PROPOSED PROCEDURE FOR ACCIDENT MITIGATION IN NUCLEAR POWER PLANTS

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ABSTRACT

The present study presents a proposed procedure for accident sequences grouping according to the expected consequences. Dominant accident sequences and major contributing engineered safety feature systems are declared through a group-sequence-system map. Introducing the concept of minimal cutset (MCS), a system - component map is constructed to declare all components in the MCS. Getting use of those two maps and a plant process variable logic scheme; very useful information could be attained towards mitigating accident consequences.

1. INTRODUCTION

Several possible initiative accident (incident) events may occur in nuclear power plants (NPPs), e.g; small loss of coolant accident (LOCA), large LOCA, anticipated transients without scram (ATWS), ... etc; and could yield severe consequences [1]. Although the engineered safety feature systems (ESFSs) are especially designed to mitigate such consequences, evaluation of actual operational experience revealed that poor operator's interpretation of what is going on may lead to disabling the ESFSs and so the accident may be propagated towards a catastrophic end. To improve the safety of the plant, a reliable information system is urgently needed for proper and timely detection of failed systems, including ESFSs, and components. Consequently, the operator should start the execution of appropriate corrective actions to mitigate accident consequences.

2. PROPOSED PROCEDURE FOR ACCIDENT SEQUENCES GROUPING

Figure (1) shows a flowchart of the evaluation steps in the proposed procedure for certain accident initiative event. These steps include:

2.1 *Qualitative Event Tree Analysis*

Starting with certain initiating event; different scenarios for the accident sequences can be postulated and qualitatively analysed using event tree methodology [2]. The postulation of any scenario is a plant specific, i.e. it depends on the design features and safety criteria of the plant's ESFSs. Complete event tree could be developed by introducing the different combinations of containment failure modes for each accident sequence [3].

2.2 *Quantitative Fault Tree Analysis*

Top event probabilities of the different ESFSs, included in the event tree, could be evaluated using an adopted software package [4]. Some modifications were done to acquire the following evaluations:

i. Top event probabilities, each probability in one run execution.
ii. Importances of the constituent components in each minimum cut set (MCS)
iii. Sequence, as well any group of sequences, probabilities in the event tree under consideration.

The program can then generate a system - component search map (SC-map) which gives the constituent components in the MCS, arranged in a descending order according to component importance, for each ESF.

2.3 *Quantitative Event Tree Analysis*

Top event probabilities and their complements, taking into consideration containment failure modes,

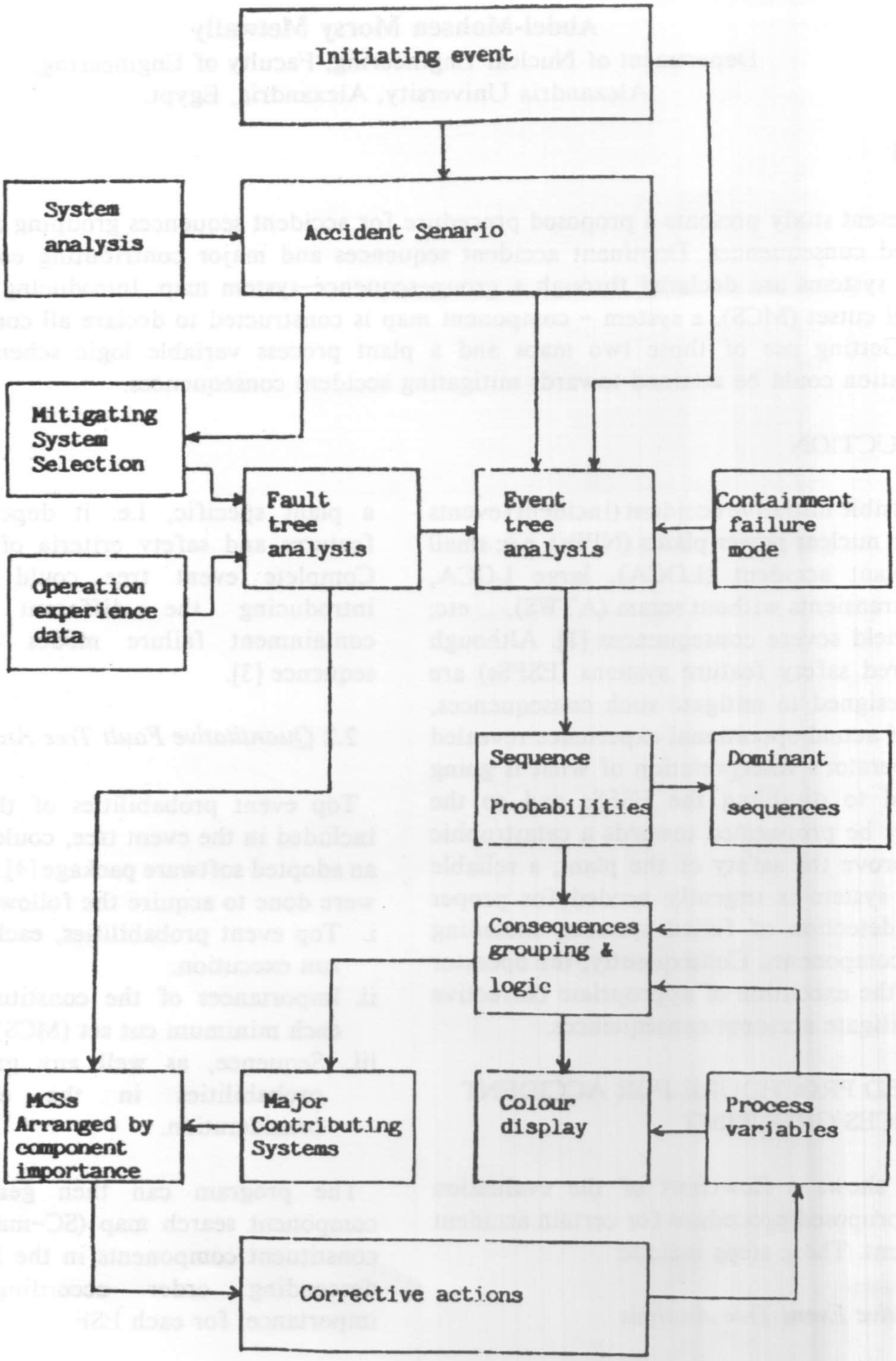

Figure 1. Flowchart showing evaluation steps in the proposed procedure.

can be used for quantitative evaluation of the complete event tree. The different sequence probabilities can be easily estimated using the usual multiplicative procedure. The main objectives of the event tree quantification are:

i. Assignment of dominant accident sequences and the ESFSs involved in each sequence [5]
ii. Grouping of dominant accident sequences.

The second objective can be achieved by evaluating the risk associated with each group. Judgmental values for the sequence severeness as well as the probability values previously determined are used in the risk evaluation.

Certain colour could be assigned to each group, to be flagged in the control room upon a verification process through a logic scheme that receives information on the plant process variables. Table (1) illustrates two alternatives for grouping of accident sequences.

Table (1) Grouping of Accident Sequences

Grouping Alternatives	Group #	Description of the Group	Colour
First Alternative	G1	Core melt and vessel steam explosion.	Colour1
	G2	Core melt and containment leakage.	Colour2
	G3	Core melt and containment over-pressurization.	Colour3
	G4	Core melt and basement melt down.	Colour4
Second Alternative	G1	No core melt.	Colour1
	G2	Core melt and containment over-pressurization.	Colour2
	G3	Core melt and containment leakage.	Colour3
	G4	Core melt and basement melt down.	Colour4
	G5	Core melt and vessel steam explosion.	Colour5

In this step, the program will generate a group-sequence-system map. (GQS-map) which gives group identification (arranged according to a prescribed grouping procedure), involved sequences in each group, and ESFS in each group.

3. CORRECTIVE ACTIONS PANEL

Proper interpretation of the annunciated and non-annunciated displays of the plant process variables by a well trained operator will help him to understand and diagnose what is going on during the course of an abnormal event. The operator have to watch carefully the situation by making sure that all ESFSs are successfully functioning. Nevertheless, he has to start the execution of appropriate action(s) using the available controls. Getting use of the GQS-map, SC-map, and process variable logic scheme, a software package can be designed for the purpose of early discovery of failed component(s). The output of such program can be displayed on a corrective actions as messages and flagging signals.

The panel should declare the following information:

i. Instantaneous severeness of accident sequences through signalization of a group indicating colour.
ii. Status of all ESFSs involved, and its correlations with the different groups (GQS-map).
iii. Status of all different components in the MCS of each ESFS (SC-map).

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