Development of TRAIN for Accident Management

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중대사고관리를 위한 훈련도구(TRAIN)의 개발

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Abstract : Severe accident management can be defined as the use of existing and alternative resources, systems, and actions to prevent or mitigate a core-melt accident in nuclear power plants. TRAIN (Training pRogram for AMP In NPP), developed for training control room staff and the technical group, is introduced in this paper. The TRAIN composes of phenomenological knowledge base (KB), accident sequence KB and accident management procedures with AM strategy control diagrams and information needs. This TRAIN might contribute to training them by obtaining phenomenological knowledge of severe accidents, understanding plant vulnerabilities, and solving problems under high stress.

초 록 : 중대사고관리는 원전의 노심손상사고를 예방하거나 완화시키기 위하여 기존의 가용자원이나 시스템, 운전의 행위를 사용하는 것을 말한다. 제어실이나 기술지원반을 위하여 중대사고관리를 위하여 개발된 TRAIN(Training pRogram for Accident Management Program In Nuclear Power Plant)의 초기문자로 명명된 시스템을 본 논문에 소개하였다. TRAIN은 중대사고현상 KB(Knowledge Base)와 사고시나리오 KB, 제어도와 함께 사고관리 절차도 그리고 필요정보로 구성되어있으며 제어실이나 기술지원반에게 중대사고의 현상지식을 취득하게 하고, 발전소의 취약특성을 파악하게 하며, 상당한 스트레스하에서 주어진 문제를 해결하게 하는데 본 연구의 결과는 기여할 것이다.
Key Words : accident Management, severe accident phenomena, accident scenario, nuclear power plants

1. Introduction

Severe accident management can be defined as the use of existing and alternative resources, systems, and actions to prevent or mitigate a core-melt accident in nuclear power plants and it provides an extension of the defense-in-depth philosophy to severe accidents. The accident management includes the measures to (1) prevent core damage, (2) terminate the progress of core damage if it begins and retain the core within the reactor vessel, (3) failing that, maintain the containment integrity as long as possible, and finally, (4) minimize the consequences of offsite releases[1]. A train- ing program for accident management needs to be developed to enable the NPP (nuclear power plants) participants to use these measures successfully. The training program is basically required to cover several topics including: the progression of severe accidents, severe accident phenomena, the IPE (Individual Plant Examination) findings of a reference plant, and the severe accident management procedures[2]. TRAIN (Training pRrogram for Accident Management Plan In Nuclear Power Plant), developed for those purposes, is introduced in this paper.

The TRAIN, written in html, may provide awareness training to the operators whose work may create a significant impact upon safety of NPPs (Nuclear Power

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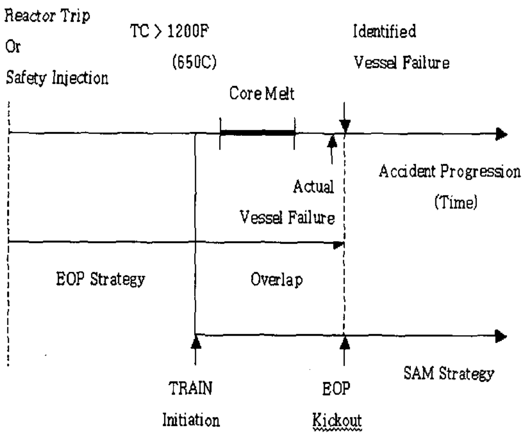

Fig. 1. The Initiation Point of TRAIN.

Plants) during accidents. It may be basically used for fundamental training in the severe accident assessment and response strategies, instrument degradation under severe accident conditions, and alternative instrumentation to verify instrument reading necessary for the implementation of severe accident strategies.

The initiation point for the TRAIN and the scopes of EOP (Emergency Operating Procedures) and severe accident management strategy are shown in Fig. 1. The TRAIN is basically developed to help the control room operators and staffs to answer questions such as the following:

What are the possible accidents sequences under given given conditions? What is the expected physical accident status after some evident symptoms? What are the minimum equipment requirements in order for accident management strategies or procedure to be effective? What are the adverse consequences if some of actions are initiated prematurely?

2. Overall Features of TRAIN

Training for accident management is especially critical in order to overcome the degradation of performance that can occur during stressful situation, to reduce the potential for human error during transition from emergency operating procedures to accident management procedures, and to promote more effective communication between the control room staff and technical support group. A well designed training program will ensure that all personnel involved in accident management have a common understanding of severe accident phenomena, (such as steam explosions, hydrogen detonation, direct containment heating, etc), the conceptual basis of the accident management procedures, and the roles and responsibilities of the various personnel during execution.

The TRAIN was developed for use as a part of this training program. It was focused on achieving a fundamental understanding of "what's happening?" during a severe accident. The TRAIN composes of phenomenological knowledge base (KB), accident sequence KB and accident management procedures and information needs, as shown in Fig. 2. The more detailed functions of TRAIN includes the definition of accident management, severe accident sequences, probable severe accident phenomena with respect to each progression step, severe accident management strategies, accident management procedures, and frequent occurring human errors. These contents include on how severe accidents progress as well as how the accident management procedures should be presented to be easily understood and to be readable, especially under conditions expected during stressful conditions.

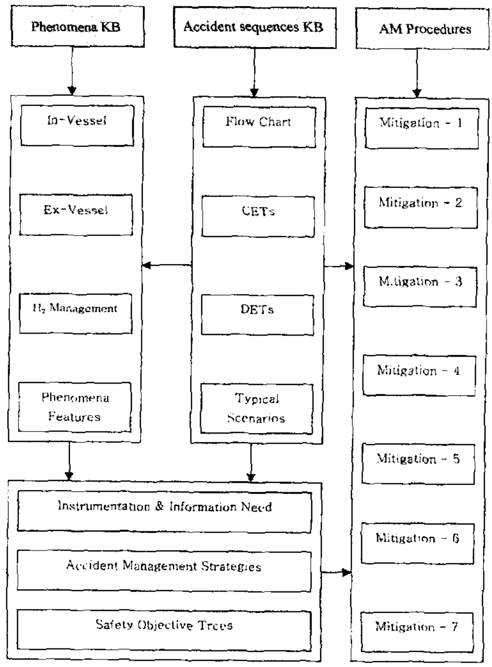

Fig. 2. The Structure of TRAIN

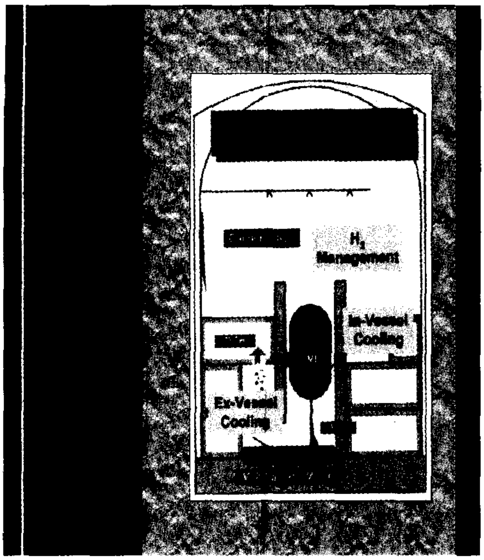

Fig. 3. The MENU for accident phenomena

3. Description of TRAIN

The YGN 3&4 plants, which are light water reactors in Korea, are used as a reference plant[3]. Based on the configurations, severe accidents scenarios of the reference plant, the severe accident phenomena knowledge base, and information / instrumentation KB was established in "TRAIN". The accident phenomena KB element in TRAIN includes: core melt progression, in-vessel steam explosion, ex-vessel steam explosion, hydrogen burns, direct containment heating, missiles, and molten core concrete interaction. The Fig. 3 represents the screen, which displays important elements of the severe accident phenomena for training operators and staffs. Each elements compose of both schematic diagrams and explanations on how the accident phenomena happen?, what's happening? as well. The same structures for the other elements of accident sequence KB, accident management procedures, and information / instrument KB was constructed in the TRAIN.

In summary, the TRAIN is comprised of four modules, which have the following functions:

3.1. Phenomena

The phenomena contents in TRAIN are: core melt progression, in-vessel steam explosion, ex-vessel steam explosion, hydrogen burns, direct containment heating, missiles, molten core concrete interaction, etc. For the phenomena of steam explosions, the explanations with important governing equations associated with heat transfer theory (conduction, convection, and radiation) are described in the left column of each display. Energetic steam explosions inside the reactor vessel due to core relocation pose two different kinds of threats to the vessel integrity. The alpha-failure is a mechanism where a steam explosion in the lower plenum accelerates a coolant slug towards the vessel head, which breaks off, becomes a missile and penetrates the containment roof. Another concern regarding in-vessel steam explosions is a possibility of the lower head failure. When the molten material discharges from the reactor vessel, the step-by-step progression diagrams coming into contact with water in the reactor cavity is also incorporated in this TRAIN. In the same manner, other important severe accident phenomena are explained with the supplementary diagrams

3.2. Accident sequences

An accident progression flowchart is modeled with respect to time, temperature, sequence event, and likely outcomes. This module gives trainee overall accident progression pictures. For more details, containment event trees (CETs), which are the precalculated IPE results, are also incorporated in TRAIN[4]. Decomposed event trees (DETs) are linked to the 9 top event headings of CETs, as shown in Fig. 4. They might contribute to predicting the possible accident sequences by operators and staffs during accidents.

3.3. Accident Management Procedures

Accident management procedures are consisted of emergency guidance, which is a set of actions before / after TSC(Technical Support Center) actuation, strategy control diagram, mitigation guidance, which is necessary for the control of fission product release, containment integrity, reactor vessel integrity and exit guidance for TSC staff[5].

3.4. Information and Instruments

Accident management procedures require various plant

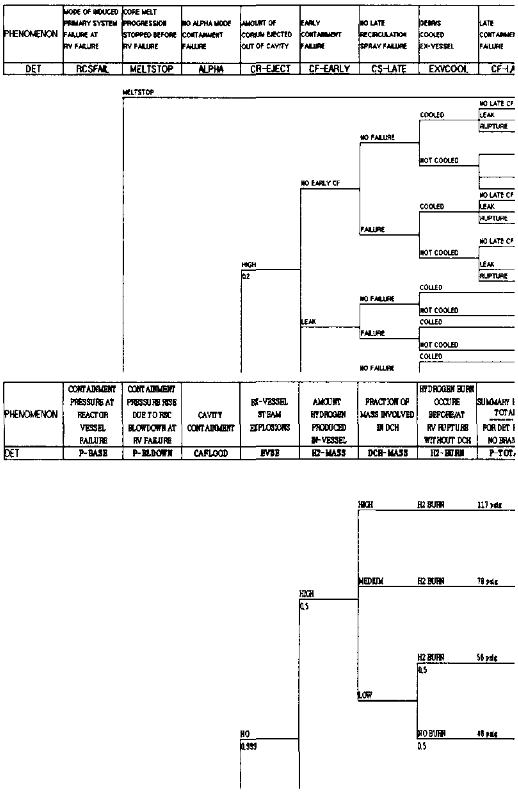

Fig. 4. Accident Sequences of CETs / DETs in TRAIN

information to make decision, by which accident management procedures shall be used at the current conditions[6]. The necessary information is acquired using various instrumentation. The safety objective trees and several computational aids are also incorporated in TRAIN to provide necessary information[7].

4. Conclusions

Training should be provided for control room operators and the technical support group with their responsibilities defined in the emergency plan. It is especially critical in order to overcome the degradation of performance that can occur during stressful situation. The TRAIN is developed for training control room staff and the technical group. The TRAIN composes of phenomenological knowledge base (KB), accident sequence KB and accident management procedures and information needs. This tool of TRAIN might be useful in training the NPP participants by obtaining phenomenological knowledge of severe accidents, understanding plant vulnerabilities, and solving problems under high stress.

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