ALTERNATED CURRENT FIELD MEASUREMENT (ACFM)

This document provides specific information relating to the Alternated Current Field Measurement (ACFM) method, with special reference to:

1) the training program depending on the level
2) the requirements to be admitted to the examination

1.1) TRAINING PROGRAM - LEVEL 1 (total hours: 32 – theory and practice)

Contents	Level 1	Duration (hours)
G.1 **Introduction to NDT terms and history**	Tasks of NDT personnel NDT history History of the ACFM method Relevant terms	1
G.2 **Physical principles of the method and associated knowledge**	ACFM theory – general physics information about electromagnetism Theory of induced currents Generation of induced currents by an AC field Effects of fields generated by induced currents Properties of induced currents Distribution of induced currents Lift-off and geometry effects Relationship between a magnetic field and a current within a coil Effects of permeability variation in magnetic materials Effects of discontinuities Relationship between frequency and penetration depth Standard penetration depth Flux leakage theory Terms and units Magnetization principles Curve B-H Magnetic properties Magnetic fields Magnetic permeability Factors affecting magnetic permeability Basic electric theory Basic unit of electrical measurement Direct-current circuits Ohm's law Faraday's law Resistance Inductance Magnetic effect of electric currents Uniform magnetic fields: interaction of field with defects, effects of field curvature, Bx and Bz field components typical displays: Bx and Bz time base, butterfly plot ACFM defect models	15
G.3 **Equipment and transducers**	ACFM equipment equipment and basic operation; basic maintenance; potential equipment faults, causes and corrective actions ACFM manual and array probes simple probes; field generation; Bx and Bz sensors; multiple coil configurations; advantages and limitations of array probes; position encoder; X and Y field direction switching; optical encoder; identity chip; multiple Bz coil pencil probes ACFM software main functions: software set up; operation of main inspection screen	4
G.4 **Signal interpretation**	Basic signal interpretation Signals influenced by geometry and material variations Defect shape and orientation; edge effect signals influenced by surface finish; effects of non-conductive coatings; false indications and causes Relationship between Bx, Bz and butterfly plots; typical defect signals Examples of signals influenced by geometry effects, edge effect, weld defects, bolt holes	4
G.5	Defect sizing	4

Contents	Level 1	Duration (hours)
Sizing of indications	Software and manual sizing; automatic sizing system limitations, minimum detectable defect size and measurement Use of ACFM model; data required to size using mathematical models and algorithms; sizing problems	
G.6 **Scanning techniques**	Function checks; probe deployment including A / C / T direction; software operation to start and stop scan and operation of markers	3
G7 **Test report**	Data acquisition and storage Marking of tested product, data printout and test reports	1

1.2) TRAINING PROGRAM - LEVEL 2 (total hours: 32 – theory and practice)

Contents	Level 1	Duration (hours)
G.9 **Review and integration**	Review and integration of basic concepts G1, G2, G3, G4, G5, G6, G7 relating to level 1. - Specific ACFM theory Probe selection and technical characteristics of the probe - Sizing Limitations of ACFM model; advanced manual sizing. - Safety Fire hazards; electrical safety - Conduct of test Test procedures and NDT instructions Use of remote scanning techniques; briefing of the remote probe operator; minimum qualifications for remote probe operator; supervision of level 1 personnel; production of probe files and their analysis - Detail signal interpretation Types of discontinuity and their identification; relevant and non-relevant indications and their cause; identification of crack features; capabilities and limitations of other NDT methods in terms of detection; characterization and confirmation of defects. - Reporting Responsibilities for reporting; origination and authentication of NDT reports; content and layout of report; presentation of the inspection results of an NDT report; hardcopy computer generated report storage	16
G.10 **Specific theory**	Specific theory a) Product technology Terminology of welds; basic principles of fusion welding processes; methods of producing welds including MMA, TIG, MAG, Submerged Arc and Electro slag; rail weld types Basic types of welds including filler welds, butt welds Variable configuration welds including T's nozzles and nodes Influence on techniques of geometry, size, surface condition, parent metal composition; influence of non-conductive and conductive paint coatings and weld repairs; types of defects in welds and parent metal including lack of fusion, porosity, cracks b) Equipment maintenance Probe care; troubleshooting; instrument and battery c) Reporting Configuring customer reports; emailing reports; incorporating results into reports; searching for and emailing data records	8
G.11 **Standards**	NDT standards and operating procedures Explaining the standards applicable to ACFM Explaining the operating procedures applicable to ACFM	8

1.3) TRAINING PROGRAM - LEVEL 3 (total hours: 40 – theory and practice)

Contents	Level 1	Duration (hours)
Foreword	Level 3 personnel are expected to be prepared to take responsibility for managing an industrial NDT structure. Therefore the level 3 examination will evaluate the candidate's competence on the following subjects: Assignment of personnel with appropriate certificates according to the customer's requirements. Supervision and revision of the documents relating to subordinates of certification and recertification registers Compiling and recording of instrument sheets, with evidences of any repairs, calibrations Revision of the reports relating to the work performed by level 1 and 2 personnel and approval of issued reports Revision and issue of operating procedures Updating to product standards and application of control techniques in accordance with the safety standard The level 3 examination program is structured as follows:	NA
G.12 General theory on other NDT methods	General theory of other NDT methods for level 2 [12 hours] General theory for level 2, including any limitations and applications, of four NDT methods. Examination programs are described in the UNI CEN ISO TR 25107 standard. In details, level 3 candidates shall demonstrate to know the level 2 general theory program that covers the NDT method for which level 3 certification is sought and also three other methods selected by the candidate among RT, UT, PT, MT, ET and VT	12
G.13 ACFM general theory	In addition to the level 2 ACFM program: Standards and Codes for the test and defect acceptance limitations Familiarity with the codes and standards relating to the application of electromagnetic tests in the weld sector; understanding their practical application Detected signal analysis	12
G.14 Technology and materials	This part of the program will be concerned with the technology of the product prevoiusly supplied to level 2, but a level 3 candidate shall also demonstrate to know the melting, forging and rolling processes, including the relevant defects	8
G.15 Procedures	Drafting of a procedure The candidates shall be requested to draft a written procedure for the inspection of a specific component, with reference to a specific code or standard This procedure shall include safety requirements adequate to the test situation, acceptance levels in accordance with specific implementation standards, NDT personnel approvals, reference documentation, use of complementary NDT methods, inspection times in relation to manufacturing and revision, special contractual requirements, actions to be taken in case of non-compliance and lack of reporting instructions (application of the procedure)	8

2) EXAMINATION ADMITTANCE REQUIREMENTS

To be admitted to the examinations, a candidate must have the minimum training, experience and physical fitness requirements set out in the UNI EN ISO 9712 standard and listed here below:

1. Physical fitness
   The candidate shall provide documented evidence of satisfactory vision, assessed by an ophthalmologist, an optometrist or another person entitled to practice medicine. The result must be written on a certificate that may not date from more than three months after the examination request date; for those candidates that are already certified by RINA a valid annual visual acuity certificate is sufficient.
   The following requirements must be satisfied:

   I. Near-vision acuity shall permit reading, with one or both eyes, either corrected or uncorrected, a minimum of number 1 of the Jaeger scale, or Times Roman No. 4.5 or equivalent letters at not less than 30 cm.
   II. Colour vision shall be sufficient that the candidate can distinguish contrast between the colours used in the NDT method for which certification is sought.

2. Training
   I. The candidate must possess the requisite knowledge for performing the expected tasks to the extent related to the level for which he/she is certified.
      This knowledge must be:
      - general basic knowledge of mathematics and physics, behaviour of materials, production technologies and types of defects
      - general and specific knowledge of test methods and applicable codes and standards

   II. The personnel must be subject to a training period, which must be recognized by RINA; training must:
      - be provided under the supervision and responsibility of a person certified to level 3
      - have the duration specified in Table I
      - write a diary with information about attendance to the course, training hours and subjects dealt with

   III. Training hours include both theory and practical courses
   IV. In case of direct access to level 2 a minimum number of training hours is required, equal to the sum of the training hours required for level 1 and 2
   V. Each participant shall receive a copy of the above diary signed by the level 3 technician
   VI. Training duration may be reduced by 50% for candidates who have graduated from technical or scientific college or university or are already certified for the ET and MT method in accordance with the ISO 9712 standard in its applicable edition.

	Level 1	Level 2	Level 3
Hours	32	32	40*

Table I – Duration of the expected training for the ACFM method

*suggested hours

   VII. Taking into account the scientific and technical potential of candidates for Level 3 certification, no specific training is foreseen. Preparation for qualification may be done by attending training courses, conferences or seminars, studying books,

periodicals and other specialized printed material. The candidate must provide RINA with documentary evidences of his/her preparation.

3. Experience
   I. Experience must be practical and repetitive, aimed at increasing knowledge of the various methods as well as the ability and capacity of judgement.
   II. The candidate must provide documentary evidences that experience has been acquired under the supervision of an expert
   III. The experience can be completed also after the qualification examination has been passed, but within the year. The candidate can receive the certificate only after providing RINA with documents, confirmed by the employer, attesting the actual acquisition of the experience
   IV. With regard to levels 1 and 2, the minimum required experience is specified in Table I considering that the number of months is based on a 40 h working week. When a person is directly certified to level 2, skipping level 1, the required experience must be equal to the sum of the time required for level 1 and for level 2.
   V. Credit for experience may be gained in one or more NDT methods with a reduction of the total required experience as follows:
      a. 2 testing methods: reduction of total required time by 25%
      b. 3 testing methods: reduction of total required time by 33%
      c. 4 testing methods: reduction of total required time by 50%

   In all cases the candidate's experience, for each of the testing methods for which certification is sought, must be equal to at least half of the required time

	Level 1	Level 2
Months	3	9

Table II – Minimum required times for the ACFM method

4. Table II provides the minimum required experience for Level 3 as a function of school education. The candidate must have a Level 2 multisector certificate. Direct access to Level 3 is possible, without the Level 2 certification, only if the candidate provides evidences of having passed the level 2 multisector examination of that method with at least 70% at a recognized Examination Centre without drafting the level 1 instructions. The required experience for Level 3 certification is the experience acquired as a level 2 certified operator. To gain direct access, the candidate must have worked at a level comparable to Level 2 for the specified period of time.
   Credit for experience may be gained simultaneously in two or more of the NDT methods defined in these Rules, with a reduction of the total required experience as follows:
   - 2 testing methods: reduction of total required time by 25%;
   - 3 testing methods: reduction of total required time by 33%;
   - 4 testing methods: reduction of total required time by 50%.

   In all cases the candidate's experience, for each of the testing methods for which certification is sought, must be equal to at least half of the required time

Education		Experience (years)
Degree in engineering or degree course (3 years) or equivalent certificate	With level 2 certification	1
	Direct access to level 3	2
Technical or scientific diploma (secondary school) or equivalent certificate	With level 2 certification	2
	Direct access to level 3	4
No education certificate	With level 2 certification	4
	Direct access to level 3	6

Table III – Minimum required experience for the ACFM method for a Level 3 candidate