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Expert Software for Accident Identification

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ABSTRACT

Each type of an accident in a Nuclear Power Plant (NPP) causes immediately after the start of the accident variations of physical parameters that are typical for that type of the accident thus enabling its identification. Examples of these parameter are: decrease of reactor coolant system pressure, increase of radiation level in the containment, increase of pressure in the containment. An expert software enabling a fast preliminary identification of the type of the accident in Krško NPP has been developed. As input data selected typical parameters from Emergency Response Data System (ERDS) of the Krško NPP are used. Based on these parameters the expert software identifies the type of the accident and also provides the user with appropriate references (past analyses and other documentation of such an accident). The expert software is to be used as a support tool by an expert team that forms in case of an emergency at Slovenian Nuclear Safety Administration (SNSA) with the task to determine the cause of the accident, its most probable scenario and the source term. The expert software should provide initial identification of the event, while the final one is still to be made after appropriate assessment of the event by the expert group considering possibility of non-typical events, multiple causes, initial conditions, influences of operators' actions etc. The expert software can be also used as an educational/training tool and even as a simple database of available accident analyses.

1 INTRODUCTION

In case of an emergency in a nuclear facility fast response to the accident and mitigation of the accident consequences are of utmost importance. First of all the type of the accident that occurred should be determined. Every specific type of accident causes typical variations of some Nuclear Power Plant (NPP) parameters immediately after its start. For example, drop of pressure in the reactor coolant system, radioactive contamination of secondary coolant system, increase of pressure in the containment and others. On the basis of these parameters an expert software could identify the type of the accident.

To deal with the emergency in a NPP, an expert team is established at Slovenian Nuclear Safety Administration (SNSA) with the task to determine the cause of the accident, to estimate the conditions of the NPP, to predict probable development of the accident scenario and to determine the source term. Our experience with the work of this expert team (SSAJN) [1] showed that a tool is needed to help in a fast identification of the accident type using the NPP parameters' data.

At SNSA we have developed an expert software which enables a preliminary identification of the type of the accident in Krško NPP using some typical NPP parameters obtained via Emergency Response Data System (ERDS) [2]. This expert software is designed as a helping tool for SSAJN group for classification of the accident type in a very short time. The expert software also lists safety analyses of the identified type of the accident for Krško NPP from SNSA library and database to make prediction of the accident development and its consequences easier.

2 IDENTIFICATION OF ACCIDENT TYPE

2.1 Scope of the Application

Since 1970 the American Nuclear Society (ANS) classification of plant conditions has been used, which classifies NPP conditions into four categories in accordance with the anticipated frequency of occurence and the potential radiological consequences to the public. These four categories are presented in table 1.

Table 1: Classification of NPP conditions

Condition I	Normal operation and operational transients
Condition II	Faults of moderate frequency
Condition III	Infrequent faults
Condition IV	Limiting faults

At the beginning of the development of the expert software we have selected to treat only the Condition IV category. The limiting faults are very rare and are not expected to take place. By NPP design, these faults' consequences are prevented or limited by NPP's safety systems and represent limiting design cases. For case of Krško NPP, there are eight faults included in this category [3]. At a first step in the development of the application, we have chosen to include in the expert software four of these faults, which can also be simulated using Nuclear Plant Analyzer [4]:

- Large Break Loss of Coolant Accident (LB LOCA),
- Small Break Loss of Coolant Accident (SB LOCA),
- Main Steam Line Break (MSLB),
- Steam Generator Tube Rupture (SGTR).

2.2 Data Input

For many systems in a NPP, some operational limits and conditions are characteristic, e.g. quantities like pressure, temperature, flow rate etc., and many of these parameters are measured continuously. These data are continuously collected by the NPP. At Krško NPP the ERDS system allows an insight into selected parameters (ca. 150 parameters and data altogether). SNSA has access to ERDS data and uses them for analyses in case of an emergency.

ERDS system also provides the data on conditions or operability of several safety system: High Pressure Safety Injection System, Auxiliary Feedwater System etc. Besides that, ERDS system provides the data on conditions in the containment: pressure and temperature of its atmosphere and level of radioactivity in the containment. Combining these data enables identification of the type of accident in the NPP. For example, fast decrease in reactor coolant pressure together with increase of radiation in the containment are typical for a Large Break Loss of Coolant Accident (LB LOCA). Another example is detection of radioactive contamination of secondary coolant main steam line due to the U tube leakage or rupture in a steam generator [5].

Many viewpoints have been considered in choosing the parameters. For quick identification of accident type, the values of parameters immediately after the start of the accident should be considered. Identification is also faster with fewer parameters to look at. On the other hand more parameters provide less uncertainty in the determination of specific accident type. Parameters should be selected from the data that are provided from ERDS system. These data are sufficient to define the accident type by the expert software. This is important since in case of an emergency it can be difficult to obtain additional information from the NPP.

3 EXPERT SOFTWARE

The expert software is developed to a stage that enables identification of the type of the accident at Krško NPP, but in principle it is not limited to this NPP design and can be used to identify accident types of other pressurized water reactor (PWR) designs. The expert software identifies the type of the accident based on variations of some parameters immediately after the start of the accident. Such parameter variations are for example:

- decrease of pressure of the reactor coolant system,
- increase of containment atmosphere pressure,
- increase in radioactivity level in the containment,
- indication of radioactivity in the secondary coolant system.

By choosing these parameters that are typical for some of the accidents of PWRs, the expert software can also be used for classification of accidents at some other NPPs with PWR design. Variations in design of a specific NPP need to be considered in selection of parameters' variations.

We decided from the beginning to use MS Access programme package for development of the expert software, because MS Access is widely used, easy to use and enables work with databases. Typical characteristics for every type of the accident have been defined in the application. Classification of an accident is based on these characteristics. Besides that the expert software also enables different operations with databases. By such operations the application identifies the type of accident based on the input data of selected ERDS parameters. Uncertainty in the identification will be lower if we consider more parameters provided that such parameters are available immediately after the start of the accident.

Operation of the expert software is user friendly and does not require any training. For the identification of the type of the accident characteristics (variations) of the ERDS parameters need to be chosen from listed options in the input field of the Graphical Form (figure 2, second column). Input values are selected by choosing one of the available characteristics for each of the available ERDS parameters. After all the characteristics of the parameters have been chosen, we run the application which selects, based on the relations defined in the Query window, the type of the accident.

The expert software is composed of three windows: a Table, the Query and the Graphical Form. In the Table window (figure 1), the accident types are listed together with typical characteristics (variations) of the ERDS parameters which define them, as well as associated accident analyses or NPA simulation results from SNSA database. In the Query window, the relations between the characteristics for every accident type are defined using AND and OR operators. The application compares relations between the input characteristics and the ones predefined in the query window for each type of the accident and so determines the type of the accident.

accident type	RCS pressure	cont. pressure	rad. in cont.	N-16 indication	acc. analysis	NPA simulation
SB LOCA	decrease	no	yes	no	IJS-DP-7111-199	NPA 01/2003
LB LOCA	fast decrease	yes	yes	no	IJS-DP-8103	NPA 02/2003
SGTR	decrease	no	no	yes	IJS-DP-8105	NPA 03/2003
MSLB	decrease	yes	no	no	NEK ESD TR 14/	NPA 04/2003

Figure 1: The Table window, listing typical characteristics of the ERDS parameters which define the accident types (MSLB is for a case with the break within the containment)

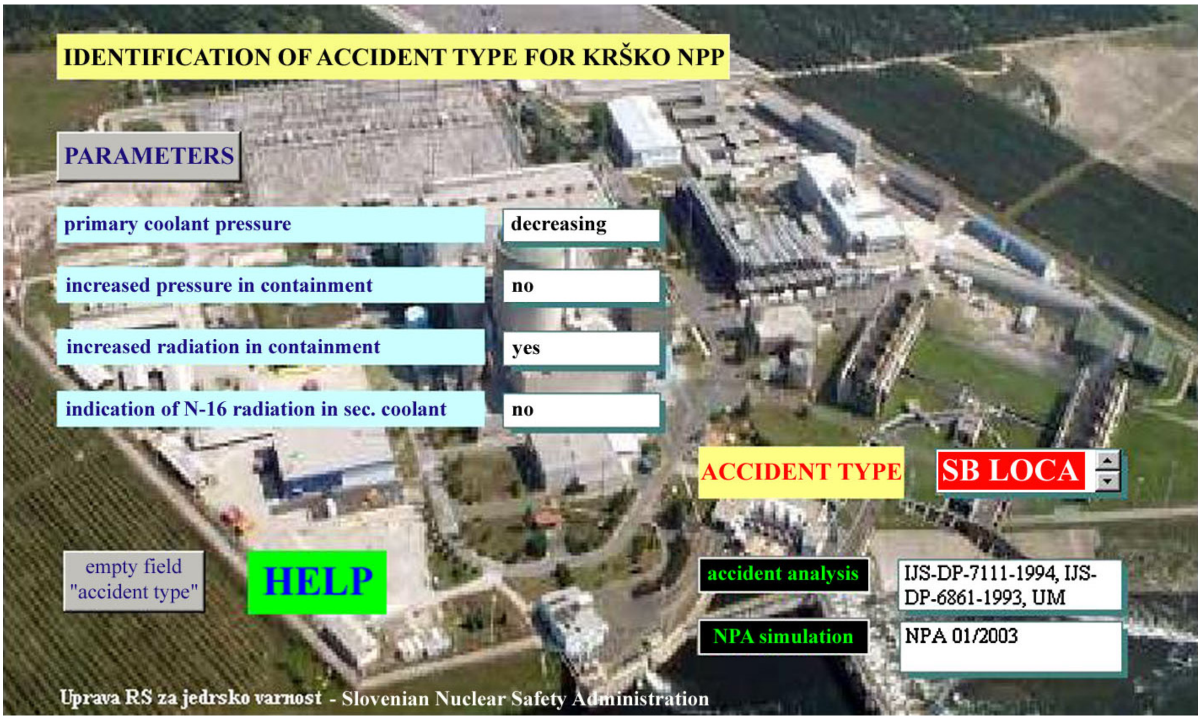

Figure 2: The Graphical Form window of the Expert software

The results of a querry are displayed in the Graphical Form window (figure 2). The application provides also a list of analyses and simulations connected with the particular type of the accident. Library of the SNSA contains numerous deterministic accident analyses that were performed by technical support organizations or scientific research institutions. Among the codes used for these analyses are RELAP, MELCOR and CONTAIN. Some of the accidents can also be simulated to some extent with the Nuclear Plant Analyzer [4]. Further development of the emergency scenario and its consequences can be therefore estimated by consulting these analyses and simulations data.

The application may also be extended to provide a link to a more detailed list of analyses which describes further information on the identified type of the accident. This list will provide more details about each analysis and will enable selection of the most appropriate analysis from the list. This application tool could also be used for a fast search through the analyses of a particular type of the accident.

A separate text document with help is connected to the application's Graphical Form (figure 2) by a hyperlink. The Help document presents general characteristics of the application and describes the use of its commands.

4 CONCLUSIONS

The application is especially suited for a preliminary identification of the accident type. The final identification is still to be made after appropriate assessment of the event by the expert group considering possibility of non-typical events, multiple causes, initial conditions, influences of operators' actions (for example, following Emergency Operating Procedures) etc. To allow fast identification of the accident the application is based on just a few parameters. This is sometimes misleading and can result in a wrong identification, therefore the application should be used only as a tool for a preliminary accident selection.

This application will be used also as one of the tools in training of the SSAJN group for actions in case of an emergency at Krško NPP. For further information this application lists also analyses of each type of the accident. Therefore the expert programme will also be used as a fast search tool through the documentation on a particular type of an accident.

Further development of the application will extend the number of types of accidents it can identify. The application, developed using MS Access, enables relatively easy addition of data needed for classification of accidents. The number of additional parameters needed increases much more rapidly than the number of types of accidents it can identify. During the accident this can result in unavailability of a certain parameter needed for the identification, especially if the parameter is not provided by the ERDS. In such a case, SSAJN would contact the NPP to obtain these data. Since in course of the accident the data are difficult to obtain we chose in the first stage of the development of the application to limit the input data only to those available by the ERDS. Further development of the application will be by inclusion of more ERDS parameters.

The application provides only preliminary identification of the accident and the final classification remains the task of SSAJN experts. The main benefit of this application is that it makes work easier for the experts under stress of the emergency, with an initial identification of the accident type and by listing further documentation on this accident. This provides guidance for further accident investigation, where discrepancies between analysis chosen by application and the available data, together with particular initial conditions of the NPP, can be used for final accident classification, estimation of the consequences and action planning.

5 REFERENCES

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