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PROPOSITION OF DEVELOPMENT OF A WELDED STRUCTURES MANUAL TO HELP IN PROMOTING OF THE ARAB WELDING INDUSTRY

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ABSTRACT

The intent of this paper is to propose a scheme of work to deal with the preparation of a proposed manual to aid in sorting out the present discrepancies currently facing the Arab welding industry. Therefore, the aim of the proposed welded structures manual is to unify the different schools currently applied within the Arab welding industrial sectors. The task would therefore be to propose a preformat for the evolution of the Arab Welding Code of Practice and the Arab Welding Standards and Specifications. The conclusions expected may be summerized in the following main points :

-As a result of the unification of the different codes of practice and the evolution of the Arab Welding Code of Practice, better welding efficiency and high productivity is expected.
-The cost of production will be very much reduced due to the evolution of the Arab Welding Code.
-The speed in the line of production will be increased, thus this code will have a major impact on economic and engineering aspects.
-The proposed code must provide the Arab designers, the Arab fabricators and the owners with a basic tool to decide on whether and when repairs must be carried out. Hence better efficiency and better earning capacity can be achieved.

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1.INTRODUCTION:

In third world countries, e.g., the Arab countries, the designer, the fabricator and the owner may face the problem of different welding codes and standards of quality control, [1 & 2] . The unification and the evolution of the Arab Codes of Welding and Quality Assurance Standards, should be the target of the industrial and research establishments in Arab countries. The basic problem in identifying the quality assurance and welding standards comes from the variations, in not only the methodolgy of the application, but also in the principals. This stimulates from the discrepancies within the different codes and the different schools of non-destructive testing (NDT) techniques. If for example the welded product is to follow the German Welding Code, thus it should be verified by the DIN Standards. If however, the same product is fabricated from the same material but welded by the Japanese Code, then the JIS Standards should be applied. The same rules apply to the American Welding, the USSR, the French, the Norwegian,... etc. and finally the British Standrads.

As a result of the variations in the requirements of the above mentioned codes and standards, the efficiency of the welders, the inspectors and the product itself will dramatically be affected [2-5] . The cost of production will be increased, the speed in the production line will be decreased, and thus there is a great need for the unification of codes of practice and quality assurance standards in all Arab countries. This code will serve in increasing the efficiency of welders and the cost of production will thus be brought to a minimum.

The major objective of this work is to identify a working plan for the evolution of design manual in a form which can be updated every, say, 5 years according to technical progress, for helping in solving problems currently facing the welding industry in Arab countries. The program should be in a form which constitutes a comprehensive source of structural design informations for applications to the practical design of conventional and unconventional welded structures. Such informations can help in the development of solutions to field industrial problems. The design procedures are to be based on structural analysis and a knowledge of loading, material properties, fabrication procedures and welding sequences [6-23] .

It should cover and provide all what is necessary for the improvement and aid in the solution of quality control of welded details. Also, maintaining up-to-date records for the purpose of corrective action must be provided, together with planning inspection and corrective remedial actions in proper sequence and timing in accordance with production schedules. Finally, it should help in carrying out in-process inspection and testing to confirm that structural elements and their associated welding operations are in

accordance with plans and specifications of the proposed Code.

2. DEFINITION OF SCOPE OF PROBLEM :

Cost effective control of production of a welded structure requires methods to handle quantitatively the involved parameters within the scope of the proposed code. This is called quantitative assessment approach to the problem. Such an assessment can be divided into:

1. Definition of the required service performance, e.g., loads, the lowest and the highest service temperatures and the general parameters which will give a quantitative measure of performance of the weldment in service.
2. Methods for assessing the mechanical properties of the weldment, and the quantity, size and distribution of any defect.
3. Assessment of the available welding prosesses and consumables for making the weldment, and the detailed specifications of the welding procedures are to be used.

The establishment of correlation among the above three areas provides a rationale and design specifications and fabrication procedures to balance the cost of a weldment against its quality, and to make decisions as to the extent to which present specifications can be safely relaxed to reduce initial costs. However, welded joints have to meet specific operational service requirements. It becomes necessary in the present climate of economic stringency to examine the possiblities of effective savings in cost by the acceptance of deliberate tolerable defects, i.e., reductions in quality standards. So, it is important to assess quantitatively the effects of the presence of such defects on the reliability of the welded joint to ensure that these still meet their essential minimum service requirements [24 - 28] .

Welding of new metals and alloys has become very complex. For instance a procedure to outline the parameters to be used by the welder in the welding process will be of great help. Some of these parameters are summerized as [29] :-

i. Filler material size and type to suit the parent material
ii. Base material preparation, joint design (incldings tolerances) and the performance of the welding process.
iii. Electrical characteristics such as arc voltage, amperage, and the welding speed.
iv. Welding sequence, and complete description of welding progression and welding position.
v. Shielding gas or flux.
vi. Heat-treatment such as pre-heat, interpass temperatures and methods of postweld heat-treatment.
vii. For the case when inert gas arc welding is to be used:
    a. specify the nominal electrode size,
    b. specify the type of filling material,
    c. specify the electrode extension beyond the gas cup, and

d. method of preparing tip of electrode (in case if inert gas tungeston arc welding is to be applied).

viii. Method of arc initiation.

ix. Method of cleaning each pass or layer of the weld if multipass welding is to be used.

x. Any other variable or parameter which may be relevant and may be observed and checked by the welder during and after welding.

Three counts are to be considered in this respect. They are

I. The penalties associated with reject welds may be costly [9].

II. The high cost of proving weld integrity by postweld inspection must be reduced.

III. The development time can be reduced significantly giving a net reduction in the overall cost of a weldment .

3. OBJECTIVES OF THE PROPOSED CODE AND MANUAL :

The principal objectives of the proposed scheme of work are ;

1. Providing all what is necessary for the improvement and aid in the solution of welding problems within the Arab industrialized and welding establishments.
2. Ensuring that all quality standards specified for the welding and the fabrication processes are clearly and strictly adhered to.
3. Maintaining up-to-date records for the purpose of corrective actions.
4. Planning inspection and corrective remedial actions in proper sequence and timing in accordance with production schedules.
5. Performing theoretical and practical calculations to confirm the compliance of welded structures with the planned specifications.
6. Helping in carrying out in-process inspection and testing to confirm that structural elements and their associated welding operations are in accordance with plans and specifications.
7. Providing of a comprehensive data bank to ensure that the welded joint is to the satisfaction of the parties concerned.

In general the approach to the proposed welding code and design manual should fulfil :

i. An appraisal of the design - analysis requirements for the variety of structures that the Arab welding industry may need.

ii. A review and analysis of the existing information from all available relevant sources and world international establishments. This is to be done in order to cover a comprehensive compilation of the existing information from all available and appropriate sources to cover state of the art of the analysis and methods together with full guidance on their applications.

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4. EXPECTED BENEFITS AND CREDIBILTY OF TECHNICAL SUCCESS:

The benefits from the proposed Welding Code of Practice and the Design Manual may be summerized as :

a. The standard of structural design expertise in Arab countries will rise up throughout the industrial problems, due to the friction between the academic research establishments and the industrial sectors.
b. The ability and the confidence of handling the structural aspects of innovative designs will be increased.
c. There may be an efficient dissemination, via the welding manual with regard to design problems and informations in a form which can be readily applied in the Arab industrial sectors.
d. Improved structural design-analysis expertise should lead to more efficient structures, i.e., lowering of structural maintenance costs, and to improved in-service performance in others, e.g., reduced fatigue and brittle failures.
e. Through the design manual and the welded code,it will be possible to consider innovative designs more readily both in the context of conventional and unconventional welded structures, e.g., offshore structures.

The manual has to cover the state of the art with regard to the welding code of practice and aimed at giving examples to clarify the design and the analysis of welded structures. There must be a group representing the concerned parties in Arab countries as well as the interested establishments, called hereafter by the Working Group, to ensure that the presentation of the contents of the Manual and the Welding Code of Practice are in a form acceptable to the Arab Industry. This group should meet once every, say a period of six months to approve the plan of work and to review the finished work. In addition to the above functions of the working group, a brief of the problems facing their firms in the field of applications of the Welding Code and the Design Manual, should be done. Also, a brief of a bridged informations with a complete description of some of the problems facing their firms in the field of welding must be carried out, and discussed.

The outcome of this project, i.e., the Arab Welding Code of Practice and the Design Manual of Welded structures, should be capable of being utilized immediately by the design and technological offices within the various establishments. The employment of the Manual and the Welding Code should be at the discretion of the design and technological departments and the concerned staff members, in the Arab industrial establishments. The contents of the Manual should, therefore, be made within a reasonable standard level and as far as practicable, in a format which is compatible with the existing levels of expertise in analysis within the design and technical staffs. Therefore the manual must provide a bridge of knowledge whereby the analytical skills are considerably increased within such offices.

5. DESIGN PHILOSOPHIES AND SCOPE OF CONTENTS :

The Manual 's material must be divided into chapters, parts, sections and sub - sections. The Manual should be made as compatible as possible in size. The philosophy of the Manual is to be based on continually reviewing with any necessary revisions suggested by the working group of the Arab industry. Detailed examples of innovative welded structures using rational design methods should also be provided. There would be classification in the design approach, this imply that for the use of such a Manual, three broad levels of design requirements have to be fulfilled. These requirements are pertaining to be preliminary, intermidiate and final. The general strategy in the preparation of the Manual should be as follows :

a. Classification of the subject area and design level and specification of the requirements.
b. Discussion of the need and specification for the requirements, is to be carried out by giving detail, clear and practical examples on how to use and to apply the Arab Welding Code of Practice.
c. Outline the origin and the theory of the technique provided, including assumptions and calculations.
d. Supply the means of carrying out the technique and give some clear guidance on areas of applications and any limitations, (if any).

Figure 1 summerizes the fields of applications. As it has been shown that the fields are included within three main categories. Each category, named here by a stage, may need at least a period of one year to be completed. Therefore, overlapping in the time scheduling is preferred in order to get the wheel moving in the right direction. The budget and scheduling time systems are to be further investigated and disccussed once the idea of having an Arab Welding Code and a Design Manual of Welded structures may be approved. Nevertheless, a period of about 3-4 years would be adequate and quite enough to cover the plan investigated in the research program. Fig. 2 shows the general contents of the proposed manual.

6. QUALITY ASSURANCE AND METHODS OF TESTING :

The non-destructive testing is considered to be a part of the quality control process. Thus the Arab Welding Code of Practice should cover the policy that no form of inspection or NDT has to be carried out without a clear strategy of what is being looked for and to what is to be done when the results of the examination are known. There are many details of present NDT practice which still need to be modified. For example, for welds in an important structure, e.g., primary structure, for which 100% NDT by radiography and ultrasonics is specified in Refs. [30-33] , this examination must be delayed for at least 72 hours after completion of welding. This is due to the hydrogen-induced cracking which may occur within this period

of time. An earlier examination may thus be the reason for this kind of defect to go undetected. The real necessity for this delay is to be studied by analysis of the results of NDT examination in particular practical situation and by the fabrication of weldments which may crack.

Figure 3 shows the reliability analysis and the reliability approach proposed to be followed in the Arab Welding Code and the Design Manual of Welded Stuctures, [34] . Figure 4 shows a complete picture of the methods of elimination of failure in welded joints[5&35]. Figure 5 gives the reliability model developed from Refs. [11 & 12] to define the limits of tolerable defect sizes. Figure 6, illustrates a flow chart for the acceptance criteria of welded defect based on assumptions made in Ref. [5] .

7. DISCUSSION OF CAPABILITY OF WELDED JOINTS AND SAMPLING :

In order to evaluate the capability of a welded joint there are several methods of estimations. However, whichever method is used the accuracy of the estimated welded joint capability will directly be related to the amount of data available. In cases where the capability distribution is obtained by combining component distributions, and where the extreme value demand distribution is derived from basic data, simulation could be used to estimate approximate confidence intervals for the safety parameter. The series of simulation may help to establish, in economic terms, relationships between sample size, cost of sampling and the benefits of more precise estimates. The cost of full scale samples of data may be high. These samples may not always be justified as the reduction in uncertainty for each extra item of data becomes less and less as the sample size increases. Considerable reduction in cost is obtained in a way if small samples may be used. Thus in fact it would be impractical to treat large welded details. One of the major problems in dealing with innovative welded joints is the shortage of data concerning actual loadings and strengths. Thus, one of the problems that the Manual must treat is the size of sampling which may be in need of for a certain representation of a set of data.

The other problem which the Manual should treat is that the repairing and the detection periods. Following the same procedure given in Figure 6, it could be determined on whether the defect will jeopardize the function of the structure or not. If it is, therefore, the structure has to cover the analysis to define critical areas, i.e., areas of critical stresses and then necessary modifications must be carried out. These modifications are illustrated in Figure 4 [5& 35] . The modified welded structure has to be NDT examined as it is outlined above. This modification or alteration may be called repairing action. The repairs must be carried out long before the welded structure may be in a state of immobilization.

8. CONCLUSIONS :

A programme of research work has been outlined and it is of the author's personnal opinion that the mutual co-operation and the interest between the industrial sectors in Arab countries and the research establishments in these countries will result in fruitful and prosperous welding era. Generally, this could be achieved and particularly require a unified team of research workers within the Arab countries. The unified welding code of welding practice and the Design Manual may need a plan of time and a thourough study of the cost implied to achieve the entire project. The impact of deviations from the schedule of the total project time should not be admitted. Therefore, the project must be in a format which can be updated, and the procedures must reflect the developments and the changes due to the advancement in the technology of welding.

The following are the main conclusions from the work suggested and proposed in this paper, if it were to be applied:

1. Elimination and reduction of defects through design for purpose approach will be of a major asset.
2. Better shape, better quality, higher strength and good performance of the welded joint may be achieved.
3. For each welded joint, a criterion to specify the tolerable defect size according to a certain loading condition, serving at a lowest minimum temperature is to be investigated by the use of fracture mechanics.
4. The study is expected to lead to allowable or acceptable limits. These limits refer to a range beyond the standard tolerances within the final quality of the welded joint. The Arab Code of Welding should therefore specify and define the acceptable limits which the welded joint may go without the need for carrying out any modifications to the joint.

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CHAPTER 1 :STUDY OF THE ARAB WELDING CODE OF PRACTICE.
CHAPTER 2 :STUDY OF THE WELDING PROCESSES CURRENTLY APPLIED IN ARAB COUNTRIES.
CHAPTER 3 :STUDY OF WELDING DEFECTS AND METHODS OF ELIMINATIONS.
CHAPTER 4 :STUDY OF METHODS OF DESIGN OF WELDED JOINTS WITH APPLICATIONS.
CHAPTER 5 :WELDING SEQUENCES AND MULTI-PASS WELDING.
CHAPTER 6 :WELDING SYMBOLS AND DEFINITIONS.
CHAPTER 7 :WELDING INSPECTION AND TESTING METHODS.
CHAPTER 8 :WELDING ENVIRONMENT, WELDING COSTS AND WELDERS SKILLS.
CHAPTER 9 :PRACTICAL AND CASE STUDIES.

Fig. 2 : MAIN CONTENTS OF THE PROPOSED DESIGN MANUAL.

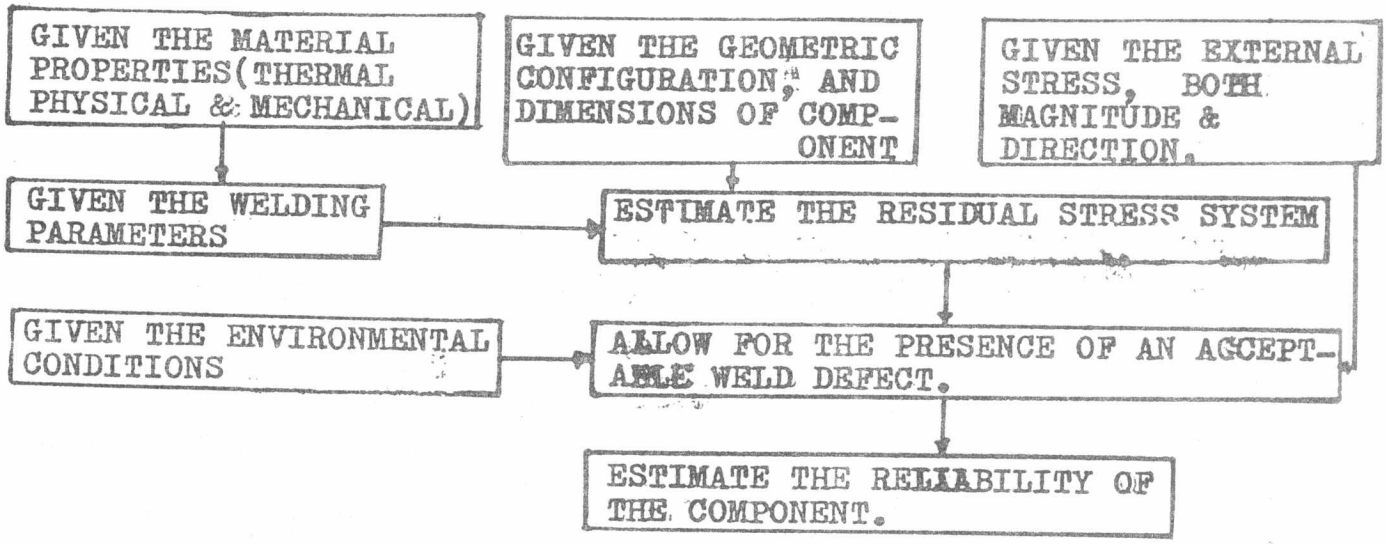


Fig. 3 : RELIABILITY ANALYSIS APPROACH TO WELDED JOINTS [4].

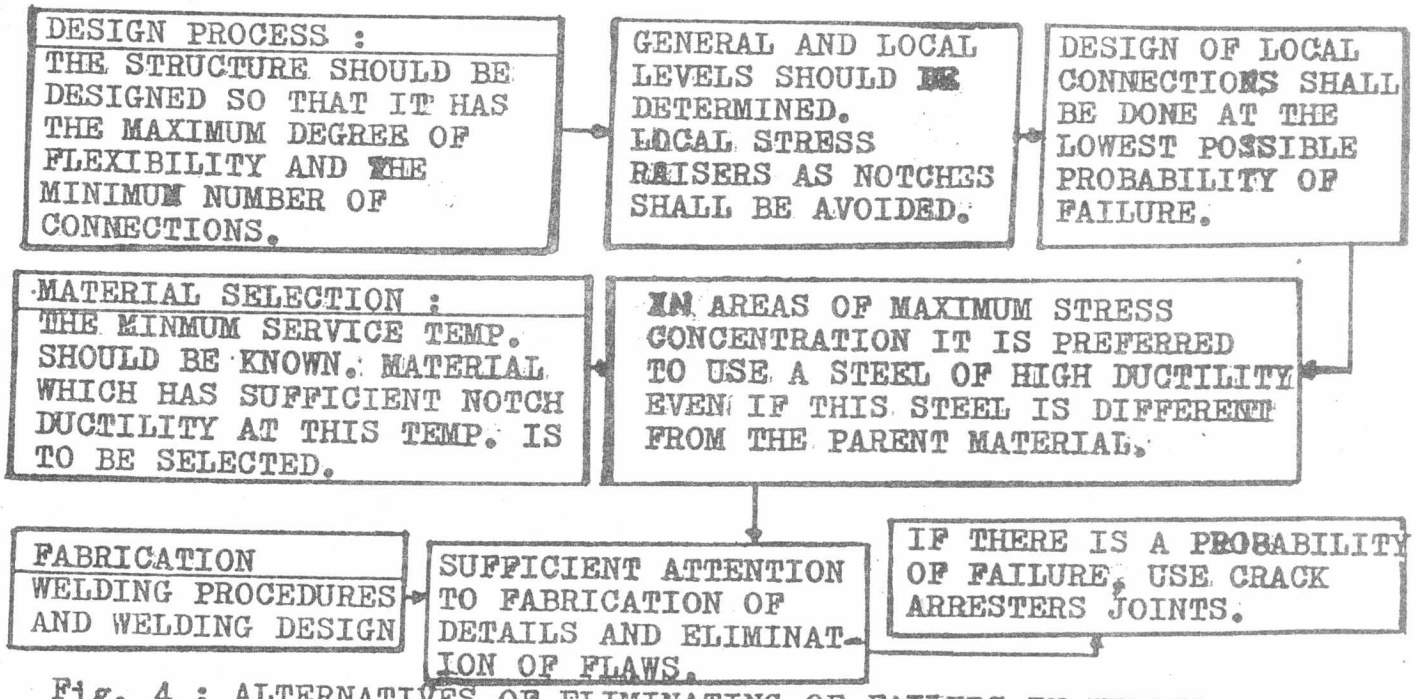
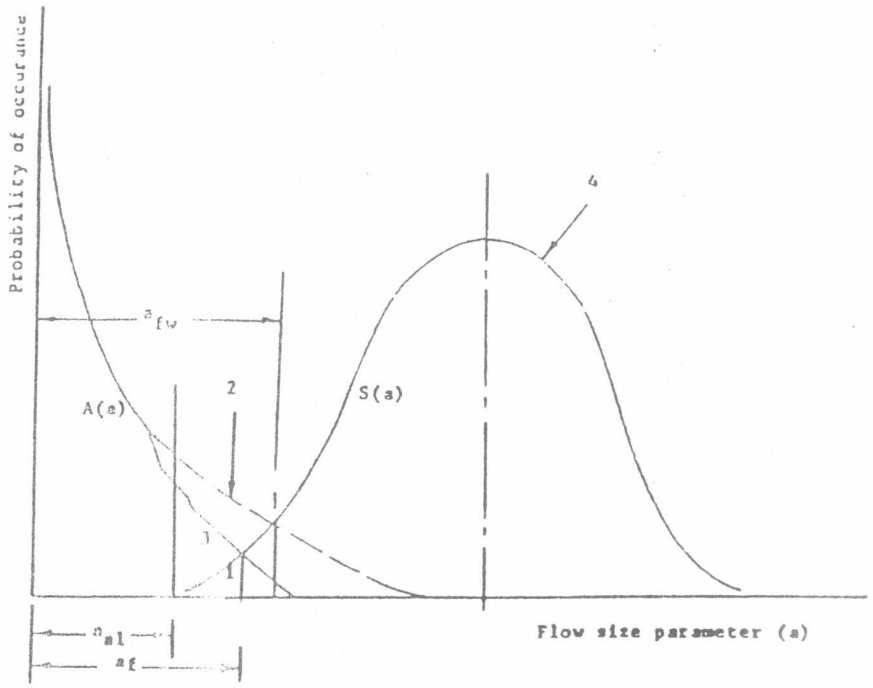


Fig. 4 : ALTERNATIVES OF ELIMINATING OF FAILERS IN WELDED



legend: a_{al} is the accepted limit of tolerable flaw length,

1 Area defines the allowable future probability,

2 Welding procedure in a material gives probable existance of flaws,

3 Area defines the probable existance of defects with different sizes after inspection and repair,

4 Area defines the distribution of critical flaw size from measured data related to fracture toughness variations in time and different loads.

Fig. 5: Reliability Model (Developed from Ref. [11 & 12]).

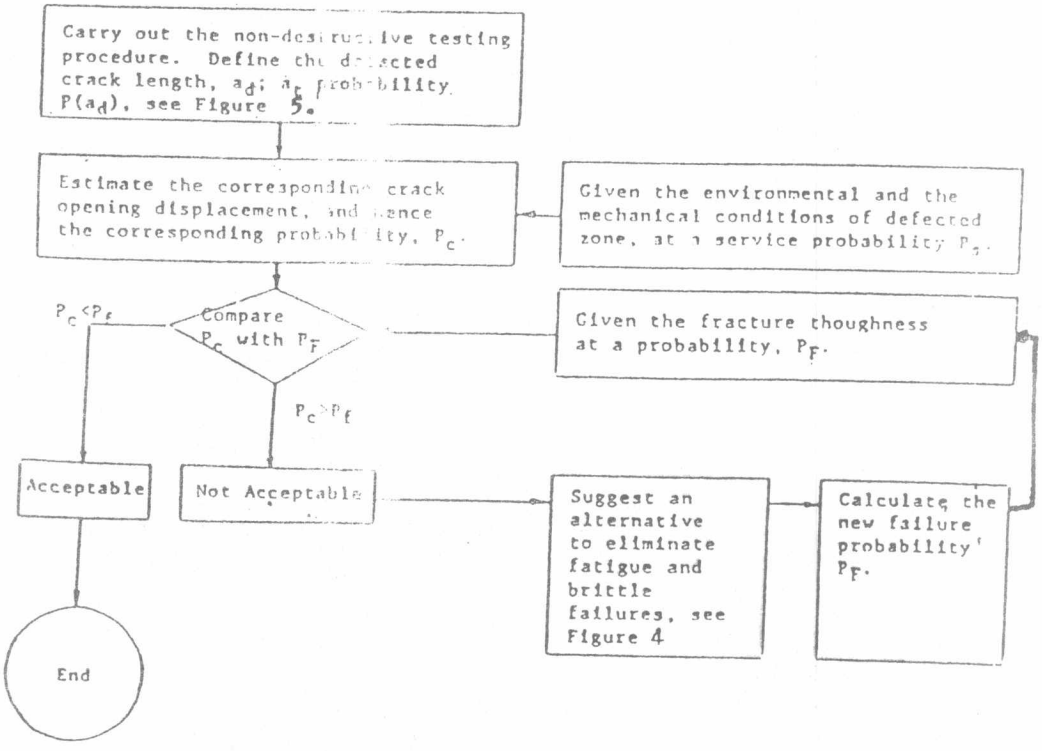


Fig. 6 Flow Diagram of Acceptance Criteria of a Welded Defect [5].