



SISIFO-GAS
A COMPUTERISED SYSTEM TO SUPPORT SEVERE ACCIDENT
TRAINING AND MANAGEMENT

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After two decades of intense international research programmes, in most of them Spanish participation, the Severe Accident Technology has reached enough level of maturity to be put in practice.

Due to the complexity of severe accidents, it seems to be clear how useful it would be for nuclear power plants to dispose of a system that supports the managing of severe accidents, so the technical response were improved before eventual events further the design basis.

The computerised system SISIFO-GAS is an example of such a technological maturity as it combines the main findings obtained at an international level with the national expertise earned at a national level, thus providing a practical severe accident management tool, including training.

BACKGROUND

The computerised system developed is the result of a joint effort IBERINCO-DTN and COFRENTES, as pilot NPP and system's final user, has precisely the objective to help the management of severe accidents and in addition can be of use as a training tool for the NPP personnel concerning this area.

Developed starting from the MAAP code, a standard code among the nuclear operators worldwide, the tool has two main uses :

- ◆ On one hand, it is a powerful auxiliary training tool in severe accident technology with an user friendly man machine interface, not requiring a previous deep knowledge of MAAP code.
- ◆ On the other hand, SISIFO-GAS, connected to the plant information system, performs a diagnosis and a prognosis of the severe accident evolution that would be of great value for its adequate management. It makes possible the identification and follow up of the events that would take place as well as the adoption of the pertinent decisions, in compliance with the Severe Accident Guidelines.

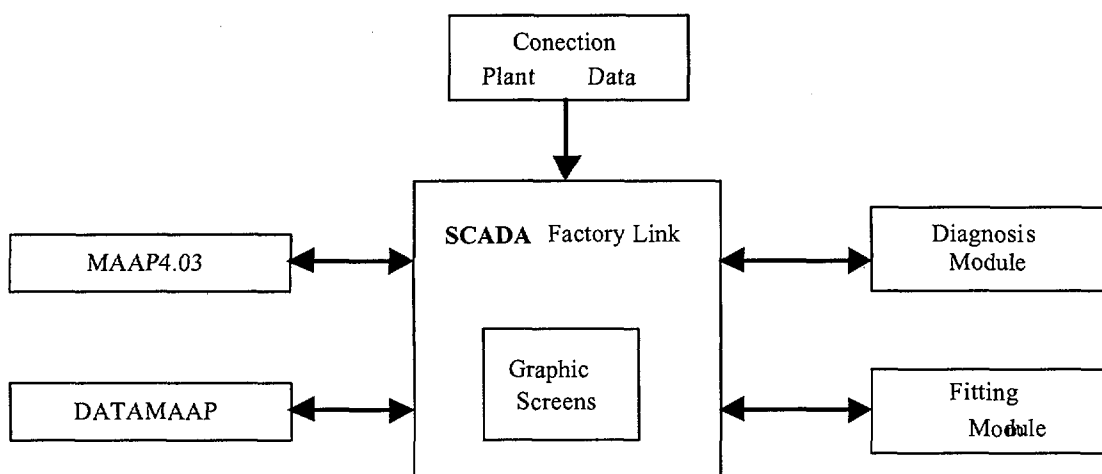
SISIFO-GAS is composed of a series of computerized modules interconnected among them, through SCADA (Supervisory Control and Data Acquisition) FactoryLink (USDATA™), that allow a diagnosis of the state of the NPP to be made, from the signals received from it, and offer an estimation of its evolution in time. It is also able to make an estimation of the category of source term to which the sequence leads us, allowing to anticipate mitigation strategies of the accident's management.

SISIFO-GAS is an open system, easily **integrable**, and can be shaped for its adaptation to other type of nuclear reactors. Although the obtained prototype is directly applicable to any other plant of the same features that Cofrentes NPP, the product can be easily adapted to any other type of plant. The system requirements are very standard and not expensive : two PC's in a Windows environment and a MAAP license.

DESCRIPTION

SISIFO-GAS is a modular system for management and training in severe accident conditions. The specific modules that constitute SISIFO-GAS are managed by a SCADA, which manages the interface with the user, through graphic screens, as well as important plant parameters.

The system's functional diagram is the following:



The SCADA feeds itself both with process data received automatically from C.N.COFRENTES and with manual readings of the status of components or variables of the process, not available in an automatic way in the plant, which will be put in by the user, through the system's interactive graphic interface.

The most relevant modules are:

MAAP Code (EPRI) is an integrated package for severe accidents analysis, internationally contrasted and of wide use, based on models that simulate the phenomenology present in such accidents, as core heating, clad oxidation and hydrogen generation, core fall down, vessel fail, molten core – concrete interaction, fission products release, transport and deposition, etc. The code contemplates the main equipment and systems of accident mitigation, incorporating the capacity to simulate the operator actions through previous scheme or in an interactive way during the simulation.

Another important characteristic of MAAP is its calculation speed, which permits to put into effect simulations of the scene's evolution, anticipating to the real evolution of the accident.

DATAMAAP database compiles and allows to run all the generated and additional information required, through analyzed sequences of accident in the plant with the MAAP code, for different objectives (PSA, license support calculations, etc.). Further more, it allows the storage, in an automatic way, of every new analysis made, under the user's supervision.

This database relates PSA sequences with inputs through the systems' unavailabilities. It also permits seeing what sequences have reached certain plant states which will be previously defined (degraded core, failed vessel, bypassed suppression pool, failed contention, etc.), and in which time.

The Diagnosis Module is the responsible for the identification of the plant status and condition in a certain moment of the accident. This module provides the necessary information for the beginning and development of predictive simulation, including the starter event of the accident, the integrity status of the plant and the behavior of the plant system during the sequence.

The Fitting Module is the connection between the Diagnosis Module and MAAP code. This Module makes the comparison between the results from the theoretic simulated scene with MAAP code and real evolution of the sequence, analyzing their differences. Under the found differences, the user can initiate once again the simulation with MAAP for its adjust to real evolution, repeating the process each time the Diagnosis Module gives a new result.

The Fitting Module determines, from plant data and the results from the Diagnosis Module, the source term category to which the sequence leads us. Comparisons are based on those status of plant, initiating event and safety barriers of the fission products that, if different, should lead to different categories of source term. In the case MAAP code at the moment is not able to proportionate the final category of the emitted source term, searchings in DATAMAAP database will be used to proceed with the comparisons.

Diagnosis Module and Fitting Module are based in decision trees and the chosen mechanism for the development of the system is Fuzzy Logic. Such Logic allows working with vaguely defined expressions and assignee a degree of certainty to its conclusions. Further more, it presents a gradual and continuous response against changes in the variables, and it is not influenced by it's potential late noise. These characteristics make the fuzzy logic an adequate mechanism to implement the system.

For the development of these modules, the Emergency Operation Procedures (EOP), the Severe Accident Guides (SAG) and Probabilistic Safety Analysis (PSA) Levels 1 and 2 of Cofrentes NPP, have been taken into account.

SISIFO-GAS system disposes of a graphic interface composed of some interactive screens for the interchange of information among the different system modules and the user.

SISIFO-GAS has two operational modes, the Management way and Education and Training way. The first, starting from the data of the plant, supports the personnel responsible for the Management of Severe Accident, and the second is used for training people who must confront this kind of situations.

In the **Management of Severe Accidents mode**, users of SISIFO-GAS will use this system for:

- Obtain the status of the plant in every instant of the accident,
- Elaborate a prognostic of the final status which includes, starting from the variables of operation, a first information about possible categories of source term that can take place if a emission to the outside occurs, and
- Obtain an indication of the existing adjustment between the execution of MAAP code and the real status of the plant. This indication could make the user to decide the code MAAP's re-initiation.

In **Education and Training mode**, users of SISIFO-GAS will employ the system to obtain, starting from DATAMAAP database and MAAP code, information of the evolution of the sequence of a simulated accident. Such evaluation of the sequence will be visualized through the graphic interface of the system. This option allows to develop simulations of severe accident without necessity of a large knowledge of MAAP nuclear code and, this way, effectuate the start up and the stop of pumps, the opening and closing of valves, and act easily on the safety systems. Further more, the user can decide the storage, in an automatic way, of every new analysis made with MAAP.

The whole system is placed upon two personal computers. In one of them is placed the SCADA, DATAMAAP database and Diagnosis and Fitting Modules, and in the other the MAAP code.

CONCLUSIONS

Nuclear Power Plants will have to be prepared to face the management of severe accidents, through the development of Severe Accident Guides and sophisticated systems of calculation, as a supporting to the decision-making.

SISIFO-GAS is a flexible computerized tool, both for the supporting to accident management and for education and training in severe accident. It is an interactive system, a visual and an easily handle one, and needs no specific knowledge in MAAP code to make complicate simulations in conditions of severe accident.

The system is configured and adjusted to work in a BWR/6 technology plant with Mark III Containment, as it is Cofrentes NPP. But it is easily portable to every other kind of reactor, having the level 2 PSA of the plant to be able to establish the categories of the source term and the most important sequences in the progression of the accident.

The graphic interface allows following in a very intuitive and formative way the evolution and the most relevant events in the accident, in the both system's way of work, training and management .