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INTEGRATED TOOL FOR NPP LIFETIME MANAGEMENT IN SPAIN

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INTRODUCTION

The project for the Integrated Nuclear Power Plant Lifetime Management System SIGEVI (Sistema Integrado de GEstión de VIda de Centrales Nucleares) was initiated in April 1998 and finalised in December 2000, the main objective of the project being to develop a computer application facilitating the assessment of the condition and lifetime of nuclear power plant components.

This constituted the second phase of a further-reaching project on NPP Lifetime Management. During the first phase of this project, carried out between 1992 and 1995, the methodology and strategy for the lifetime management of the Spanish NPP's were developed. Among others, degradation phenomena were assessed and the most adequate methods for their monitoring were defined.

The SIGEVI Project has been performed under the management of UNESA (Spanish Electricity Association) and with the collaboration of different engineering firms and research institutes (Tecnatom, Empresarios Agrupados, Ufisa, Initec and IIT), with Vandellós II as the pilot plant. The rest of the Spanish NPP's have also actively participated through the Project Steering Committee.

The following sections describe the scope, the structure and the main functionalities of the system SIGEVI.

TECHNICAL OBJETIVES AND SCOPE

The main objective of the SIGEVI project is to provide the Spanish NPP's with a tool facilitating the assessment of the status or condition of components, thus contributing to optimization of their lifetime management. In addition, the project aims to achieve the following:

- Demonstration of the feasibility and usefulness, for lifetime management purposes, of integrating different methodologies, tools and computer programs.

33 / 11

- Implementation and validation of a prototype at a Pilot Plant (Vandellós II).
- Taking advantage of developments already performed in other electricity sector projects.

Given that a prototype was used, the scope was limited as regards both components and assessment techniques. The selection of the scope was led by the Pilot Plant, and was accomplished in accordance with criteria of the feasibility of data acquisition, the critical nature of the equipment, and occurrence of degradation phenomena, implementation costs, etc.

Each of the components or groups of similar components included in the Integrated Lifetime Management System constitutes a module. An additional module, comprising the external data acquisition system, alerts, etc., supplies and receives information from the different modules making up the System.

The modules currently developed are as follows:

- Reactor Vessel
- Steam Generator
- Pressurizer
- Vessel internals
- Diesel generator
- Turbine-generator set
- Turbine-driven pumps
- Breakers
- Relays
- Electrical machines
- Transformers
- Hydraulic valves
- Cables
- Pumps
- Piping
- Structures:

Given that the degradation mechanisms may affect different areas or components depending on material, working conditions, etc., a structure has been established that makes it possible to include new component-degradation phenomenon pairs, as well as monitoring techniques and assessment methods, in each of the modules. At the pilot system, and for each component included, consideration has been given to the main degradation phenomena that might have an effect, for example fatigue, thermal ageing, IGSCC, fretting, erosion-corrosion, etc.

In turn, different assessment techniques are contemplated for each of the modules considered; these constitute the core of the system and are based on the information available at the plant. These assessment techniques vary in their complexity, ranging from the trending of significant parameters and the comparison of acceptance criteria to determination of accumulated material damage or defect assessment.

Thus, for certain components, the use of different techniques and tests has been contemplated for monitoring of the degradation phenomena considered. Occasionally these tests provide complementary information that contributes to better and more accurate understanding of component status: for example, the results of visual, surface and volumetric inspections on one same component. A typical case is the use of a conventional probe to determine the general status of heat exchanger tubes and of a rotating coil to examine their critical areas in greater detail. At other times, various different tests provide similar information, as a result of which they may be used as alternatives. This occurs fundamentally with certain electrical tests.

The modules have been designed such that it be relatively easy to add new component-degradation phenomenon pairs at low cost, and to incorporate new component status assessment techniques.

The system is, therefore, particularly flexible in its configuration and may be adapted to the circumstances and design of each plant. This facilitates adaptation of the System to other plants using different tests from those applied at the pilot plant. Likewise, this flexibility in configuration allows component monitoring to be improved, through the integration of the new techniques emerging, the incorporation of the new component-degradation phenomenon pairs detected, etc.

Furthermore, since the tracking of certain parameters and the techniques to be used for certain components and degradation phenomena are common to several, and are consequently included in various modules, horizontal modules shared by various modules have been designed. Among these horizontal modules are those that carry out the monitoring of lubricating and control oils, fluid chemistry and vibrations.

Finally, it should be pointed out that providing the system with additional functionalities, allowing it to be of use not only for those responsible for lifetime management but also to the operations and maintenance personnel, has been considered a highly important factor. In this respect, consideration has been given to the possibility of using the system to check for compliance with the Maintenance Rule, monitor the evolution of operating variables such as temperatures and water chemistry and track the preventive and predictive maintenance of the components, such as oil changes, vibration levels, etc.

SYSTEM STRUCTURE AND FUNCTIONALITIES

The system has been designed with a modular, flexible structure (Figure 1), in order to facilitate adaptation to different Nuclear Power Plants and the integration of future modules.

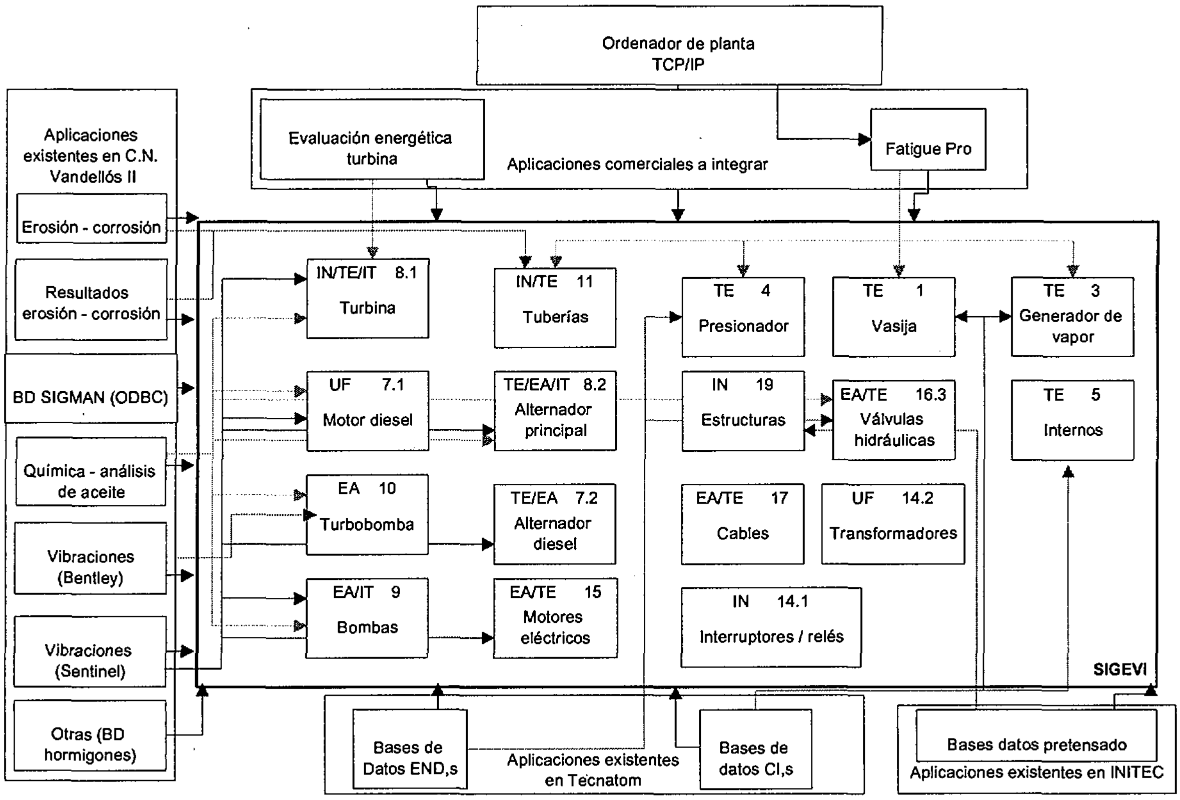

Figure 1 - Structure of the Integrated Lifetime Management System (SIGEVI)

The central core of the system is constituted by the condition and lifetime assessment methods used for each of the modules, supported by a series of specific databases containing historic information on operating parameters, chemistry, inspections, electrical tests, etc., as well as a series of associated calculation algorithms.

This central core is connected to the plant process computer, different computer programs already available at the plant and other commercial systems (e.g., turbine energy assessment and fatigue monitoring), which have also been included within the scope of the project.

With a view to optimising and reducing the system computer resources, a client-server structure has been used, such that the database –managed by the most popular engine on the market, ORACLE^{tm} – is located in a server, whose only requirements are to execute this manager and have available sufficient hard disk space for storage of the necessary data. The system is executed fundamentally at the client machine, under Windows 9.x. Given the complexity of the computer applications, and in order to reduce the requirements of the clients, it is possible to partially store and execute the application in a second server, which must necessarily run under Windows NT 3.5 or a later release.

In order to guarantee the portability of the data and results, the system generates output documents in Word and Excel formats, or in formats compatible with OLE, such that they may be merged with reports generated by the user.

In addition, the system has a user interface, from which all the maintenance, queries and reports and graphics acquisition tasks are performed (Figure 2).

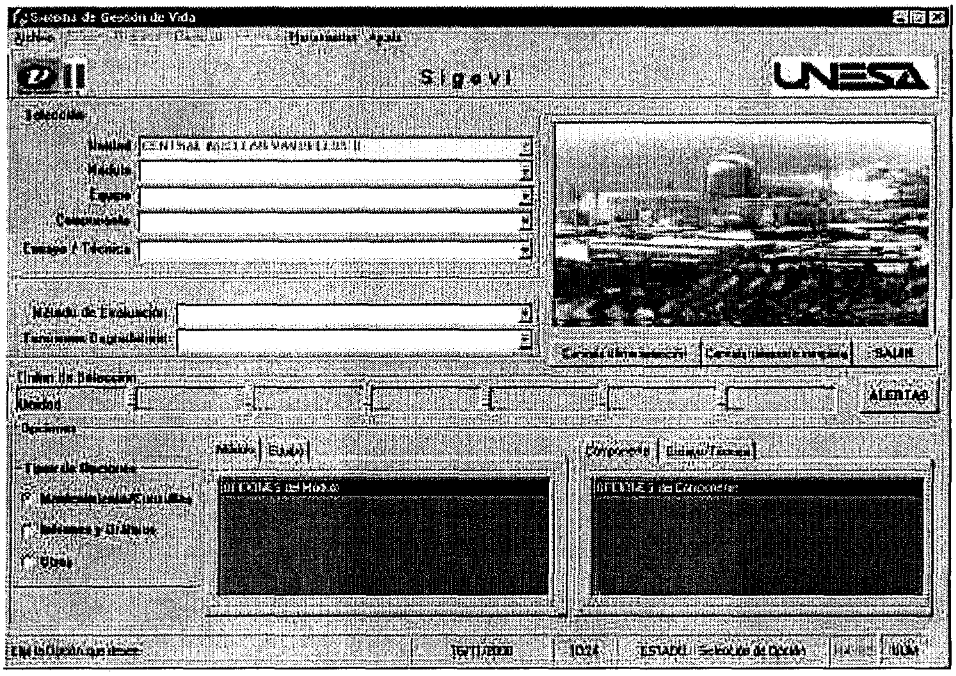

Figure 2 - SIGEVI access and navigation screen

The different functionalities of SIGEVI are briefly described below.

Data maintenance and consultation

The reliable assessment of component condition often requires a large volume of data coming from different sources: process computer, monitoring systems, inspection databases, maintenance history, etc. The system has been designed to minimize manual data loading, and is consequently connected to different databases and computer applications. Data must be input manually only in those cases in which the information required is available only on paper or when the connection between data-processing systems is especially complex.

The system offers all the habitual maintenance options: entries, deletions and modifications, and any type of consultation may be performed with respect to the existing data through the introduction of different types of selection filters. For this reason, the user profiles are configurable, such that the system administrator may allow or prohibit reading and/or writing for each of the users and in each of the modules.

Figure 3 shows an example of a maintenance screen, and Figure 4 a worksheet used for the collecting and subsequent display of test results. This type of sheets allows outage data to be collected using the same formats as are applied at the plant, and even allows the latter to be printed blank, for use as a manual data acquisition format, if the user considers this to be appropriate.

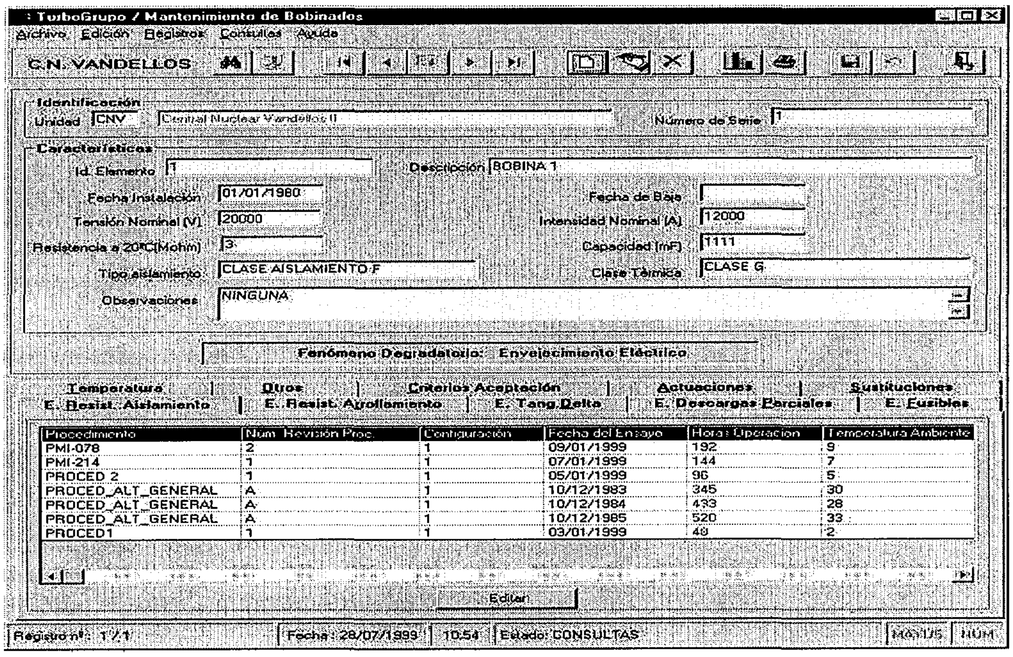

Figure 3 - Example of maintenance and consultation screen

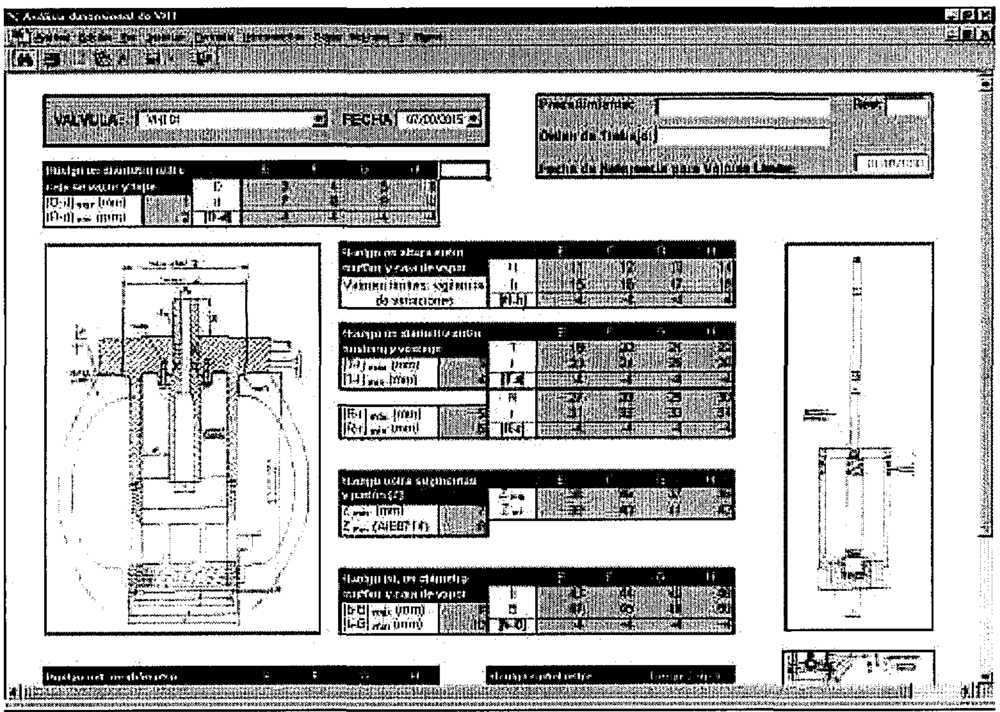

Figure 4 - Example of worksheet

Certain tools have been designed within the general module to increase the flexibility of the System, such as the one that allows the administrator to personalize user profile configuration for each module, and the alerts that provide quick access to reports or forms requiring specific attention or analysis by the users.

Calculation algorithms

The calculation algorithms used in the SIGEVI vary depending on the assessment method, and consequently vary also in their complexity, ranging from simple data extrapolations to defect assessment by fracture mechanics.

Although these algorithms are not visible to the user, since they are included in the code of the system, attempts have been made to allow the user to follow the algorithm calculation process in the most transparent way possible, and to have access to acceptance criteria, maximum levels, materials data, etc.

For certain items of equipment there are no calculation algorithms capable of relating their ageing status with a given monitoring parameter. In these cases, and order to ensure that SIGEVI provides added value for the user, consideration has been given to the possibility of correlating the maintenance activities performed on the equipment with the evolution of the associated parameters. Although the determination of the equipment status or condition is not direct, valuable information is obtained for assessment of the effectiveness of the maintenance or the level of accumulated ageing.

Figure 5 shows an example calculation algorithm.

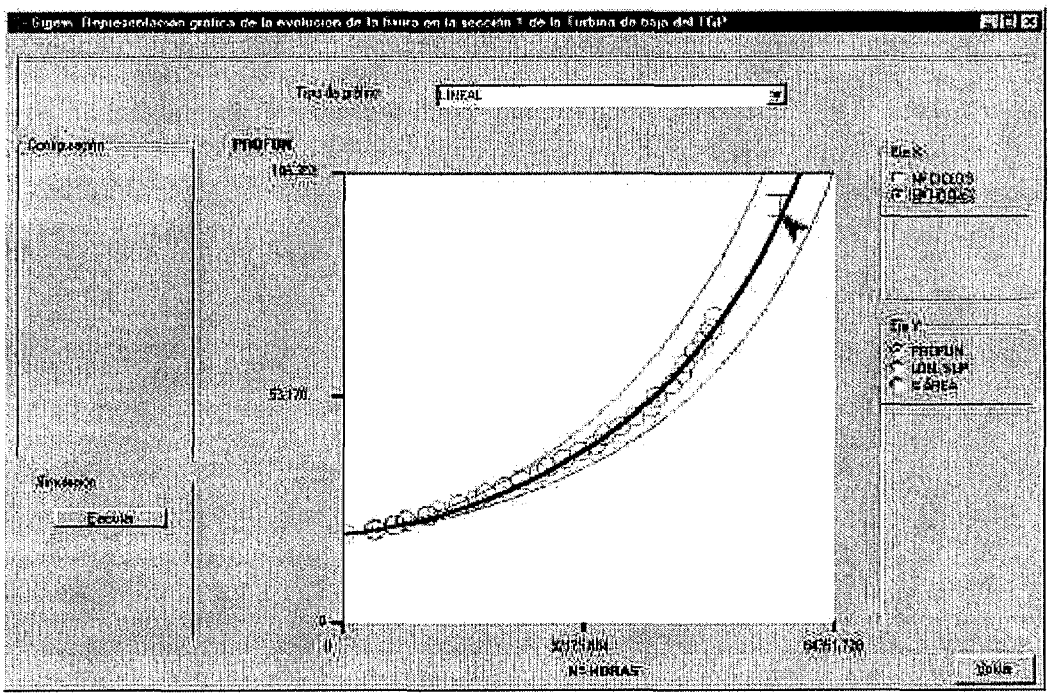

Figure 5 - Example of calculation algorithm

Reports and graphics

The reports and graphics that are most representative of equipment status and condition have been previously determined and defined in each module. The reports and graphics contemplated show the evolution of significant parameters or the results of inspections and tests, compare different parameters or items of equipment and relate parameters with maintenance activities. Overall reports are also included.

In addition, the user is given the possibility of selecting and displaying any parameter for any item o equipment, in order to be able to perform additional studies or obtain his own correlations.

Figures 6 and 7 include examples of a report and a graphic, respectively, obtained from the SIGEVI.

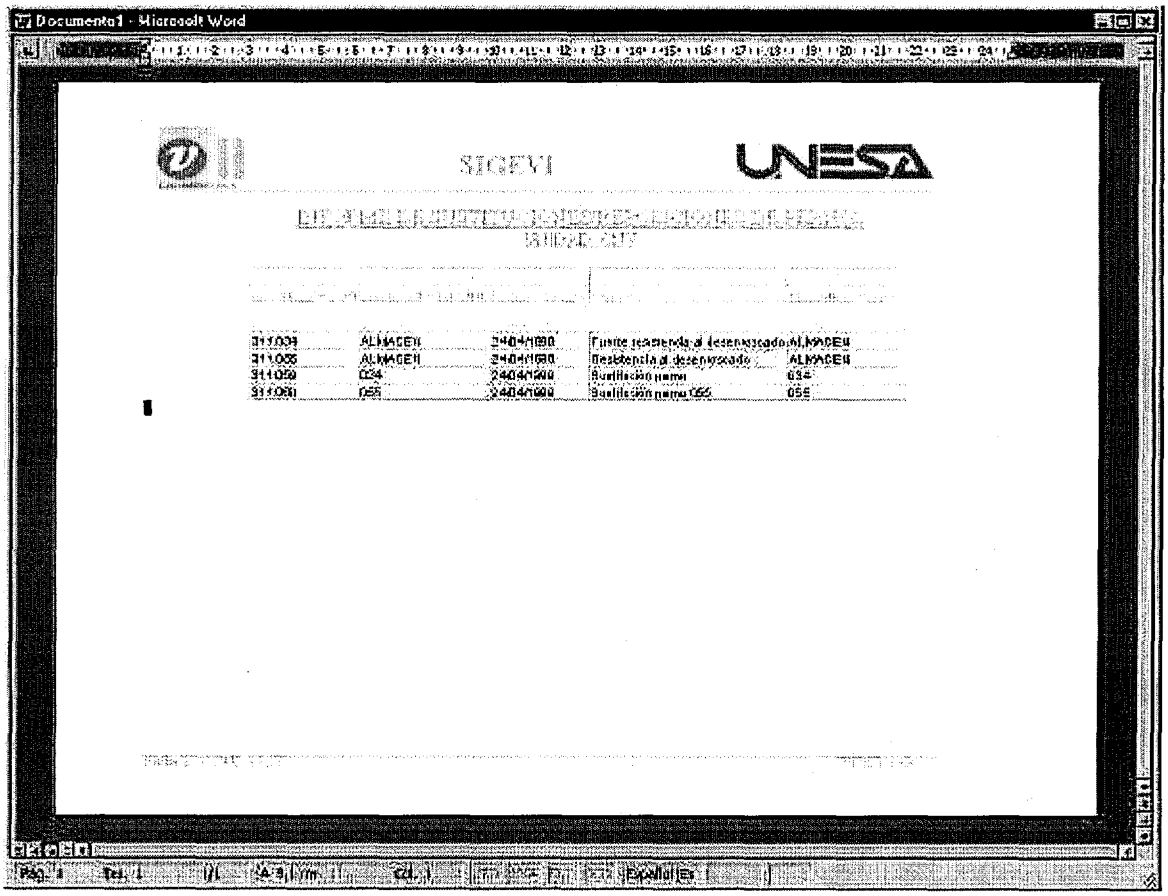

Figure 6 - Example of tabular report

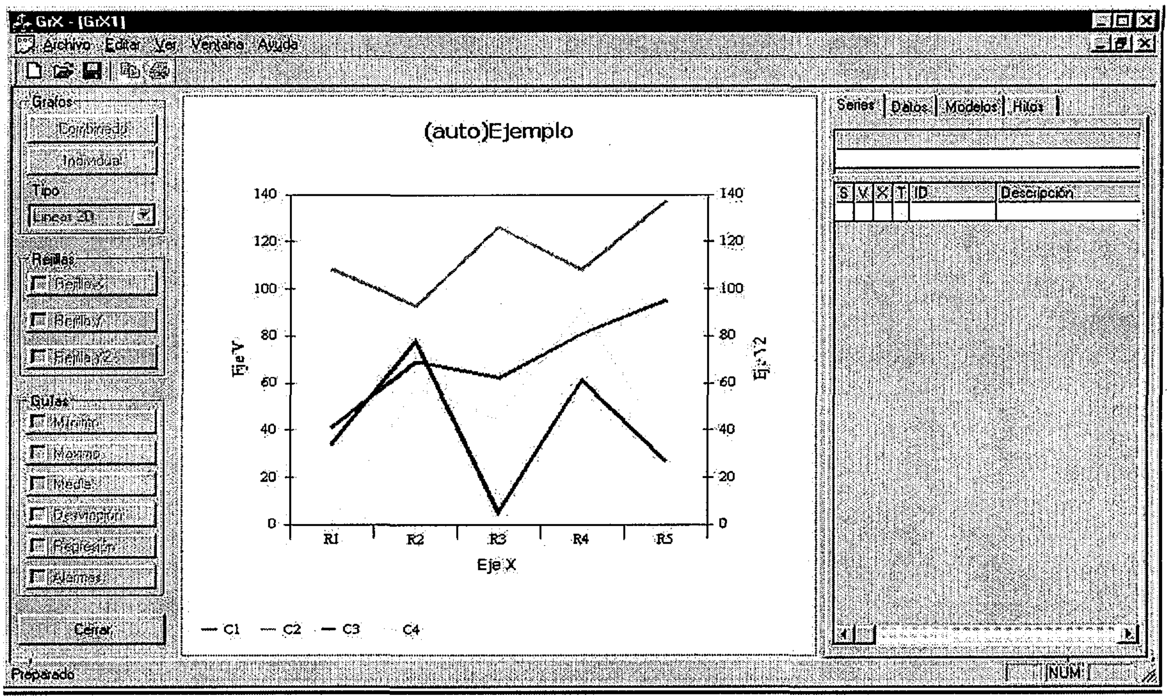

Figure 7 - Example of graphic

Finally, specific graphics have been created to facilitate understanding of the results of certain tests and techniques, along with overall equipment reports summarizing the status of the main components. Some examples of special graphics and reports may be seen in Figure 8.

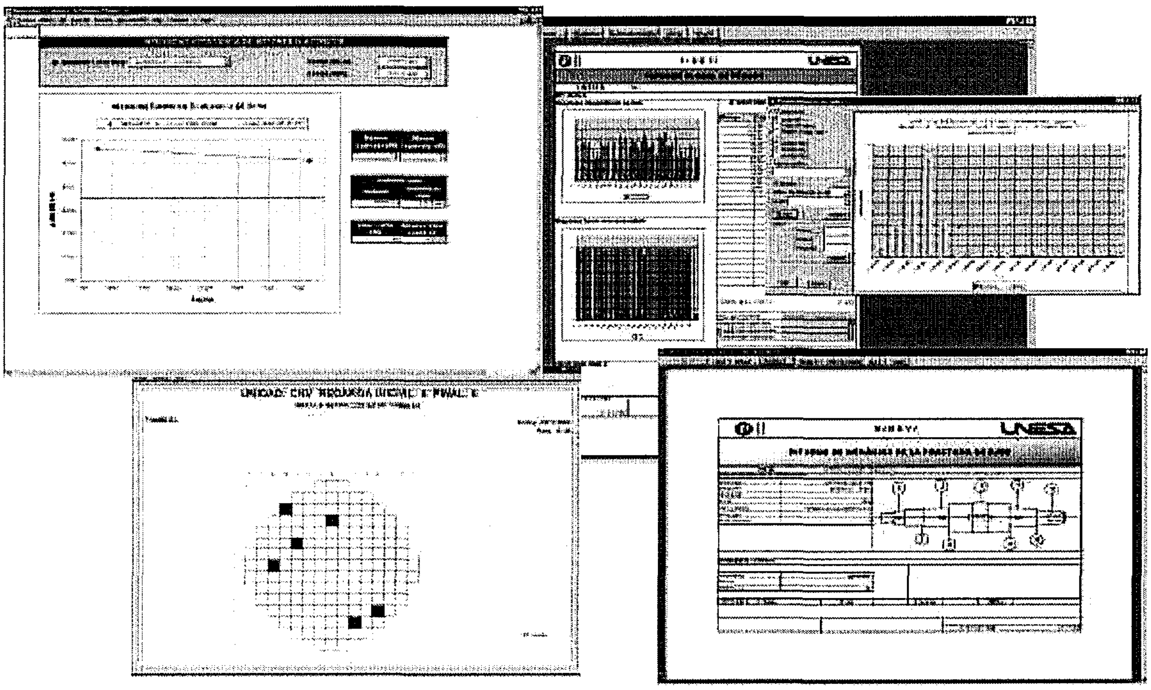

Figure 8 - Special graphics and reports

CONCLUSIONS

On completion of Phase 1 of the UNESA Lifetime Management Project, which included the development of basic methodologies for the monitoring of nuclear power plant component status and lifetime, Phase 2 was performed, including the development of a computer tool facilitating the assessment of component status or condition.

Sixteen modules are integrated in the System, contemplating different monitoring methods, with a flexible, modular structure that facilitates adaptation to the other Spanish nuclear plants and the integration of future modules.

The most reliable methodologies currently available have been incorporated in the System, providing the user with the maximum possible information on equipment status while also leaving open the possibility for him to carry out his own additional studies.

Finally, the SIGEVI has been designed as a user-friendly tool, with multiple options for maintenance, queries and reports and graphics acquisition.

In summary, the aim is for SIGEVI to be a useful tool for the Spanish NPP's, contributing to the integration of all the information of value as regards insight into equipment status, and to the optimization of the NPP lifetime management.