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Advisory Circular

CAA-AC-AWS012

May 2018

QUALIFICATION GUIDELINES FOR SPECIALIZED MAINTENANCE ACTIVITIES: NON-DESTRUCTIVE TESTING AND WELDING

1.0 PURPOSE

This Advisory Circular is issued to provide guidance to personnel who are engaged in Specialized Maintenance Activities i.e. Non-Destructive Testing methods and Aircraft Welding.

2.0 REFERENCE

2.1 Civil Aviation (Air Operators Certification and Administration) Regulation, 2018

2.2 Civil Aviation (Approved Maintenance Organization) Regulation, 2018

2.3 KCAA Advisory Circular CAA-AC-GEN-003C the Five Phase Certification and Approval Process

2.4 FAA Advisory Circular AC43-13, Chapter 4 – Welding and Chapter 5 – Non-Destructive Inspection

2.5 UK Civil Aviation Aircraft Inspection Procedures (CAAIP)

3.0 GENERAL

3.1 The Authority, under the provisions of Civil Aviation (Personnel Licensing) Regulations, 2018, may grant an approval to a maintenance organization applicable classes of "Aviation Repair Specialist Authorizations" to perform specialized maintenance on airframes, engines, avionics or other systems.

3.2 An applicant for specialized maintenance or additional rating to an existing AMO shall:

a) Be at least 18 years of age;

b) Demonstrate the ability to read, speak, write and understand the English language and interpret technical reports and maintenance publications and carry out technical discussions in English language;

c) Be specially qualified to perform maintenance on aircraft, or aircraft component appropriate to the job for which the aviation repair specialist was employed;

d) Be employed for a specific job requiring special qualifications by an approved maintenance organization certificated under the Civil Aviation (Approved Maintenance Organizations) Regulations 2018; and

e) Be recommended for certification by the aviation repair specialist employer, to the satisfaction of the Authority as able to satisfactorily maintain aircraft or components, appropriate to the job for which the aviation repair specialist is employed and either.

3.3 An applicant shall submit the following to the Authority at least 90 days before the intended day of operations:

a) an application on a form and in a manner prescribed by the Authority;
b) the applicant's maintenance procedures manual in duplicate;
c) a list of the maintenance functions to be performed for it, under contract, by another AMO;
d) a list of all AMO certificates and ratings pertinent to those certificates issued by any Contracting State other than Kenya; and
e) any additional information the Authority may require the applicant to submit.

3.4 The Authority, on accepting the application will establish a schedule of events for evaluation and assessment of the applicant's capability.

3.5 The approval process ensures that the applicant's proposed programmes, systems, arrangements, facilities, documentation, personnel and intended methods of compliance are reviewed, evaluated and tested in accordance with approved standards before approval. Minimum requirements shall require the organization's quality system procedures to include qualification procedure covering initial and recurrent training, skills and experience, and examinations including medical examinations.

3.6 Specialized maintenance is a class of maintenance that require an extra depth of training in both theoretical and practical training conducted in accordance with approved Training Programme, and at least 18 months of practical experience in the procedures, practices, inspection methods, materials, tools, machine tools, and equipment generally used in the maintenance duties of the specific jobs.

4.7 Specialized maintenance cover one or more of the following:

a) non-destructive testing (NDT);
b) welding;
c) borescope inspections;
d) composite repairs;
e) in-flight entertainment equipment that requires specialist software management; or
f) other maintenance such as Acoustic Emission, Neutron Radiography, Penetrant Leak Testing, Thermography, Holography and Computer Tomography as approved by the Authority as specialized maintenance.

4.8 The Authority may recognize and accept training standards and qualifications obtained from:

a) the European Aviation Safety Agency (EASA);
b) the Federal Aviation Administration (FAA); and
c) the Transport Canada (TC).

4.9 Personnel engaged in specialized maintenance shall have "annual visual acuity tests" performed by approved medical practitioners to ensure that their vision and color

perception meets the required criteria for the precision and accuracy. Such medical records will be kept in confidence.

An authorization may be withdrawn where a holder of such authorization performs work or issues a certificate in respect of work which has been performed in contraventions of the Civil Aviation Regulations. The certificate or authorization may be revoked or suspended.

5.0 NON-DESTRUCTIVE TESTING – APPROVAL PROCESS

5.1 Approval of a maintenance organization to undertake non-destructive testing (NDT) of aircraft, components or equipment shall be made pursuant to Regulation 13 (2) of the Civil Aviation (Approved Maintenance Organization) Regulation, 2018.

5.2 The following methods are used in NDT:

a) Liquid penetrant inspection involving the use of dip tanks, emulsifiers, and fluorescent dye.
b) Magnetic particle inspection.
c) Radiographic inspection.
d) Ultrasonic inspection.
e) Eddy current inspection.
f) Holographic inspection.

Note: The term testing and inspection are sometimes used interchangeably but it is important to note that there is a slight difference between the two. The "testing" methods include those listed above and the "inspection" methods include processes like borescope inspection and coin tapping for delamination inspection.

5.2.1 In addition to the requirements in paragraph 4.12, an applicant for the grant or extension of a non-destructive testing approval shall:

a)have a reasonable minimum standard of visual acuity capability to read the J-1 letters of the standard Jaegers test type hart or Times Roman N4 at not less than 16" (42cm) or an equivalent type test for near vision in at least one eye, natural or corrected. The test for colour perception is not required of applicants for radiographic and eddy current approvals.

b) have acceptable experience of at least 18 months on practical inspection of aircraft structures and components. Specific practical experience and training shall be obtained from an approved training facility and scope of work limited to the applicant's training and experience. Where the applicant scope of work is extended to aircraft structures, and practical aircraft experience is insufficient, the examination will include a supplementary paper on aircraft structures.

c)pass a written and/or oral examination to a standard and syllabus approved by the Authority.

d) demonstrate that applicant has adequate practical proficiency in the relevant NDT test method.

5.2.2 In lieu of paragraph 5.1.1 (c) and (e) above, the Authority may accept the following:

a)The UK National Scheme in NDT (PCN Aerospace sector examinations or equivalent).

b) The Australian Institute for NDT scheme for aerospace qualifications.

c)The American Society for NDT recommended practice SNT-TC-1A, and National Aerospace Standards NAS 410.

d) International Standard ISO 9712.

e)European Standard EN473 /EN4179 qualifications.

f) Completion of training schemes approved by the Authority.

5.2.3 The specific experience training requirements for approved radiographic and ultrasonic operators are:

a)Practical experience including at least 18 months' work using the particular method in the examination of aircraft structures, parts and components. For a radiographic inspection approval, the experience must also include processing and interpretation of radiographic.

b) Successful completion of a formal practical training course on the particular inspection method.

5.2.4 The practical examination to qualify for an approval will require a demonstration of using the particular NDT method. For a radiographic inspection approval, the examination will include a practical test and an interpretation test consisting of:

a)The development and recording of techniques for the examination of an aircraft part;

b) The practical application of the techniques;

c)The processing of radiographic films;

d) The co-relation of radiograph with a report; and

e)Identification of various features of radiographs.

Note: In view of the serious consequences of excessive exposure of the human body to X-radiation, it is recommended that the following precautions should be observed by organization: Film badge monitoring and total radiation absorbed dose records to be kept; An annual blood count; Personnel dosimeter; and A radiation intensity meter.

5.3 Pursuant to the Civil Aviation Regulations, an approved Non-Destructive Testing specialist is approved to certify for the completion of NDT inspections on a Certificate of Release to Service or on an Approved Certificate, as appropriate, provided:

a)The inspection is made by/or under the direct supervision of the AMO.

b) The approval is valid and appropriate for the method of inspection.

c)Where relevant the inspection is made in accordance with approved data and design documents.

d) The certification is made solely in respect of the results of the inspection.

5.4 Three levels of competence for NDT personnel are prescribed as per NAS 410/ EN 4179. For issue of certification authorization, the minimum competency level is "LEVEL-II "

Note: A trainee is one at the early stages of skills acquisition in NDT. The individual shall be taken through an approved training programme to obtain theoretical class-room work as well as work experience while under the guidance of Level 2 or 3 personnel. Any guidance from Level 1 personnel should be very limited and be supervised by Level 2 or Level 3 personnel.

a) *Level 1* - defines the level of competency required by the applicant to have the skills and knowledge to process parts, any necessary preparation of parts before or after inspection and perform equipment standardization in accordance with written instruction approved by level 3. Level-I qualification does not entitle a person for issue of certification authorization.

b) *Level II* - defines the level of competency required by the applicant for certification of NDT. Level-II calls for in-depth training, experience, and basic knowledge of aircraft product manufacturing and inspection technology. The applicant will be capable of setting up and calibrate test equipment, make decision and judgment, evaluate, interpret and certify inspection result in technique in the area of qualification. Have the skills and knowledge to set up and standardize equipment, process parts, interpret and evaluate for acceptance or rejection, and document results.

c) *LEVEL- III* defines the level of competency required by the applicant for certification of NDT. Level-III should have the skills and knowledge to interpret codes, standards and other contractual documents that control NDT method(s) as utilized by the employer. The applicant will be capable of selecting, preparing and verifying the adequacy of procedures in the method certified and technique for a specific inspection. He will also be capable of providing or directing training, examination and certification of personnel in the method in which he is certified.

6 AIRCRAFT WELDING – APPROVAL PROCESS

6.0 This section prescribes requirements for approval of a maintenance organization to undertake welding process of aircraft, components or equipment pursuant to Regulation 13 (2) of the Civil Aviation (Approved Maintenance Organization) Regulation, 2018

6.1 An approved organization may employ, train, qualify and grant approval to welders to perform work in accordance with approved maintenance programme, subject to the following:

a) It has an established system of training including training records, qualifying, testing, approving, re-approving and monitoring the welders in its employment;
b) Such system shall be approved by the Authority.

6.2 Approved Organization may be approved to utilize an external approved organization for training of welders.

6.3 Welder Approvals are granted with a maximum validity period of twenty-four months. The approval granted to a welder in an Approved Organization will be invalidated automatically if the welder leaves that Organization.

6.4 To carry out welding on an aircraft, components or equipment a person shall receive professional training in both theoretical and practical training in the particular type of welding and parent metal group qualification sought. An approved training acceptable to the Authority is expected to cover the following subjects:

a) Safety in Welding,
b) Welding Equipment,
c) Theory and Application of Welding Processes,
d) Welded Joints,
e) Welding Metallurgy,
f) Welding Practice and Production

6.5 Welder Approvals are granted with specific ratings of metal groups and welding processes.

6.5.1 *Parent Metal Groups* for which qualification may be sought include the following;

a) Aluminum Alloys,

b) Magnesium Alloys,
c) Carbon Steel and Low Carbon Steels,
d) Corrosion and Heat Resisting Steels,
e) Nickel Alloys,
f) Copper based Alloys,
g) Titanium Alloys.

6.5.2 *Welding Process* shall include but not limited to the following;

a) Gas (oxy-acetylene, etc.) Welding,
b) Braze Welding,
c) Metal Arc (flux coated consumable electrode) Welding,
d) TIG (Tungsten-Arc inert gas) Welding,
e) MIG (Metal-Arc inert gas shielded –consumable electrode) Welding, and
f) Plasma Arc Welding.

6.6 In addition to the requirements in paragraph 4.4, an applicant of a welder's approval shall:

a) Provide evidence of qualifications and practical experience in welding; and
b) Satisfactorily complete appropriate test samples as specified in Appendix 2.

6.7 The holder of a welder's approval may certify completion of work provided:

a) the approval is valid and appropriate for the parent metal group and welding process used.
b) the work consists solely of welding.
c) that where necessary the welding process followed and the material used comply with approved data or design documents specified for the work.
d) the certification is only made in respect of the quality of the welding and of the fact that an approved process has been followed.

Note: An approved welder is not permitted to certify the welded parts unless approved as a person competent to issue a Certificate of Release to Service.

6.8 **Welding Standards**

6.8.1 The Authority recognizes welding standards from the following:

a) International Organization for Standardization (ISO) Standards;
b) American Welding Society (AWS) Standards;
c) British Standards (BS); and,
d) European Union (CEN) Standards.

6.8.2 Examples of recognized welding standards

a) BS EN ISO 14343 : 2009 – Welding consumables. Wire electrodes, wires and rods for arc welding of stainless and heat resisting steels.
b) BS EN ISO 10042 : 2005 – Arc welded joints in aluminum and its alloys.
c) BS 5500 – Specifications for welded pressure vessels.
d) BS 5135 – Specifications for structural steel.
e) DEF STA 00-932 – Specifications for tensile steel.

6.9 **Procedures for the Issue of Approval**

6.9.1 The AMO employing the welder shall make arrangements for the welder to prepare and weld test samples in accordance with the requirements specified in Appendix 2 and submit the test samples to an Approved Test Organization for examination together with full particulars of the welder, materials and welding processes used, test sample figure numbers and identification marks on the test samples.

6.9.2 When the welder has made an application and after the test results furnished by the Approved Test Organization are found satisfactory, the AMO may then issue a welder's approval to the welder for the materials and welding processes used and prescribing any restrictions.

6.10 **Procedures for the Renewal of Approval**

Note: Should approval be sought for a rating (material and welding process used) different from that already granted, the procedures for the approval as detailed in paragraph 7 shall be followed.

6.10.1 The AMO employing the welder shall arrange for the renewal examinations of the welder's competency for each of the approved rating/restriction combination.

6.10.2 To ensure continuity of a welder's approval, the renewal examination should be carried out before the expiry date of the approval, but not more than two months before the expiry date. The examination should be scheduled so that the results can be known before the approval expires.

6.10.3 At each renewal examination, the AMO shall make arrangements for the welder to prepare and weld an appropriate test sample in accordance with the requirements specified in Appendix 2.

6.10.4 The AMO shall arrange to submit the test sample to an Approved Test Organization for examination together with full particulars of the welder concerned, material and welding process used, test sample figure number and identification marks on the test sample.

6.10.5 When the welder has made an application and after the test results furnished by the Approved Test Organization are found satisfactory, the AMO may then renew the welder's approval.

6.10.6 If the test results are unsatisfactory the AMO employing the welder shall arrange for the renewal examination to be repeated immediately and the test sample sent to an Approved Test Organization for examination. After these unsatisfactory test results are known and before the results of the repeated renewal examination are known the welder shall not weld parts that are essential to the airworthiness of an aircraft. If the test results of the repeated renewal examination are satisfactory, the welder's approval may then be renewed.

Note: If the test results of the repeated renewal examination are again unsatisfactory the welder's approval shall be suspended until further training and/or experience has been gained to the satisfaction of the Approved Organization, and a further examination has been satisfactorily completed.

6.11 The Approved Test Organizations examining the test samples shall send a copy of all test reports to the Approved Organization. The test reports shall detail the test results and indicate also the date of receipt of the test samples and the date when testing is completed.

6.12 An AMO employing approved welders shall maintain a register of the welders' approvals indicating:

a) the date of preparation of the test sample.
b) the name of the authorized person supervising the preparation.
c) the name of the Approved Test Organization to which the test sample has been sent for examination.
d) the date the test sample has been sent to the Approved Test Organization.
e) the date the test report was received.
f) the test report reference.

6.12.1 In relation to the renewal of approvals, records shall indicate:

a) the scheduled date for the next renewal examination; and
b) the period of suspension of approval, if any.

6.12.2 All records shall be made available to an authorized person on request.

6.13 The Authority may select samples of approved welders' work at any time for additional check examination purposes.

7.0 OTHER SPECIALIZED MAINTENANCE ACTIVITIES

7.1 Approved Maintenance Organizations engaged in "Metal Plating" and "Borescope Inspections" shall be required to develop training and qualification procedures for personnel performing such functions. All training shall be as guided by equipment manufacturers.

Kenya Civil Aviation Authority

APPENDIX 1 - NON-DESTRUCTIVE TESTING EXAMINATION REQUIREMENTS

1.0 Types of Test Samples.

1.1 The standard test samples are shown in the following figures:

Figure 1 - Sheet to sheet butt weld

Figure 2 - Sheet to tube weld

Figure 3 - Tube to tube weld

Note 1: The dimensions given in the figures are in millimetres and may be regarded as approximate.

Note 2: Approval will be limited to welding material from the specified metal group using the specified process. The selection of test samples to be welded by the applicant will further determine any restrictions to an approval in respect of the type of work to be undertaken.

1.2 The test samples shall be prepared by the applicant under the direct supervision of a supervisor. The supervisor will examine the dimensions, preparation and fitting of the test samples, and ensure that the required materials and process are used.

1.3 Additional test samples may be used if the applicant is not satisfied with the quality of the weld. The test samples shall be submitted complete and suitably identified to an Approved Test Organization for examination.

2.0 Welding of Test Samples

Note: Irrespective of the type of test samples, completed welds shall not be dressed, hammered or sand blasted. Light tapping with a hammer to remove scale deposits is acceptable. Flux shall be removed by standard procedures.

2.1 *Figure 1 Test Sample.* The edges of the sheet to be welded may be chamfered when 1.5mm or thicker sheet is used. Edge preparation is not necessary for aluminium alloys thinner than 2.5mm. The welding shall be performed with the test piece flat and by forehand welding from one side only using the correct filler rod, flux or shielding gas as applicable.

2.2 *Figure 2 Test Sample.* A 12mm diameter hole shall be drilled in the centre of each end plate prior to welding. The end plates may be positioned by tack welds. The first weld shall be completed by working around the test piece with the end plate flat on the bench and the tube vertical. The second weld shall be completed by working under and over the test piece with the tube horizontal and not moved during the welding process.

2.3 *Figure 3 Test Sample.* The tubes shall be prepared, assembled in a jig and tack welded. The assembly is then to be removed from the jig and mounted in a vertical position with the 150mm long tube vertical and 75mm long tube (at 45 degrees) at the top. The assembly shall not be moved from this position until all welds are completed. The welding of the lower tube shall be made by working around the test piece and the other welds by overhead welding and working around the test piece.

3.0 **Cutting Test Specimens.** Test specimens shall be cut from test samples by an Approved Test Organization in accordance with the details given in the appropriate figures.

4.0 **Specimen Examination.** Assessment of a weld shall be based on consideration of the sample weld as a whole, including the results obtained by visual, microscopical, and where applicable, mechanical testing. If any doubt exists regarding the quality of the weld, or any defect revealed is thought to be of a local character, further sections should be examined and final assessment shall be based on all the specimens examined.

Note: Figure 1 test specimens shall be subjected to tensile and bend tests. Figure 3 test specimens shall be subjected to tensile test.

4.1 The micro test specimen shall be examined at suitable magnifications in the unetched and etched conditions. A list of suitable etching reagents is given in Table 2.

4.2 The presence of intergranular oxide films is considered to be detrimental to the weld due to their embrittling effect, but the extent of these films is very difficult to determine in etched specimens. If the area of intergranular oxide is only very slight and satisfactory results are obtained by mechanical testing, further sections of the weld shall be examined before a decision is reached.

4.3 Where fillet welds are concerned, unless complete fusion is required by the drawing, a certain degree of lack of fusion is permissible at the roots:

a) For fillet welds of 45° or more, the maximum lack of fusion which can normally be accepted is that revealed by a line of oxide extending from the root of the weld for a distance not greater than one-third of that between the root and the toes of the weld. Provided the amount of weld material used has been adequate, this method of assessment should ensure that the effective throat thickness of the weld is not less than the thickness of the sheets or tubes used for the specimens.

b) For fillet welds at acute angles such as 30°, complete penetration in the root of tubular sections is difficult to achieve and there is a danger of collapse of the tube walls if excessive penetration is attempted. The presence of a fairly large cavity, or corresponding lack of fusion, is permissible at the root of such welds but there should be a bridge of weld metal and reasonable throat depth, showing satisfactory fusion to the basic metal.

4.4 *Sheet to Sheet Butt Welds.* The section must be free from excess oxidation, burning cracks, cavitation, porosity, scale and slag. The specimen must show adequate penetration when the underside of the weld is examined. If excessive penetration occurs along the entire length of the weld the specimen must be rejected, but isolated excrescence on the underside are permissible, provided the weld itself is free from cavities, oxide films, and other defects.

4.5 *Tube to Sheet and Tube to Tube Welds.* The specimen must show adequate penetration and freedom from excess oxidation, cracks, cavitation, porosity, scale and slag.

5.0 Mechanical Testing of Specimens

5.1 *Tensile Test*

5.1.1 Tensile test specimens shall be tested to destruction in direct tension. The ultimate stress (calculated on the minimum area of cross section of the specimen, i.e. ignoring the increase in thickness due to welding) and the location of the break shall be recorded. Tube to tube weld specimens shall be broken in a tensile test machine fitted with suitable shackles and pins, the pins being passed through the top and bottom cross tubes of the specimens, so that the tensile load may be applied without bending the specimens.

5.1.2 A weld will be considered satisfactory when the failure occurs in the parent metal. A test piece failing at the toe of the weld or in the weld material can only be considered satisfactory if the ultimate stress is found to exceed the minimum tensile strength of the parent metal as given in the appropriate material specification, and if the fracture surfaces are free from defects such as cracking, blow holes, excessive porosity or inclusions. No evidence of lack of adhesion such as the peeling away of the filler metal shall be apparent.

5.2 *Bend Test*

5.2.1 Bend test specimen shall be tested in bending so that the weld lies along the centre line of the bend and the weld face (the side from which the welding was performed) is on the outside of the bend.

5.2.2 To ensure the close contact of the specimen to the bar about which it is bent, the side of the specimen away from the weld face should be dressed down by filing or grinding until the weld is level with the parent metal. The edges of the specimen in the vicinity of the weld should be given reasonable radii.

5.2.3 Austenitic steel specimens must be given the "weld decay" pickling test prescribed in the relevant specification or in accordance with British Standard 5903 prior to the bend test.

5.2.4 The test sample is to withstand bending through an angle of 180° over a radius of twice the nominal thickness, 'T', of the test sample without breaking or developing a crack visible to the unaided eye, except for the material listed in the following table and where the material specification for the parent metal specifies a less severe bend.

Table 1: Specific Specifications

	Material	**Angle of Bend (degrees)**	**Radius of Bend (T = nominal thickness)**
a)	Austenitic steels	90	3T
b)	Magnesium alloys	180	10T
c)	Aluminium alloys	180	5T
d)	Steels containing boron	180	3T
e)	Titanium alloys	180	5T
f)	Others	180	2T

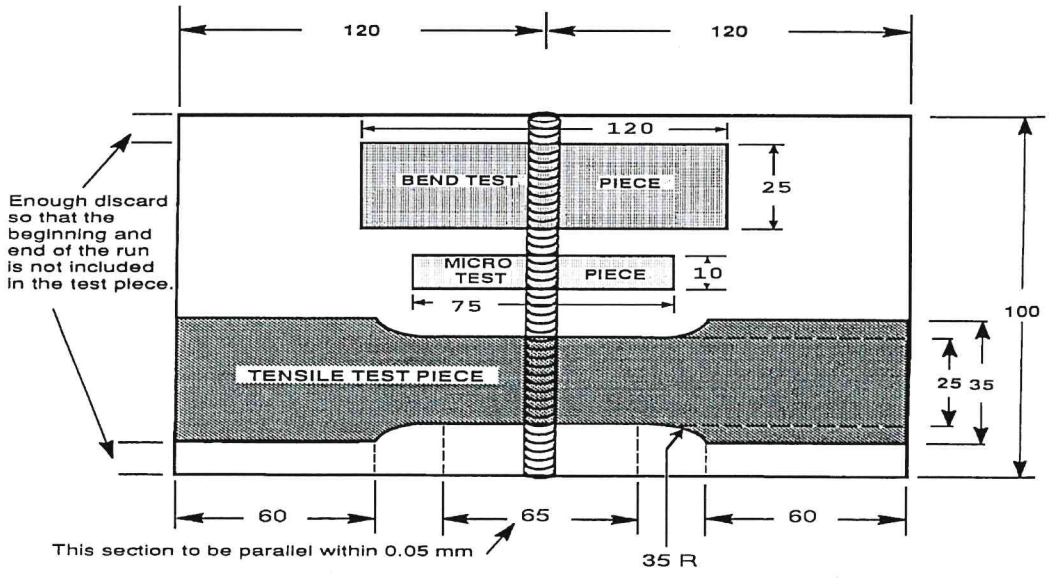
Note: In the event the bend test details exceed distortion limits of the parent material, the bend limitations of the parent material shall be used.

5.2.5 A bend test will be considered satisfactory if the test specimen withstands the bending without developing cracks visible to the unaided eye.

Note: If interpretation of the bend test results is in doubt, comparison may be made with the bend test performance of a separate sample of the parent material from which the test specimens were prepared.

Table 1 - Etching Reagents

Material	Reagent
Carbon steels	Saturated solution of picric acid in ethyl alcohol (industrial spirit grade)
	Concentrated nitric acid 2%) Ethyl alcohol (industrial spirit grade) 98%) (V/V)
Corrosion-resisting steels and nickel base alloys	Ferric Chloride 5g Concentrated hydrochloric acid 50ml Distilled water 100ml Concentrated nitric acid (used electrolytically)
	Oxalic acid) used 10g Distilled water) electrolytically 90ml
	Phosphoric acid) used electrolytically 85%) Glycerin) at 85° 15%) (V/V)
Aluminium alloys	Concentrated nitric acid 20%) Hydrofluoric acid (40%) 2%) (V/V) Distilled water 78%)
	Hydrofluoric acid (40%) 0.5%) Distilled water 99.5%) (V/V)
Magnesium	Concentrated nitric acid 1%) Distilled water 99%) (V/V)
Copper base alloys	Ferric Chloride 5g Concentrated hydrochloric acid 50ml Distilled water 100ml
Titanium alloys	Nitric acid 1 19%) Hydrofluoric acid 1% (V/V) Distilled water 80%)



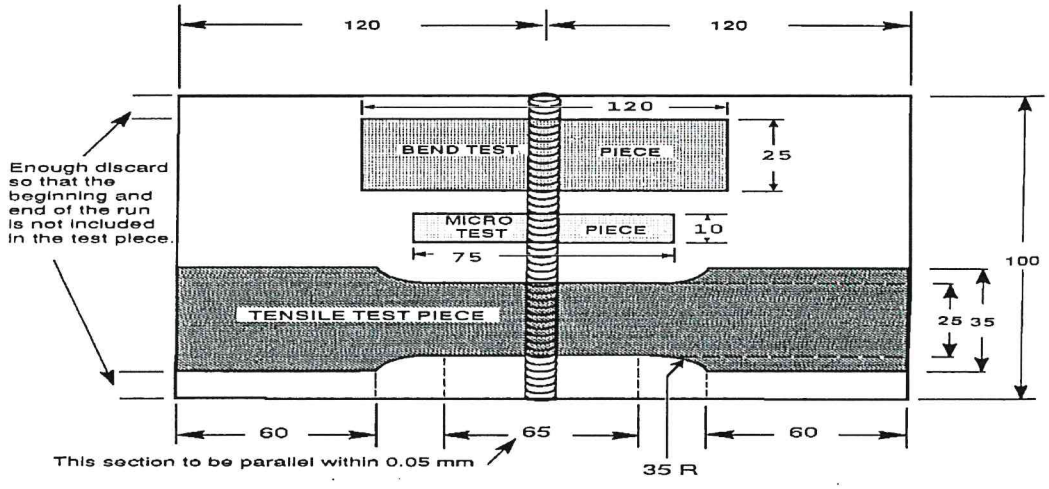


Figure: 1 Sheet to Sheet Butt Weld

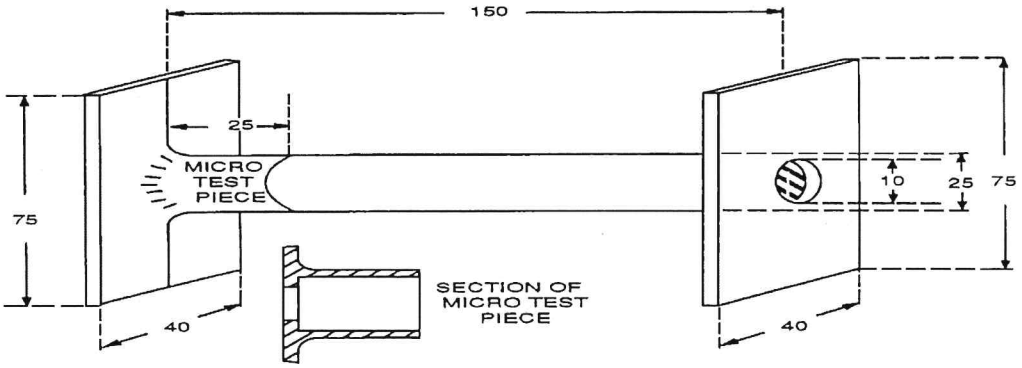
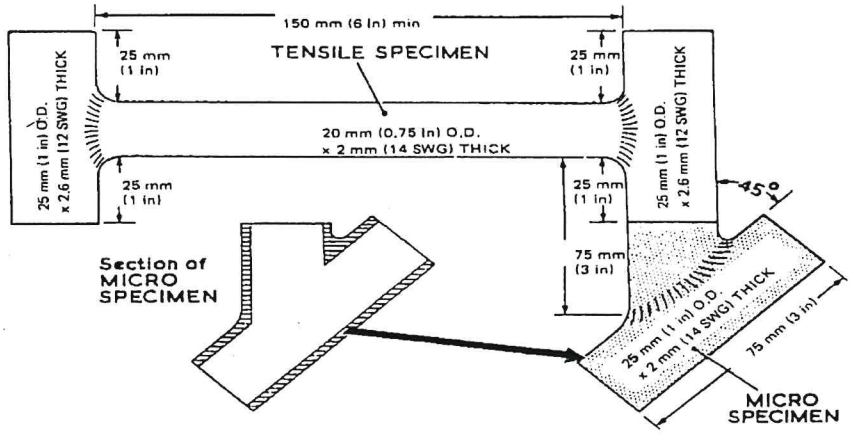


Figure 2: Sheet to Tube Weld



NOTE: If desired, small air vent holes may be drilled in the 2.6 mm (12 swg) tubes in the tensile specimen and the 2 mm (14 swg) tube in the micro specimen.

Figure 3: Tube to Tube Weld

APPENDIX 2 –NDT SYLLABUS

1.0 Dye Penetrant Inspection Syllabus

1.1 Principles of penetrant inspection.

1.2 Applicability; Types and characteristics of flaws, detectability of flaws, limitations on applicability to types of materials and types of flaws.

1.3 Penetrant Systems; Characteristics and basis of selection of types of penetrants, emulsifiers and developers; compatibility of penetrants.

1.4 Techniques of inspection; Advantages and limitations of the various methods of preparation; selection of methods of application of penetrant, emulsifier and developer; dwell times; temperature effects; re-running; interpretation of indications.

1.5 Equipment and control; Black lights and measurement of intensity; methods of control of contamination of penetrants, emulsifiers and developers; inspection area conditions.

1.6 The characteristics and terminology of defects arising from casting welding, heat treatment, fatigue and stress corrosion cracking.

2.0 Magnetic Particle Inspection Syllabus

2.1 Elementary theory of magnetism; Concepts of flux density, permeability, reluctance and the hysteresis loop.

2.2 Principles of magnetic particle testing; Theory, fields, current and demagnetization.

2.3 Method of magnetization; Circular magnetization by current flow, threading bar, induced current and longitudinal magnetization by coil, magnetic flow.

2.4 Methods of establishment of flux density for inspection; The significant of reverse fields in coil magnetization; characteristics of magnetization by ac and dc.

2.5 Test procedures by continuous and residual methods; Application of wet and dry magnetic particles.

2.6 Characteristics and section of types of magnetic particle indicators; Methods of preparation of and the control of concentration of wet bath indicators; measurement of black light intensity.

2.7 The Applicability and Limitations of the Methods; Types of flaws and the interpretation of indications; factors governing sensitivity characteristics and sources of non-relevant indications.

3.0 Radiographic Inspection Syllabus

3.1 Elementary theory; The properties, characteristics and generation of X and gamma rays including the electro-magnetic spectrum; monochromatic characteristic and bremsstrahlung radiation; propagation and inverse square law, absorption, scattering and the interaction of X-rays and matter.

3.2 Equipment; Principles of basic design and operation of X-ray generating equipment including the effects of voltage and amperage in the control of quality and intensity of radiation.

3.3 The principles of the method; the factors controlling sensitivity to the detection of cracking and corrosion including definition, contrast, alignment of the beam.

3.4 Basic technique; The relationship and interdependence of factors controlling definition and contrast including subject contrast, variation of absorption coefficient with quality of

radiation, scatter, optimum film density, geometric unsharpness, focal spot size and geometric distribution in the beam, focus to object and focus to film distances.

3.5 The nature of X-ray; The properties and selection of films including characteristics curves, optimum density and film contrast amplification.

3.6 Screens; The principles, selection and use of metal and fluorescent screens.

3.7 The principles of film processing; The preparation, use and maintenance of film developing and fixing processes.

3.8 Exposure control; The preparation and use of exposure curves, the factors governing the selection of exposure including the voltage, milliamperage, film to focus distance and exposure time; the principles and use of filters; methods of minimizing scattered radiation. Calculation for correct exposure. Relationship between SI units and non SI units in radiography.

3.9 Viewers and optimum conditions.

3.10 Interpretation; Types of flaws and their interpretation, the significance of image quality indicators, the characteristics and terminology of flaws arising from casting, welding, heat treatment, fatigue, stress corrosion cracking; the recognition of image quality degradation or spurious images caused by faulty film processing or handling.

3.11 The advantages and limitations of the method.

3.12 Radiation hazards and safety.

3.13 Methods of recording, reporting and identification and filing of radiographs.

3.14 General knowledge of aircraft structures, methods of manufacture and interpretation of engineering drawings. Construction of fuselages, empennages, centre sections, mainplanes, undercarriages and control surfaces. Identification of areas and locations i.e. station numbers.

4.0 Ultra-Sonic Inspection Syllabus

4.1 Basic properties and nature of sound; The acoustic spectrum; frequency wave length and velocity relationship; propagation; acoustic impedance, reflection and impedance, mismatch, refraction, Snell's law; intensity, the decibel; attenuation by absorption and diffraction; types of sound waves and their characteristics. longitudinal, transverse, surface, plate and standing; factors affecting wave velocity; mode conversion at boundaries, acoustic coupling.

4.2 Generation of Ultrasonic Waves; The piezoelectric effects; electro-acoustic transducers, crystal thickness and resonant frequency, sound beam geometry, near zone and far zone characteristics, band width, pulsed beams, relative efficiencies of crystal types as transmitters and receivers - quartz, barium titanate, lithium sulphate, lead zirconate.

4.3 Probe Design; The ringing of a crystal, damping and the need for a short pulse length; types of probes and their construction, transceiver, combined, separate, focused; the dead zone.

4.4 The basis of the methods; The pulse echo and through transmission systems, resonance testing, immersion and contact scanning, the relationship between travel time of a reflected pulse and the position of the reflecting boundary, arithmetic of scanning and identification f echoes.

4.5 Instruments and equipment; The basic operation of the circuit of the pulse echo systems, the cathode ray tube, time base, pulse generation, pulse repetition frequency, amplifier gain, suppression, range, time delay, the significance of time base and receiver amplifier linearity, scale expansion; supplementary equipment, thickness gauge, flaw alarm, swept gain control, interface trigger, A, B and C scan presentations, rectified and unrectified trace.

4.6 Techniques: Surface preparation, the use of viscous couplants on rough surfaces, the necessity to remove uneven or poorly adhering paint and surface adherents such as heat treatment scale. The choice of transducer size and frequency as a function of the requirements of access, critical defect size, and minimal near zone length and beam divergence. The choice of shear wave refracted angle as a function of the geometry of the part under examination. The choice of overall test sensitivity and the use of standard reflectors and/or reference signals to confirm correct sensitivity. The IIW block, flat bottomed holes, the use of suppression and its effect on reflector area to signal height relationship. The use of defective parts or models containing artificial defect as test comparators. The estimation of defect size using comparative signal amplitude and surface plotting techniques. Factors governing amplitude of signals from defects. The reporting and recording of test results.

4.7 The characteristics and terminology of defects arising from casting, welding, heat treatment, fatigue, stress corrosion cracking.

4.8 A general knowledge of aircraft structures, methods of manufacture and interpretation of engineering drawings. Construction of fuselages, empennages, centre sections, mainplanes, undercarriages and controls surfaces. Identification of areas and locations i.e. station numbers.

5.0 Eddy Current Inspection Syllabus

5.1 Basic principles of the method.

5.2 Basic theory of electricity and magnetism and induced eddy currents: direct current including simple circuits, alternating current including simple circuits, Ohms Law, Faraday's Law, Lenz's Law, power formulae, induction, inductance, capacitance, reactance, impedance, frequency, resonance, phase relationships; magnetic effect of current flow; magnetic field intensity, hysteresis loop, permeability; inducing eddy currents by coil. Concepts, definitions and units of measurement.

5.3 Factors to consider in eddy current testing: factors affecting the eddy current field; effective depth of penetration and factors affecting penetration, test coil information from impedance, coupling and phase changes.

5.4 Equipment and related applications: coil arrangements and types of coil; principles of probe design and construction principles; types of circuits including bridge, resonance and phase analysis, impedance change instruments. The selection, care, maintenance and calibration of equipment.

5.5 Techniques: probe characteristics and selection, probe field size to flaw size relationship. Factors affecting sensitivity including probe to test piece distance, angularity, edge effect contact pressure, conductive and non-conductive coating thickness, alloy composition variations, lift-off adjustment, signal/noise ratio, depth or skin effect. Design fundamentals of eddy current flaw standards and flaw detectability limitations.

5.6 Assessment of mechanical properties by the measurement of electrical conductivity; metallurgical factors affecting mechanical properties and electrical conductivity of heat treated aluminium alloys including alloy composition, size and distribution of precipitates. Variables affecting electrical conductivity measurements; thickness curvature, thickness of conducting and non-conducting coatings, temperature, precautions necessary for the assessment of heat affected aluminium alloys, e.g. fire damage. Conductivity standards.