testing Handbook, First Edition, edited by R McMaster.
- Principles of Magnetic Particle Testing, C E Betz, Magnaflux Corp., Chicago. 1967, or:
- Non-Destructive Testing handbook, Vol 6 - Magnetic Particle Testing. ASNT.
- ASNT Classroom Training Handbook originally published by General Dynamics.
- ASNT Self Study Handbook originally published by General Dynamics.
- ASNT Question and Answer Book.
- ASNT Level III Study Guide.
- ASNT Student Package.
- ASNT Instructor Package (overheads for training).

LIQUID PENETRANT TESTING OF AEROSPACE PRODUCTS

LEVEL 2

LIQUID PENETRANT GENERAL THEORY

Principles of Penetrant Inspection

- Basic principles of Liquid Penetrant Testing: surface tension, viscosity, volatility, capillary action and their relevance to penetrating fluids.
- Properties and requirements of emulsifiers, spirit remover and of a developer. Terminology associated with penetrant flaw detection.

Equipment and Materials

- Fixed installations, portable inspection kits and auxiliary equipment. Penetrants: colour contrast, fluorescent, combined colour contrast and fluorescent.
- Penetrant removers: solvents in liquid form, water only, water soluble, oil soluble emulsifiers.
- Developers: dry powders, powders in aqueous liquid carriers, developers in solution, powder in non-aqueous liquid carrier.

Methods of Assessing Sensitivity and Control Testing

- Chromium plated aluminium test blocks, Sherwin Panels, defective components.
- Colour, fluorescent intensity and comparator checks of penetrants.
- Efficiency of penetrant removers.
- Fluorescence, coverage and concentration checks on developers.

LIQUID PENETRANT SECTOR SPECIFIC THEORY

Preparation for Testing

Surface preparation, cleaning methods, effect of surface finish and contaminants. Compatibility of materials.

1Safety Precautions

Fire hazards, electrical safety, ventilation, toxic materials and safe use of UV(A) radiation.

Test Procedures

- Selection of penetrant and developer process for optimum sensitivity with due regard to inspection criteria, surface condition and ambient light levels.
- Method of application of penetrant, significance of temperature, drainage and self-drying, removal of excess penetrant, contact time.
- Penetrant removal: liquid solvents, aqueous washes, post emulsifiers, contact times.
- Drying of components. Application of developers; dry powders, liquid developers (aqueous and non-aqueous).
- Viewing conditions: white light and UV(A) radiation and their assessment.
- Types of discontinuity and their identification, false indications and their cause.

Detectability of Defects

- General - advantages and limitations of the test method with regard to defect detection.
- Characteristics of indications.
- Factors affecting indications - surface preparation, detecting medium and application.

Interpretation and Reporting

- Types of discontinuity and their identification.
- Relevant, non-relevant and false indications and their cause.

- Preservation of indications: transparent tape transfer and other coating transfers, photographic (fluorescent and non-fluorescent), lacquer developers.

Post Test Procedures

Post test cleaning and the need for restoration of preservation coatings.

Standards and Specifications (See essential reading list).

LEVEL 3

Level 3 personnel are expected to be competent to assume the responsibilities of management of an industrial NDT facility. The PCN level 3 examination will therefore evaluate the candidate's knowledge of the following:

Allocation of staff with appropriate certification according to customer's requirements. Supervision and maintenance of subordinate's certification and recertification documents and records.

Compilation of records of equipment performance, repairs and maintenance; the work done and results achieved by supervised staff. The review of reports of work done by subordinates, its periodic validation, and the endorsement of routine reports. Review of current practices, equipment, techniques and instructions. Maintenance of standards and text book libraries. Safe working practices and current legislation.

The examination syllabus is as follows:

LIQUID PENETRANT GENERAL THEORY

Candidates will be required to be familiar with all the content of the General Theory syllabus for level 2.

General Theory at Level 2 of Other NDT Methods

A knowledge of the level 2 General Theory, limitations and applications of the principal alternative methods of NDT to Liquid Penetrant Testing is required. The examination syllabi are detailed in various documents obtainable from PCN.

In detail, the level 3 candidate will be required to demonstrate a knowledge of the General Theory syllabus for:

- PCN Radiographic Testing Level 2 (which may include the interpretation of radiographs to a code or defect acceptance standard)
- PCN Ultrasonic Testing Level 2
- PCN Magnetic Particle Testing Level 2
- PCN Eddy Current Testing Level 2

Knowledge of PCN Requirements

A thorough understanding of the PCN criteria for certification of all Levels of aerospace sector NDT personnel as applied in PCN/AERO.

SECTOR SPECIFIC THEORY

This examination part will cover the syllabus given earlier for level 2 examination, but the level 3 will generally require a greater understanding of the application of the NDT method in the Aerospace sector.

Materials Technology and Science

The Level 3 examination will require the candidate to have a technical knowledge in materials science and technology, including production and in-service defects in a wide range of products, including castings, welds and wrought products.

Procedure Writing

- Candidates will be required to produce a written procedure for the inspection of a specified component to a provided code or standard. PCN publishes a document, PCN document CP25, for information and for use by candidates in this open book examination.

NOTE: Codes and standards of other national (or international) origins may be proposed by candidates, if appropriate to their job responsibilities, for use in this examination module. Candidates should notify the test centre of their choice on the enrolment form and will be permitted to bring a copy of the chosen code or standard to the test centre for use in this examination.

- The procedure must include safety requirements appropriate to the test situation, acceptance levels to specified application standards, NDT personnel approvals, reference documentation, the use of complementary NDT methods, the timing of inspection in relation to manufacture and overhaul, special contractual requirements, action to be taken in case of non-compliance and reporting instructions (implementation of the procedure).

REFERENCE LITERATURE

Essential Reading

- BS EN 1330-2: Non-destructive testing – Terminology – Part 2: Terms common to the non-destructive testing methods
- BS EN 1330-1: Non-destructive testing-Terminology – Part 1 List of general terms
- BS M 38: Guide to compilation of instructions and reports for the in-service Non- Destructive Testing of Aerospace Products.
- BS M 39: Method for Penetrant Inspection of Aerospace Materials and Components.
- BS EN 571-1: Penetrant Testing. Part 1: General principles for the examination.
- BS EN ISO 23277: Non-destructive testing of welds. Penetrant testing of welds. Acceptance levels

  BS EN ISO 3059: Non-destructive testing. Penetrant testing and magnetic particle testing. Viewing conditions.
- BS EN ISO 3452-2: Non-destructive testing. Penetrant testing. Testing of penetrant materials
- BS EN ISO 3452-3: Non-destructive testing. Penetrant testing. Reference test blocks
- BS EN ISO 3452-4: Non-destructive testing. Penetrant testing. Equipment
- BS EN ISO 12706: Non-destructive testing. Penetrant testing. Vocabulary
- QPL-AMS-2644-4: Qualified Products List of Products - Inspection Material, Penetrant
- MIL-I-25135E: Inspection Materials, Penetrants.
- ASTM E1417: Standard practice for Liquid Penetrant examination.
- Product Technology Classroom Training Handbook. Obtainable from the Certification Services Division, The British Institute of Non-Destructive Testing, Newton Building, St George's Avenue, Northampton NN2 6JB.
- Training Course Notes. PCN requires candidates to have attended an approved course of training. Accredited Training Establishments are required to provide trainees with an up to date set of training course notes. These are considered essential reading.