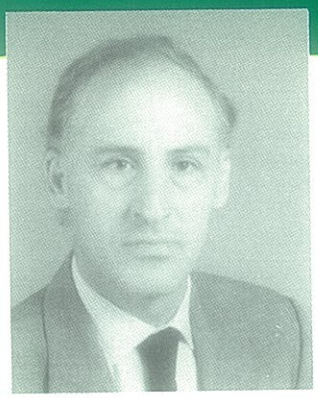


Martín REGAÑO has an Industrial Engineering degree from the 'Escuela Técnica Superior de Ingenieros Industriales' in Bilbao. He joined Iberduero in 1974 and worked on the electrical installation at Lemóniz NPP.
From 1981 to 1984, he collaborated with the Nuclenor Engineering Department to develop the Systematic Evaluation Program.
From 1984 to 1988, he participated in the Trillo NPP project as Head of the Electrical Engineering Section and later as Manager of the On-Site Engineering Office.
In 1988, he joined Nuclenor and performs the functions of Project Group Manager.
He is the coordinator of the Plant Life Extension Committee of the BWR Plant Owners' Group.

SANTA MARIA DE GAROÑA NPP

PLANT LIFE MANAGEMENT

M. REGAÑO

Santa María de Garoña NPP is equipped with a 460 MWe BWR-3 type boiling water reactor, Mark-I type primary containment. It was put into commercial operation in May 1971, and since then it has been operating with an accumulated capacity factor of 67.5%. NUCLENOR, which owns the Garoña Plant, has at all times followed the policy of investing whatever is required to maintain a high safety level in the Plant. As a result, a Systematic Evaluation Program was undertaken in 1983, the purpose of which was to upgrade the Plant as required so that Santa María de Garoña NPP would comply with the design and safety levels found in the latest generation of plants.

In April 1987, NUCLENOR decided to perform a feasibility study to lengthen the useful life of Santa María de Garoña NPP. This study evaluated the status of the Plant's most critical components on the basis of the data from these components' original design, operating history, maintenance records, periodic test results, material tests performed, technological innovations, and design changes made to date.

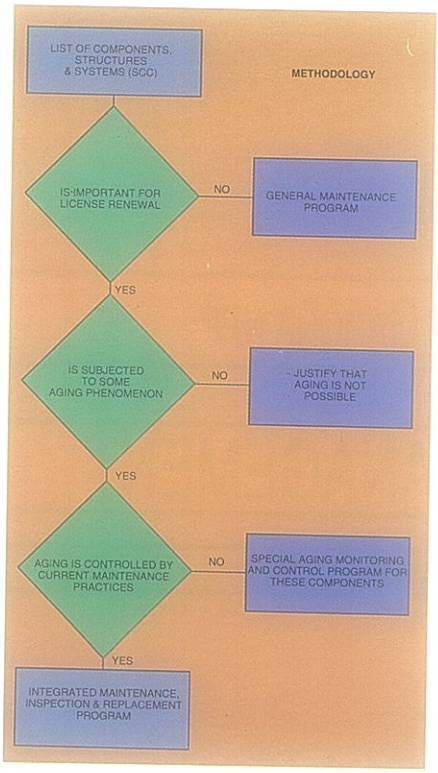
The study concluded that the Garoña Plant was an excellent candidate for a plant life extension program, and it was recommended that a program be developed that included those activities that had to be performed on a short-term basis to keep open the option of extending the Plant's useful life.

OBJECTIVES OF THE PLANT LIFE MANAGEMENT (PLM) PROGRAM

Independently of the short-term activity program recommended in the feasibility study conclusions, at the end of 1988 Nuclenor decided to prepare a program to manage the remaining life of the Plant.
The main objective of the Santa María de Garoña Plant Life Management Program (PLM) is to keep open the possibility of extending its Operating License and lengthening its useful life beyond 40 years of operation.
In addition to this main objective and as a result of a greater control and monitoring of equipment aging processes, other objectives are being indirectly fulfilled such as improved Plant availability, operating factor and performance.

PLM PROGRAM SCOPE AND METHODOLOGY

The methodology that is gradually being applied in the Santa María de Garoña Plant Life Management Program is based on the methodology approved by the NRC in standard 10 CFR 54, which is summarized in Figure I.
This methodology is based on identifying the aging mechanisms of critical components and analyzing whether these mechanisms are controlled by current maintenance testing, inspection and



F I *Methodology.*

monitoring practices that are systematically performed. Those components and aging mechanisms that are not covered by current maintenance practices are the ones included in the scope of the Plant Life Management Program.

Critical components and known aging mechanisms are being identified on the basis of documents published by EPRI, NRC, NUMARC, Owners Groups, etc., which summarize the results of research being performed in this field.

The initial scope of the Plant Life Management Program does not cover all important components, but rather those classified as critical due to their importance as regards safety, the feasibility of replacing them, the economic impact of their replacement, and their importance in relation to Plant availability. The Program philosophy is to progressively increase its scope by including other important components and more thoroughly identifying aging mechanisms and evaluating current integral maintenance practices of the installation.

PLANT LIFE MANAGEMENT (PLM) PROGRAM

In accordance with the indicated methodology and takeoff bases, NUCLENOR prepared the Santa María de Garoña Plant Life Management Program throughout 1989. The most important chapters and status of execution are summarized in Figure II.

Following is a description of the most significant activities of each chapter of the Plant Life Management Program.

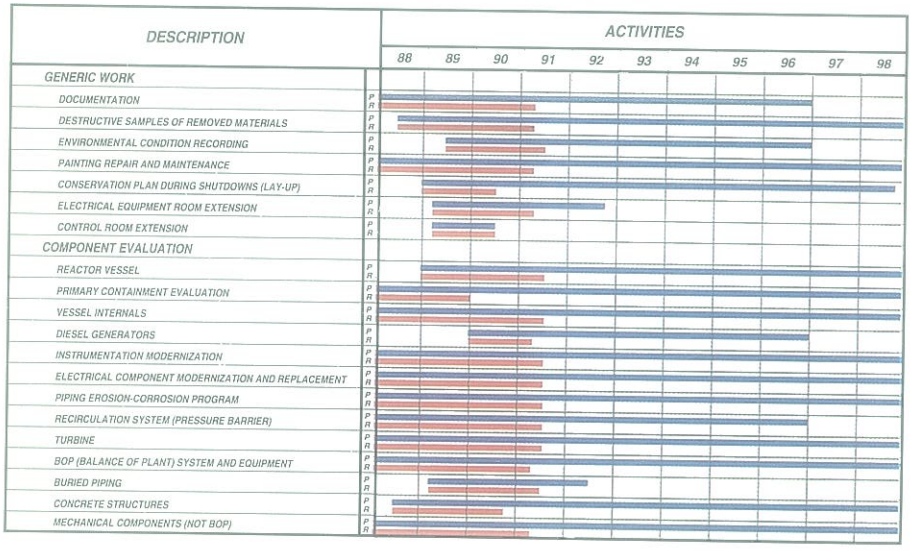
DOCUMENTATION

This activity should be undertaken on a short-term basis. It consists of the identification and orderly filing of all operating and maintenance records, classifying them by types of operational transients, as well as preparation of a dossier for each of these transients with the parameters that apply to it.

In the case of Santa María de Garoña, 603 operational transients were analyzed and the corresponding dossiers were prepared for subsequent evaluation of the affected equipment.

This chapter also includes important activities that are being performed in relation to the review and updating of all Plant documentation, beginning with extension of the Final Safety Study and the Component Lists.

F II *Santa María de Garoña Nuclear Power Plant Life Management Program.*



ELECTRICAL EQUIPMENT ROOM AND CONTROL ROOM EXTENSION

The objective of this activity is to provide free space for anticipated extensions related to the Plant's electrical system and for future extensions and/or modernizations of the protection and control systems. The necessary space has been obtained by reconditioning the old instrumentation shop that was next to the Control Room and by fitting out the demineralized water system room that has been moved to the old medical center. The new rooms have been designed and built with the capacity to withstand the design base earthquake.

COMPONENT EVALUATION

Following is a brief description of the results of the evaluation of main Plant components and current and future activities.

Reactor Vessel

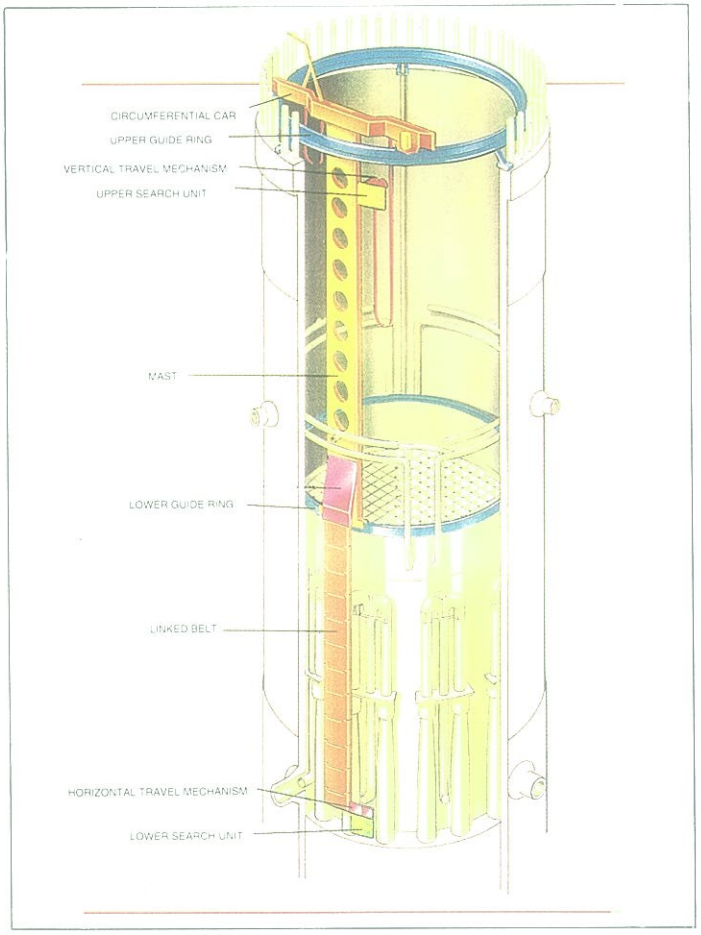
As regards evaluation of the Plant vessel's Life Management, the most important activities being performed are as follows:

- Fatigue evaluation.
- Weld inspection.
- Loss of toughness (embrittlement) due to irradiation.
- Feedwater sparger and sleeve replacement.

Fatigue Evaluation

The objective is to perform a more realistic calculation of the fatigue usage factor of vessel components. A historical compilation of Plant transients is currently being carried out, grouping them together by families and identifying and filing the records related to these transients in order to perform this calculation. During the last refueling shutdown, a system was installed that will permit the real-time calculation of the fatigue usage factor of any transient occurring in the future. This system is going to be put into operation during 1993 to monitor the fatigue usage factor of feedwater nozzles, having previously developed the influence functions of these nozzles to calculate the thermal fatigue caused by a unitary temperature transient.

In successive phases, the monitoring and supervision of the fatigue usage factor of other vessel components will gradually be implemented.



F III *Manipulator Geometry.*

F IV *Manipulator Operation.*

Vessel Weld Inspections

The objective is to fulfill the new NRC requirements (ZWA 2500, Section XI, ASME Code) regarding inspectability of BWR-3 vessel welds that are not inspectable from the outside.

During the last refueling shutdown in 1992, half of the circumferential welds (there are no vertical welds) were inspected by using a manipulator that is supported by and travels along the vessel flange and shroud and that permits inspection from the inside without interfering with refueling activities. Inspection of the remaining circumferential welds is scheduled for the next refueling shutdown (1994).

The inspection results were very satisfactory, and it is noteworthy that it is the first vessel of this type that has been inspected from the inside with this type of manipulator. Figures III and IV show the manipulator geometry and operation.

Loss of Toughness (Embrittlement Surveillance Program)

The objective is to more accurately learn the extent of loss of toughness of the vessel material due to neutron fluence. For this purpose, a series of tests to complement the test specimens made in 1981, previously reconstituted through the electron beam procedure, were performed. More precise calculations are also being made of the neutronic flow "seen" by the different vessel components. The results of these tests and the extrapolations made in accordance with Regulatory Guide 1.9 9 show that the useful vessel life could be extended beyond 40 years of operation.

During the 1994 refueling shutdown, the plan is to remove the next set of test specimens, test them, reconstitute them, and put them back inside the vessel. On the basis of these test results, it will be possible to obtain more accurate data on the influence of this phenomenon.

Feedwater Sparger and Sleeve Replacement

The objective is to replace the nozzle sleeves and feedwater spargers with a new design providing double interference between the thermal sleeve and the nozzle, thus insuring that no leaks will occur that can cause high frequency thermal fatigue in these nozzles. The planned program provides for replacements in the four nozzles throughout the 1994 and 1996 refueling shutdowns.

Primary Containment Evaluation

In addition to preventive measures related to painting maintenance and concrete-steel interface sealing, a program has been set up to measure thicknesses at 23 selected points of the drywell and drywell cover and at 12 selected points of the wetwall. This is being carried out in all refueling shutdowns, starting with the 1990 shutdown. No degradation or loss of thickness in the liner has been detected to date.

Vessel Internals

The objective is to check the state of internal vessel components subject to aging or degradation due to intergranular corrosion, irradiation-assisted corrosion and fatigue. As regards monitoring of these components, the following activities are being carried out:

– Visual TV inspections during all refuelings.

- H_2 injection and monitoring of coolant chemistry.
- Inspection tool development.
- Repair tool development.

H_2 Injection and Monitoring of Coolant Chemistry

The objective is to protect the internals located on the bottom of the vessel by means of H_2 injection through the recirculation pipes until an electrochemical potential is reached that mitigates the intergranular corrosion phenomena of these internals.
An on-line intergranular corrosion monitoring system for the internals located on the bottom of the vessel has been operating since 1990. This system consists of an autoclave with test specimens of different materials that are precracked and subjected to tensile stresses in the presence of the reactor coolant that is piped from the vessel drainage line. The results are satisfactory and prove that H_2 injection mitigates the intergranular corrosion phenomenon in recirculation pipes and perhaps also at the bottom of the vessel. Figure V shows a diagram of the recirculation piping and lower vessel intergranular corrosion monitoring system.

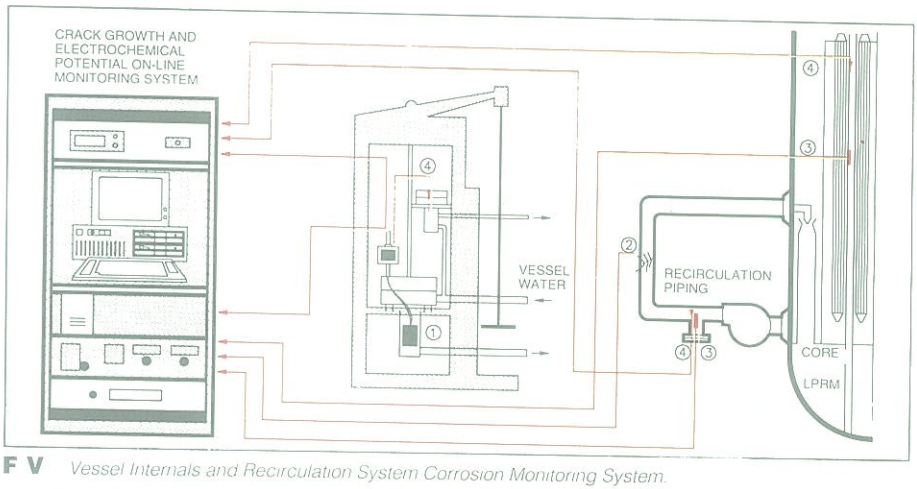
Inspection Tool Development

Several robotized tools have been developed and constructed that permit ultrasonic inspection inside the vessel and under water of some of the vessel internals.
The principal tools that have been designed and manufactured are as follows:

- TV inspection tools.
- Tools to determine stub tube geometry (eccentricities, profiles, dimensions, etc.).
- Stub tube ultrasonic inspection tools (from inside and outside the vessel).
- Housing ultrasonic inspection tools.

Repair Tool Development

An ongoing repair procedure for stub tubes has been developed. At present, repairs are being successfully made by installing mechanical seals in these stub tubes.
During 1989 and 1990, remotely controlled tools were designed and manufactured. These tools are capable of performing inspection, ED, machining, and underwater welding procedures. The qualification tests of the procedures and all associated tools were performed during 1991.



F V *Vessel Internals and Recirculation System Corrosion Monitoring System.*

Instrumentation Modernization

The objective is to progressively carry through a program to renovate and modernize Plant instrumentation systems and loops that are becoming obsolete or that entail operating problems, drifting, imprecisions, etc. The Life Extension strategy for these components is to gradually replace them.
The activities that have been or are being performed include the following:

- Replacement of Control Room alarm panels.
- Replacement and repair of drywell penetration for instrumentation cables.
- Installation of the ATS analog control system.
  This activity consists of replacing the current process switch type sensors with the corresponding transmitters and analog loops in all control loops pertaining to the emergency systems and containment isolation systems. This replacement was performed during the 1990 and 1992 refueling shutdowns.
- Modification of containment isolation system logic to improve physical separation, redundancy and electrical independence, in accordance with the safety classification of their components.
- Replacement of the processing computer due to obsolescence of the GE-PAC-4010 computer.

Activities planned for the future: Anticipated medium- or long-term activities include the following:

- Replace the SRM and IRM nuclear instrumentation with new wide range sensors that will be installed in a fixed position in the core and will serve to eliminate the current mechanical sensor selection and insertion systems, thus reducing breakdowns, doses and maintenance required for this equipment.
- Modernization study of other control loops such as feedwater, recirculation and heater control.

Modernization and Replacement of Electrical Components

The purpose of this program is to progressively modernize or enlarge electrical equipment that is becoming obsolete, is aging, or for which there are serious spare part procurement problems. The activities that have been or are being performed include the following:

- Replacement of all safety-related cables that are inside the drywell.
- Replacement of the safety-related valve motor drives that are inside the drywell.
- Improvements in the internal electrical system, with the installation of new uninterrupted power supply (UPS) sources.
- Replacement of some 4,160 V electrical switchboards and 400V power centers with more modern ones in order to solve spare part problems.
- Enlargement of the class 1E, 125 V direct current system with an additional battery to provide equalization charges to the other two.
- Replacement of the class 1E direct current batteries. During the 1990 refueling shutdown, one of the two batteries with obvious signs of aging was replaced. The other one will be replaced in 1994 or 1996, depending on the results of periodic testing.

Activities planned for the future: Although they are not sufficiently analyzed or programmed, the anticipated long-term activities will involve replacement or

enlargement of some electrical equipment.
The most significant short- and medium-term activities are as follows:

- Replacement of medium voltage electrical penetrations.
- Replacement of lighting panels.
- Replacement of high voltage line metering instruments.
- Upgrade commercial grade equipment and components in order to be able to obtain alternative spare parts for class 1E electrical components.

Erosion-Corrosion

Analysis of the causes of several leak incidents that have occurred in some plants in recent years has made it clear how important it is to monitor the degradation caused in carbon or low alloy steel pipe walls in certain systems by the erosion-corrosion process. In order to control and mitigate aging of these pipes, the following activities are being performed:

- Implementating a computer program that predicts erosion-corrosion rate.
- During each refueling shutdown, performing a pipe thickness measurement program.
- Implementing a computer program to evaluate measured thicknesses in order to determine if the thickness is acceptable.
- Studying corrective actions such as repairs, material replacements and/or substitutions, design changes, O_2 injections, etc.

Figure VI indicates the scope of the inspections that have been performed during each shutdown and the corrective measures that have been taken. The results of the gradual replacement of accessories with alloyed material (P-11) are quite satisfactory.

Recirculation System (Pressure Barrier)

In order to mitigate the intergranular corrosion problem in stainless steel piping, the following projects were set up and have already been completed or are near completion:

- Partial replacement of recirculation circuits with stainless steel pipes that are more resistant to intergranular corrosion (IGSCC). This work was done during the 1985 refueling shutdown.
- Installation of the H_2 Injection System in the feedwater system to decrease the O_2 content in the coolant and thus the electrochemical potential. This system was installed and has been operating since 1987, with the results described hereinabove in the chapter on internal vessel components.
- Relief of residual stresses in some welds subject to IGSCC by applying the process known as Mechanical Stress Improvement Process, which consists in very slightly plasticizing the zone next to the weld in order to reverse the residual stresses in the interior piping fibers so that they work under compression. This process has been used for approximately 20 welds pertaining to lines and systems connected to the recirculation circuit.
- Study of loss of toughness due to aging of cast stainless steel. The embrittlement process intensifies and accelerates with increasing ferrite contents and depends fundamentally on the temperature of the processed fluid. Tests are being performed on aged materials removed from the Plant.

Turbine

The results of evaluations and inspections carried out during the last refueling shutdowns to fully ascertain the turbine condition indicated that the low pressure rotors, low pressure casings, and some diaphragms were affected by stress corrosion (rotors) and by erosion-corrosion (inner casings and diaphragms).
To solve these problems, the following activities have been or will be performed:

- Installation of new low pressure rotors. During the 1992 refueling shutdown, a new forged, monoblock type, low pressure rotor was installed that eliminated the previous shrunk-on, keyed disc design which was causing stress corrosion cracking in some discs. There are plans to replace the second low pressure rotor in the next refueling shutdown in 1994.
- Repair and conditioning of inner casings. This activity began during the 1990 shutdown and will continue during the 1992 and 1994 shutdowns. It involves welding plates made of erosion-corrosion resistant material to the parts of the inner shells that are liable to be affected by this phenomenon.
- Repair and conditioning of the diaphragms affected by erosion-corrosion phenomena. There are medium-term plans to replace some diaphragms, as they are castings and it is very difficult to repair them.
- Installation of a bearing oil filtering system. This system was installed during the 1992 refueling shutdown in order to improve the quality of the lubricant and indirectly the quality of the electrohydraulic control system oil, thus improving operation of the Pressure Control system (EPR).

BOP (Balance of Plant) Systems and Equipment

The purpose of this area of activities is to inspect, evaluate, and repair or replace the Balance of Plant-related family of components indicated below:

- Main condenser.
- Feedwater heaters.
- Moisture separators.
- Circulating water pumps.
- Extraction and drain line control valves.

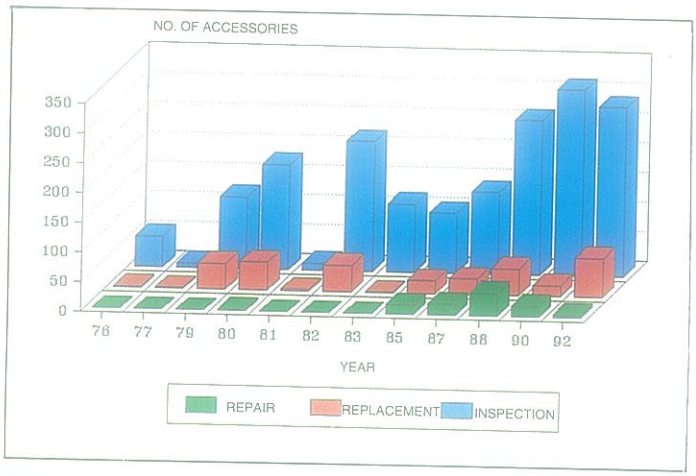
The main condenser activity program mainly involves periodic inspections of the condenser tubes. To date, condenser behavior has been very satisfactory with approximately 3.5% plugged tubes. Most of the damaged tubes are located in the zone next to the turbine exhausts.
As a result of heater inspections and analyses, the four high pressure heaters have been replaced with new ones, and the low pressure heater monitoring program has been maintained as there are no short-term plans to replace them.
The moisture separators were visually inspected during the 1990 refueling shutdown, and it was found that their internal components were in very good condition. During the last operating cycle, efficiency tests were performed on them, and as a result it was decided to replace the separator plates with more efficient ones in order to improve the quality of steam entering the low pressure turbines and thus increase cycle efficiency.
Activities planned for the future include replacement of all heater drain and extraction line control valves and performance of new efficieny tests on the moisture separators.

Buried Piping

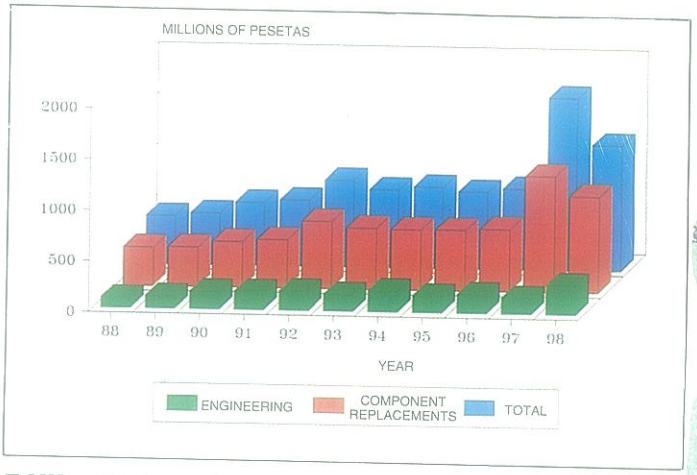
To provide for possible aging of pipes that are buried outside the buildings, an alternate route was laid out during the last operating cycle through new inspectable galleries.

Concrete Structure

The objective is to keep the Plant's concrete structures in perfect condition. During 1988, 1989 and 1990, the level of conservation of the main concrete structures was evaluated on the basis of design, construction and test documents, visual inspections of the structures to identify the extent of concrete fissuring, performance of additional tests on concrete specimens corresponding to removed material, determination of infiltrated water pH and alkalinity, sclerometry, etc. These evaluations provided very satisfactory conclusions, as the Plant's concrete structures are generally in optimal



F VI *Piping Erosion-Corrosion Program*



F VII *PLM Program Budget.*

condition. The resistance values measured are much higher than those required and the fissures observed are due to rheological and thermal type phenomena.

Mechanical Components (Not BOP)

The purpose of this area of activities is to inspect, evaluate and repair or replace families of components outside the Balance of Plant scope, and in particular rotating equipment, heat exchangers and motorized valves. Specifically, the following activities have been or are being performed:

- Replacement of recirculation pump shafts and covers.
- Replacement of the tubular bundles of the isolation condenser.
- Inspection, repair and/or replacement program for heat exchangers.
- Vibration inspection and diagnosis of rotating equipment.
- Motorized valve inspection and diagnosis.

PLM PROGRAM BUDGET

Figure VII shows the estimate of investments that will be required to carry out the PLM program. Logically, the estimate contains many uncertainties, but it gives an approximate idea of the total investment required. This budget includes material, equipment and component repair and replacement activities.
Part of the investment will be recovered as Plant performance improves and equipment aging processes are more efficiently controlled.