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Establish the training program of alternating current field measurement - level II according to SNT-TC-1A

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Abstract: Alternating Current Field Measurement (ACFM) is a technique of the Electromagnetic method used to detect surface defects of metal materials. Currently, this technique is widely applied in the field of maintenance of Oil and Gas projects as an alternative to the Magnetic Particle Testing method. The establishment of ACFM training program according to Recommended Practice No. SNT-TC-1A of The American Society for Nondestructive Testing (ASNT) will increase the autonomy of the domestic testing human resources, especially advanced techniques. Based on documents and standards combined with the actual survey, training programs, training materials, question banks, examinations developed meet the requirements of international standards and in accordance with the conditions applied in Vietnam.

Keywords: *Nondestructive Testing, Alternating Current Field Measurement, Magnetic Particle Testing, ASNT, NDT, ACFM, MT, SNT-TC-1A.*

I. INTRODUCTION

Non-Destructive Testing (NDT) has a long history of development, starting with conventional methods using simple testing equipment and tools that has brought benefits by creating products with high quality and reliability. Nowadays, dramatic advances in science & technology development have led to constantly invention of new test principles with the equipment systems integrating many features and supporting software continuously developing toward modernity. Based on that characteristic, the world has formed a classification with two categories that are conventional methods and advanced techniques with new principles and complex equipment system for specific applications. Alternating Current Field Measurement (ACFM) is one of the standout techniques.

The ACFM technique is commonly used for detecting surface defects of metallic materials (both ferromagnetic and non-ferromagnetic). This technique has more upsides than the Magnetic Particle (MT) and Eddy Current (ECT) test, especially providing both length and depth information of cracks in carbon steel welds at the same time through the test results. These results are stored for a long time as a signal that enables authorized personnel to retrieve the reassessment at any time and use them to track and calculate the rate of development of defects, which leads to decision on the right time to repair or replace. It can result in the project operating safely and increasing economic efficiency.

The ACFM technique is used in the annual maintenance inspection program, providing input information for caculating the remaining life in fields such as: Oil and gas, thermal or nuclear power, transportation, lifting equipment, etc.

The increasing demand for applying ACFM techniques in Vietnam leads to the need of developing human resources trained,

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assessed and certified in accordance with international standards.

II. CONTENT

II.1. Objects and Methods

II.1.1 Introduction to ACFM technique [1], [2], [3]

ACFM is a technique based on the principle of electromagnetic induction as described in Figure 1. A primary magnetic field is generated by passing an alternating current through a coil. When the coil is placed near the surface of the conductive material test object, the magnetic field will induce an inductive current flowing in that object (eddy currents). When the coil goes through a cracked area, eddy currents will be disturbed to flow around and below the crack which changes the magnetic field above the surface of the test object. The ACFM probe uses two coil sensors, one used to measure the vertical magnetic field (Bz) and the other used to measure the horizontal magnetic field (Bx) relative to the surface.

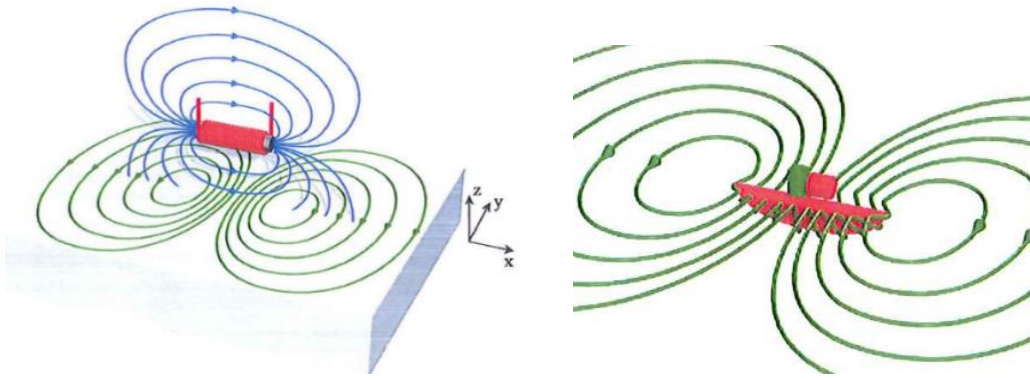

Fig. 1. ACFM principle

The disturbed magnetic field around the crack is obtained by sensors from the tips of the crack (Bz) and the depth of the crack (Bx). When these signals are combined simultaneously on a graph with the Bx and Bz axes perpendicular to each other, they create a circle and is called a "Butterfly plot" as shown in figure 2. During the test the operator will rely on these signals to detect the presence of a crack as well as determine the length and depth of the crack. All of these data are saved by the equipment system to serve for review, evaluation and reporting.

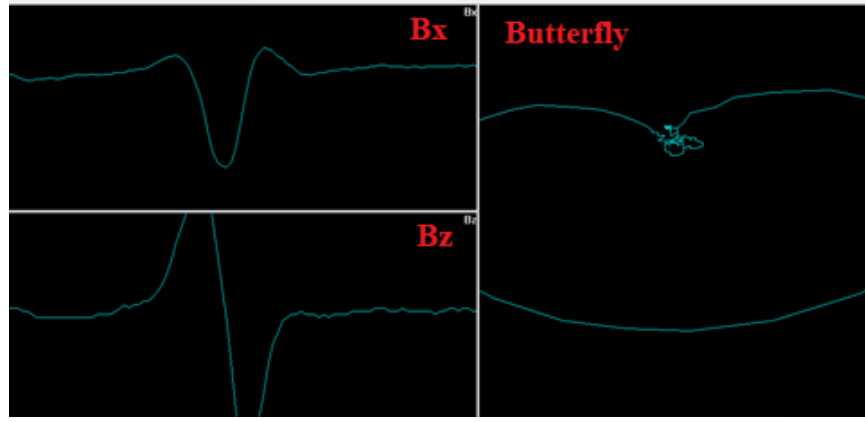

Fig. 2. ACFM signals

Based on its characteristic test principle, the ACFM technique has advantages and disadvantages compared with other surface inspection techniques such as Eddy Current Testing (ECT) and Magnetic Particle Testing (MT).

Table I. Characteristics of ACFM compared to other techniques

Đặc điểm	**ACFM**	**ECT**	**MT**
Through-coating detection	√	√	x
No need for chemicals	√	√	x
Duplex and non-ferromagnetic metal detection	√	√	x
Remote deployment	√	x	x
Long-term storage results as accurate and re-evaluated signals	√	x	x
Sizing crack length and depth	√	x	x
High probability of dectection (PoD) and low false call rate	√	x	x
Note: √: Yes x: No			

Besides the above featrures, ACFM technique also has certain downsides such as:

- Should be used only to detect surface defects such as fatigue cracks;

- Defect sizing models available for certain types of materials;

- Defect sizing models based on planar cracks and not work on complex branced cracks;

- Expensive model technology equipment;

- The technicians have been required more trained and experience than the MT method.

II.1.2 Research method

The actual survey of ACFM technical application needs is focus on the industrial sector, especially in the oil and gas which often has high requirements on the quality of the project as well as has enough economic potential for application of advanced testing technique. Survey results show that all organizations need to train ACFM staff according to the organization in charge certification system (under SNT-TC-1A) and/or the Central certification system (CSWIP) to apply for weld testing during the operation and maintenance of objects such as drilling rigs, pressure tanks, lifting equipment.

From the survey results and practical conditions in Vietnam, the NDE Center has established a training program under the organization in charge certification system by following the training program requirements of the SNT-TC-1A document and training contents included in ANSI/ ASNT CP-105 document, researching the technical requirements contained in the standards ASTM and ASME. According to the requirements of the training program to content standards, main topic content, references and equipment manuals, the team elaborates on developing the training program, training materials, question bank, assessment test to meet practical needs applied to the industrial sectors in Vietnam.

II. 2. Results

Through the survey results on actual application needs and research on popular standard documents in the world, the project team has achieved the following results:

II.2.1 Training program [4], [5]

No.	Contents	Training Hours
1	Introduction to common welding methods and related discontinuities	4
2	Introduction to Nondestructive Testing (NDT)	4
3	Principle of Electromagnetic Testing (ET)	4
4	Principle of Eddy Current Testing (ECT)	4
5	Principle of Alternating Current Field Measurement (ACFM)	4
6	Alternating Current Field Measurement equipment systems	8
7	Procedure	8
8	Practice of Testing	32
9	Introduction to application standards	8
10	Review and discussion	4
Total duration time		**80**

Note: 60 minutes per hour training

II.2.2 Training materials [1], [2], [7], [8]

The training materials including Training book, Presentation Lectures cover the contents of the training program.

II.2.3 Review question bank [6]

The review question bank has 130 edited multiple-choice questions based on the ASNT Electromagnetic Question and Answer published by ASNT and the creativity of the team. The questions include 04 answers and cover the following contents: Welding process and related discontinuities; Principle basis; Methods and techniques; Equipment system used; Standard validation and Test applications.

II.2.4 Examinations [4]

The examinations for ACFM level II meet the requirements of the recommended practice No. SNT-TC-1A, 2016 edition, including:

a) Vision examinations: the content to test the ability to near vision acuity and color contrast differentiation.

b) General examination: includes 40 multiple-choice questions with 04 answer options, similar questions but not the same review questions bank provided to students. The content focuses on the basis of test principles, equipment operating principles, pros and cons of testing techniques, welding processes and related discontinuities. The duration is 60 minutes. Candidates are not allowed to use other documents except relevant documents such as graphs, tables, diagrams, etc. provided with the examination.

c) Specific examination: includes 20 multiple-choice questions with 04 answer options. The question address the equipment (used), testing procedures, applicable standards. The duration is 60 minutes. Candidates are allowed to use the references (procedures, applicable standards).

d) Practical examination: requires the candidate to demonstrate the ability to operate the equipment system proficiently, standard/confirm the standard before and after

the test, perform on 02 different samples, detect and define the position parameters of the discontinuity size, evaluate the discontinuity based on given criteria. The test must have at least 10 different checkpoints to evaluate the candidate's ability. The duration is 120 minutes.

Fig. 3. Training materials

II.2.5 Drawing and manufacturing of reference standards [7], [8]

Generally, NDT methods' nature are indirect. Therefore, the equipment needs to be standardized / validated before conducting, especially Ultrasonic or Electromagnetic Test, which helps the test results to be consistent and reliable.

With the ACFM technique, both the standards ASTM E2261 / E2261M and the ASME BPV section V code, article 15 specify that the equipment must be validated through the reference standards before and after each test. Based on the requirements of each standard, the team designed and fabricated the ones as shown in Figures 4 and 5.

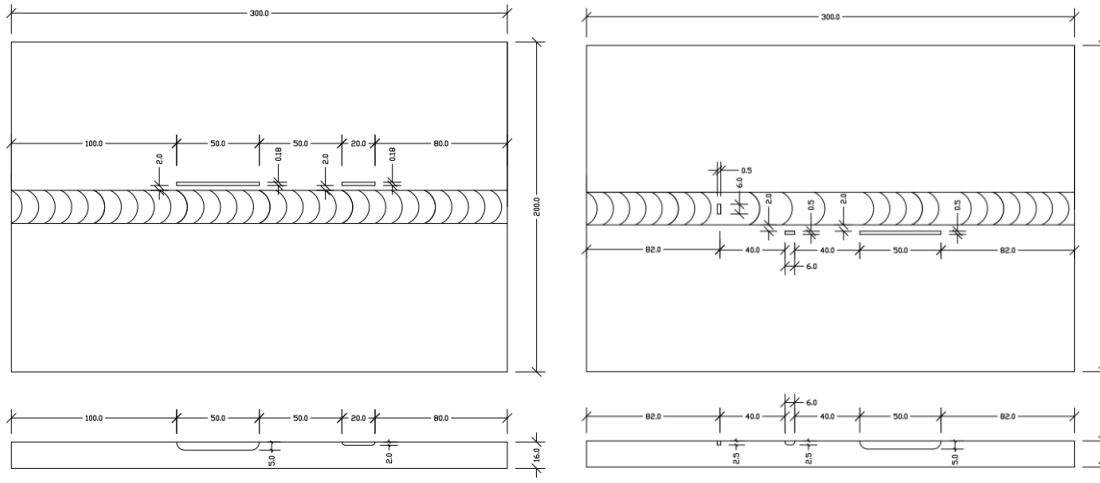

Fig. 4. Drawing of the reference standards according to ASTM E2261/2261M and ASME V, article 15

After the fabrication process, the reference standards are accepted to ensure dimensional parameters given in the drawings. Finally, the ones are verified by a calibrated ACFM equipment, a cut of 50 x 5 mm on each sample produces a Butterfly signal with a length x width of about 175 x 50% of the screen display of the device (Figure 5).

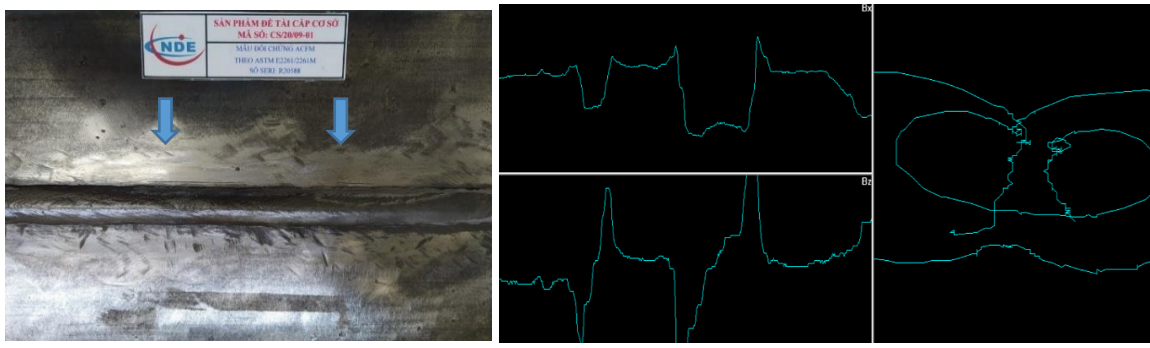

Fig. 5. Reference standards according to ASTM E2261/2261M and ASME V, article 15

II.3. Discussion

- The ACFM training program has been established over 80 hour duration, ensuring to satisfy the requirements of the recommended practice No. SNT-TC-1A given for technician to study directly to Level II.

- Developing the contents for theoretical and practical examinations as the basis for the individual qualification process under the in-house certification system.

- The successful fabrication of reference standards with high precision requirements has helped to master technology from design to manufacturing in Vietnam, minimizing dependence on foreign countries. In addition, the on-site fabrication should reduce shipping costs and import duties, which leads to lower testing costs.

- The ACFM training program has initially applied for NDE Center and Petroleum College (PVMTC) - a unit with high demand in using ACFM technique to test welds in the oil and gas industry in Vietnam. This achieved good results and received positive reviews from representatives of PVMTC and trainees.

- The initial training program is specifically designed for weld inspection in the oil and gas field, Which is the first step for continuing to develop training programs for other applications such as energy - thermal power, bridges, roads, railways, ...

- The completion of the ACFM level II training program could create the foundation of the training program development for Electromagnetic Testing level III with knowledge cover three techniques: Eddy Current Testing (ECT), Alternating Current Field Measurement (ACFM) and Remote Field Testing (RFT).

III. CONCLUSION

The ACFM training program has met the requirements of SNT-TC-1A standards with the introduction of a system supporting documents for the training program including training materials, lectures, question bank, examination in Vietnamese which could be suitable to the needs of practical application in Vietnam.

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