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RSE-M code progress in the field of examination evaluation and flaw acceptance criteria

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ABSTRACT : The RSE-M Code provides rules and requirements for in service inspection of light water cooled nuclear power plants. The code first edition was established by EDF and published in 1990 by AFCEN. In 1992, a second RSE-M project was launched by EDF and FRAMATOME with the objective to address a 1995 edition more completed considering the needs of owners, users, manufacturers and inspectors. This paper focuses on evaluation of examination results and presents the work done in the field of flaw acceptance criteria over the last three years.

1. INTRODUCTION

The RSE-M Code provides rules and requirements for in service inspection of light water cooled nuclear power plants. The code first edition was established by EDF and published in 1990 by AFCEN. In 1992, a second RSE-M project was launched with the objective to address a 1995 edition more completed considering the needs of owners, users, manufacturers and inspectors.

Efforts have been renewed and indeed stepped up to complete codification by the creation of four engineering study groups responsible for : inspection programs and general measures, in-operating monitoring methods and non-destructive tests, mechanical analysis methods for assessing the harmfulness of defects and material properties, and lastly repair and maintenance procedures. A number of studies, research and experience feedback analysis actions contribute to the actual codification work.

This paper presents advances in evaluation of examination results, flaw acceptance standards and analytical evaluation of flaws.

2. PROCESSING OF N.D.T. INDICATIONS

Having stipulated the examination requirements together with frequency, one must then specify the way in which the results of these checks are to be interpreted. The processing of the indications given by the NDE has a particular importance, both from technical and from quality organisation points of view. It is illustrated by fig. 1.

a) An initial stage, which is the responsibility of the NDT department, and during which the following actions must be carried out :

- characterise the indication resulting from NDTs, giving a description of the physical defect, its location, and its cause must be searched for ;
- assess, by comparing with former inspections, whether the defect may be assumed to have grown or not ;
- compare the dimensions of the defect with the limits given by acceptance standards, defined on the basis of conservative fracture mechanics studies.

b) If the defect exceeds these acceptance standards, or if a previous growth of the defect can be assumed, an anomaly procedure must be launched and a specific study estimates the potential impact of the anomaly on safety. Depending on the case, this study can result in a decision to :

- either make immediate repairs,
- or maintain the current state of equipment, while implementing specific measures, such a reinforcement of inspections and restrictions in operating conditions, to be defined on a case-by-case basis.

3. ACCEPTANCE STANDARDS

A defect for which there is no presumption of previous growth may be accepted if it meets RCC-M acceptance criteria or RSE-M acceptance standards.

The RSE-M standards were set up and justified originally by several type of considerations (see reference n°1 and 2) :

- detection thresholds of examination employed,
- fracture mechanics simplified methods,
- information derived from a large number of analyses of postulated and actual cracks.

A review of the 1990 edition acceptable defect sizes and a comparison with recent detailed flaw analyses for vessels leads to minor changes in the new tables in the course of preparation.

The RSE-M allowable flaw depths are consistent with the corresponding ASME XI values ; some differences are justified by the RSE-M component and material dependant approach.

A simplified method is proposed to analyse sub-surface flaws when they are closed to the surface. Thanks to numerous elastoplastic computations of J integral, this new approach was set up and allows to better estimate plastic correction of J elastic due to small ligament yielding [3]. Figure n°2 presents a comparison of small ligament effect on acceptable flaw size for RSE-M proposed method and for ASME XI. The RSE-M values are more conservative.

4. ANALYTICAL EVALUATION OF FLAWS

a) Non mandatory guidance for analytical evaluation of flaw is in progress. Electricité de France, FRAMATOME and CEA are promoting simplified methods for K_J and J integral. The approach is derived from Nuclear Electric R6 rule and EPRI handbooks.

A simplified method [4] is available for computing J in flawed piping under thermal loadings, starting from an elastic calculation J_e.

$$J = k_{th}^2 \, J_e$$

Four curves in figure n°3 give an upper bound of k_{th} as a function of a parameter L_{th} for linear gradients and thermal shocks, for ferritic and austenitic steels.

$$L_{th} = \frac{E\alpha\Delta T_1}{2(1-\nu)Sy}\left(1 - 5\left(\frac{a}{t}\right)^2\right)$$

b) The rules that used to verify the acceptability of flaws in nuclear components rely on deterministic criteria supposed to ensure the safe operating of plants.

The interest of having a reliable method of evaluating the safety margins and the integrity of components led Electricité de France to launch a study [5] to link safety coefficients with safety levels. Based on a simplified probabilistic methodology, safety factors on the main random variables (primary stress, secondary stress, crack size, yield strength and material toughness) are obtained in relation with reliability target values. These safety factors depend also on the appropriate failure mode : plastic collapse, elastic-plastic fracture mechanics, or linear elastic fracture mechanics.

Statistical data for the mechanical properties of the main basic materials complement the study. The work involvues labotory results and manufacture data.

5. CONCLUSION

The RSE-M Code provides rules and requirements for in service inspection of light water cooled nuclear power plants. Effort have been renewed and indeed stepped up to complete codification on evaluation of examination results and in the field of flaw acceptance standards and analytical evaluation of flaws.

Small changes will be made in the flaw acceptance standards and the acceptable defect sizes are consistent with the corresponding ASME XI values.

Non mandatory guidance for analytical evaluation of flaw is in progress. Simplified methods will be proposed for the computing of J integral in simple structures. Acceptance criteria will involve safety factors on the variables in relation with reliability target values.

Codified articles are supported by criteria documents regarding consistency and validity of these articles. Once codified, these articles are submitted to, and discussed with the Safety Authorities, and, where appropriate, with operators, suppliers, outside contractors, or any other users, before being finally approved by the RSE-M approval committee.

The general organisation of this work means than RSE-M can be integrate into the overall series of design and construction (RCC) published by the AFCEN, and more specifically the RCC-M (mechanical components) and RCC-P (process).

REFERENCES

[1] BARTHELET B., HÉLIOT J.; CHEVANNE H.
Development of acceptance standards for flaws detected by in-service inspections of P.W.R. components.
10th SMIRT Anaheim, California, USA

[2] HÉLIOT J., GRANDEMANGE J.M.; BARTHELET B.
Defect acceptance rule for in-service inspections in nuclear power plant
12th SMIRT 1993, Stuttgart, Germany

[3] COUSTILLAS F., BARTHELET B.
Elastic-plastic analysis of surface and sub-surface flaws in cylinders.
23rd National symposium of ASTM on Fracture Mechanics College Station, Texas, USA

[4] BARTHELET B., COUSTILLAS F., POLLEZ P.
Simplified evaluation of J integral in cylinders under thermal loading
13th SMIRT 1995 Porto Alegre, Brazil

[5] ARDILLON E., PITNER P., BARTHELET B., RÉMOND A.
Probabilistic calibration of safety coefficient for flawed components in nuclear engineering
13th SMIRT 1995 porto Alegre, Brazil

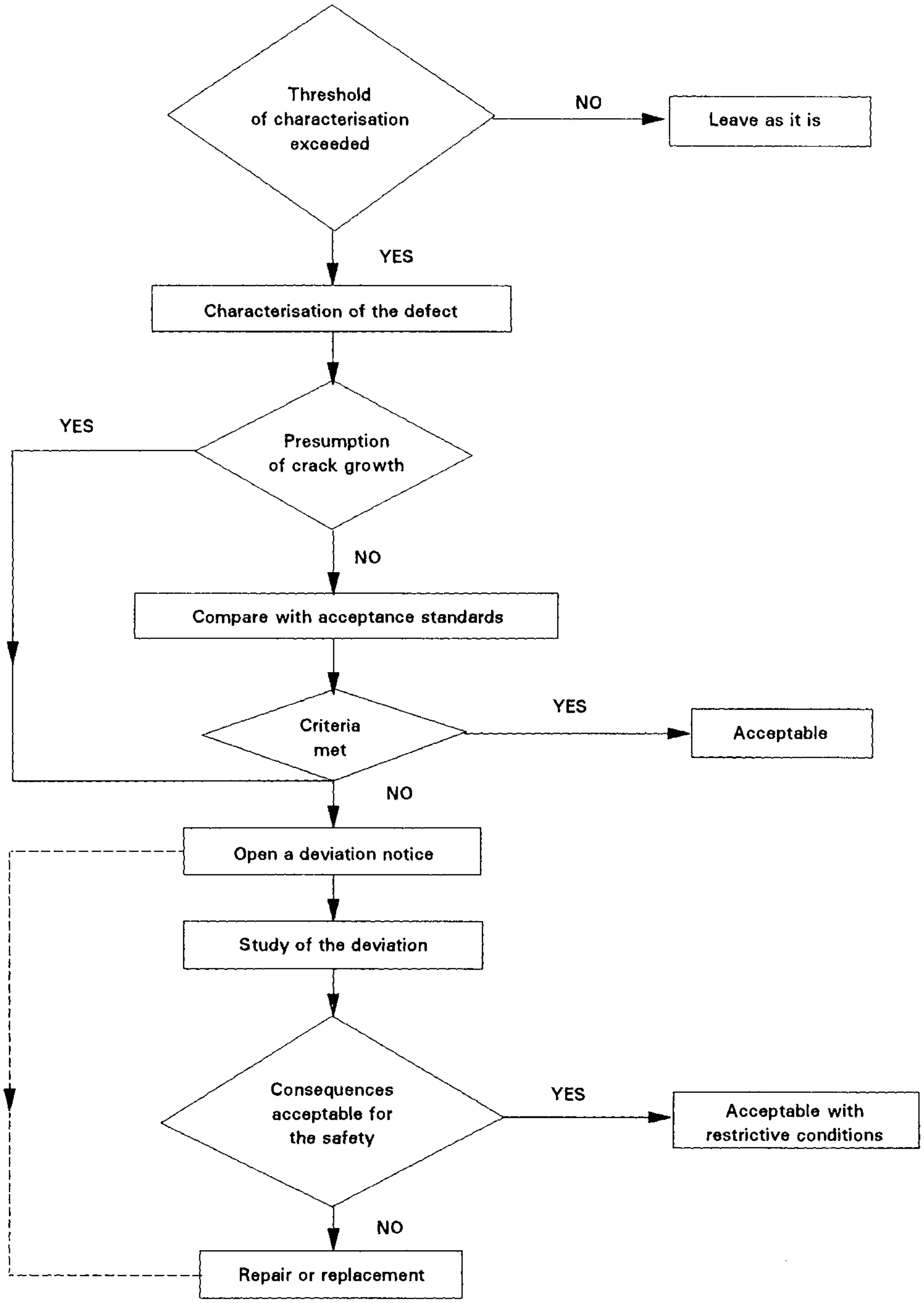

FIGURE 1

Flow chart for processing of NDE indications

Figure n°2 : comparison of small ligament effect on acceptable sub surface flaw size (RSE-M and ASME XI)

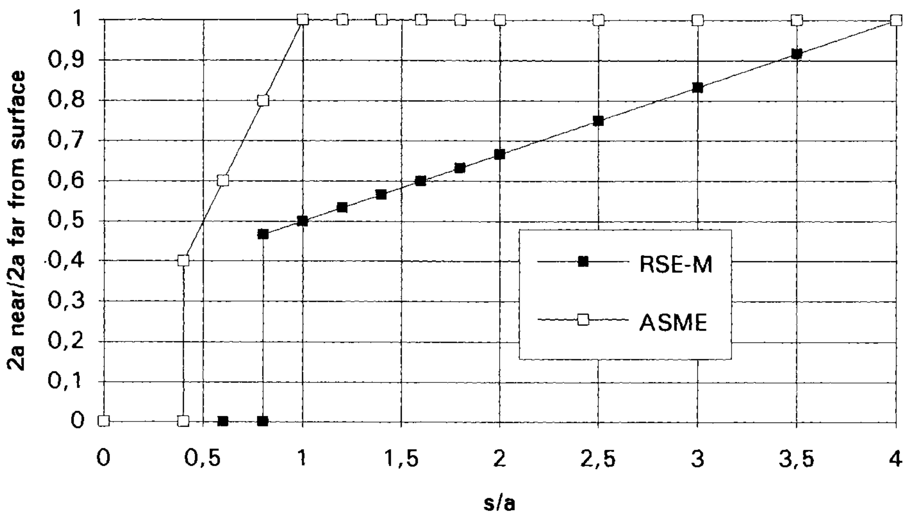

Figure n°3 : kth function of Lth for linear temperature gradients and thermal shocks (ferritic and austenitic steel)