



STRATEGIES TO REDUCE PWR INSPECTION TIME

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Key words : Inspection, PWR, Vessel

ABSTRACT

During last few years, a constant reduction in inspection time was clearly demanded by most nuclear plant owners. This requirement has to be accomplished without any impact in inspection quality that, in general, has also to be improved. All this in a market with increasing competition that forces price reductions.

Under these new demands from our customers, Tecnatom reoriented its development efforts to improve his products and services to meet this challenges.

Two of our main inspection activities that have clear impact in outage duration are Steam Generator and Vessel inspections. This paper describes the improvements made in these two activities as an example of the reorientation of our development efforts with a focus on the technical improvements made on the software and robotic tools applied as in the data acquisition and analysis systems.

In the Steam Generator inspections, new robots with dual guide tubes are commonly used. New eddy current instruments and software were developed to keep up with the data rates produced by the faster acquisition system. Use of automatic analysis software is also helping to improve speed while reducing cost and improving overall job quality. Production rates are close to double from the previous inspection system.

Tecnatom's new tool, called TIME, for Reactor Pressure Vessel examination was completely in house redesigned by Tecnatom and after undergoing extensive functional and acceptance tests, it was first deployed in late March 1999 at the Vandellós-2 NPP a 930 Mw three loop W-PWR located on the Northeast coast of Spain. During the 10-year RPV examination performed at that NPP it was established what is believed to be a record with a total time on vessel, TOV of only 68 hours (2.8 days) This paper describes all those significant improvements implemented on the TIME tool used during the mentioned examination, making special remark also on the special topics that makes a RPV inspection to be faster and reliable, among others, those topics include UT Data Acquisition and Evaluation System, planning and logistics, training of personnel, etc.

These improvements are just a milestone in the roadmap of a continuous improvement effort over inspection tools and procedures that will help to reduce outage time and reliability of nuclear power plants.



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General considerations

As general considerations that are common to most of our activities, the following issues were reviewed based on lessons learned and field experience feedback:

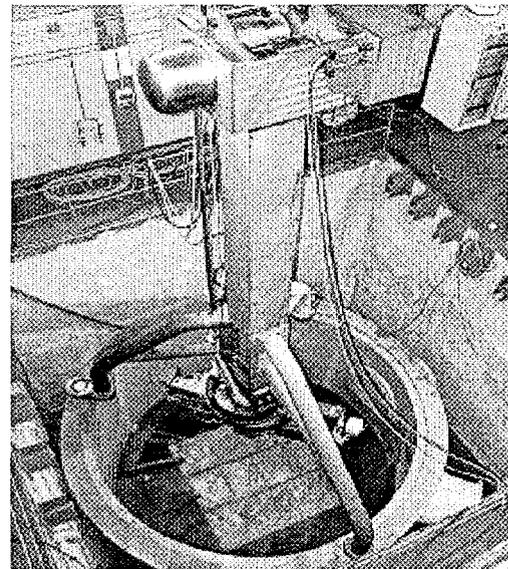
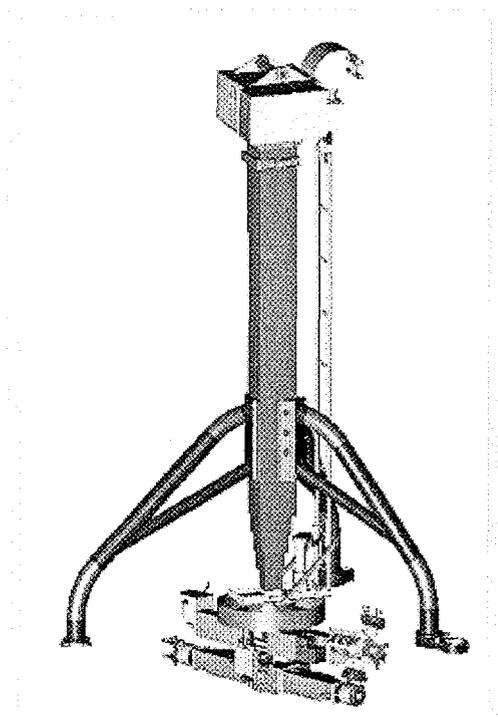
- **Work preparation:** this is a critical issue. Most preparation activities were reviewed for jobs performed on critical path. After this work, the planned duration of this activity was increased considerably. This had an impact in costs that was clearly compensated with a reduction in the duration of the job on the plant. The balance was an overall cost reduction while the inspection time was reduced. Also, as part of the preparation, involvement of the customer is essential to ensure a correct performance during the job.
- **Training of the inspection crew:** This an important factor on the quality and duration of the job. We have actually very skilled crews with more than 15 years experience on NDE services. A careful selection of the experience and training of the personnel has lead to a general reduction on the amount of breakdowns and increase in the production in the inspections.
- **On site availability of spares:** For critical path activities, whenever it is suitable, a complete set of equipments is available on site for immediate replacement of damaged parts or equipments.

- **Maintenance personnel:** It is essential to have on site maintenance personnel, very well trained to the equipment used, to help troubleshooting during the inspection.
- **Experience feedback:** As part of the inspection process, a well established procedure to formalize the experience feed back is of great help. A benchmarking system will also help to keep track of performance progress.
- **Equipment performance:** Equipment should be continuously updated and improved, based on experience feedback and general advances in technologies. This has a direct impact in performance and inspection quality.

Vessel inspection system

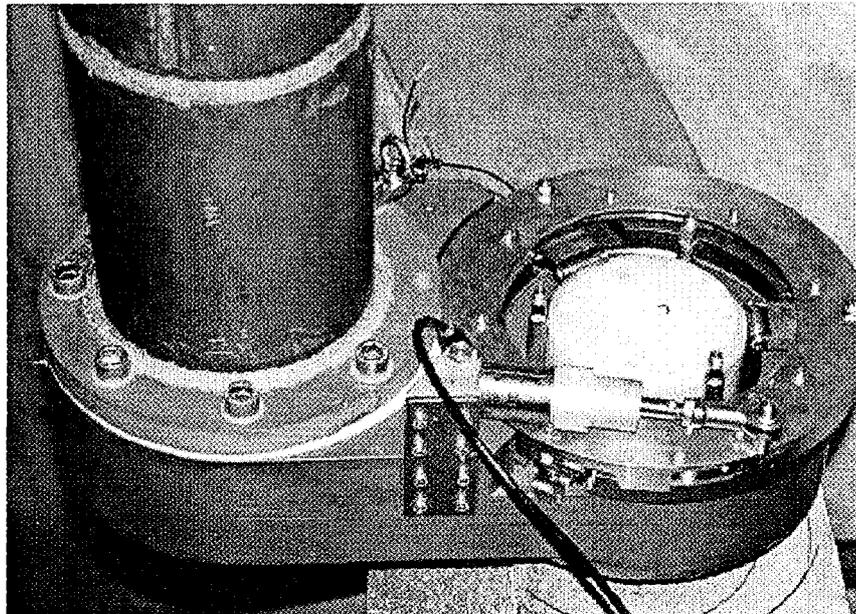
This is one of the most complex NDE activities performed on PWR plants, and also one that is performed always in the critical path of the outage.

Tecnatom has been involved in vessel inspection activities since more than 20 years. In 1999 a new inspection tool, the TIME, was used for the first time in a real inspection at Vandellos NPP, in Spain. Next picture shows the mechanical part of TIME manipulator.

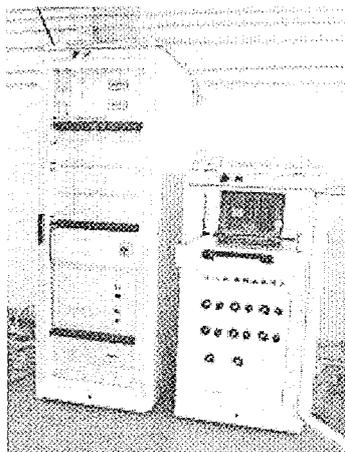


Apart from the numerous technical improvements of the TIME that ended in a dramatic increase of the mechanical accuracy over the previous tool (the PAR), many improvements were made with the reduction of vessel occupation time. As improvements with more impact in time reduction are the following:

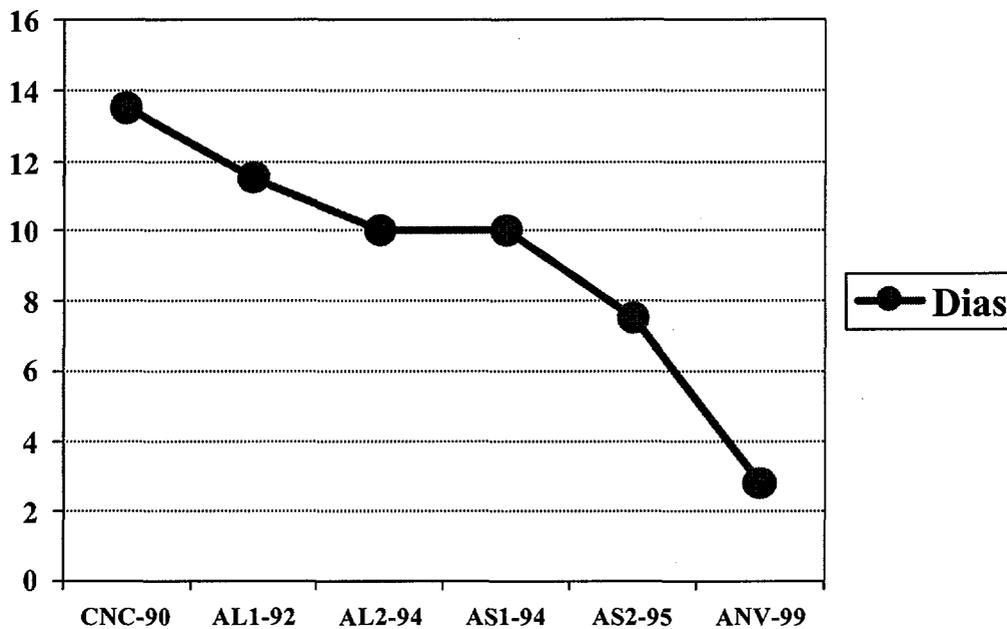
- Increase in the number of arms. The TIME has four arms that permit to perform the inspection of 2 nozzles at the same time or inspect the core area welds with two arms simultaneously.
- Self centring device to speedup the installation process. The operation of centring the mast on the axis of the vessel has been simplified with this tool while the precision of the centring itself has been improved.



- Reliability of the mechanical parts. This has been improved over previous tool. As a proof of it, during the inspection at Vandellos, the system worked with not a single failure.
- Improved control electronics and software. State of the art control electronics and software was developed with safety, accuracy and speed in mind. A key part of the control system is its software that allows for a fast and safe operation thanks to its anti collision module and other features to avoid possible problems due to wrong operation of the system.



After all this improvements made over the previous manipulator that were based mainly in the experience feedback from the inspection crews and the use of state of the art computer, electronic and mechanical technologies, the results in terms of vessel occupation days are the following:



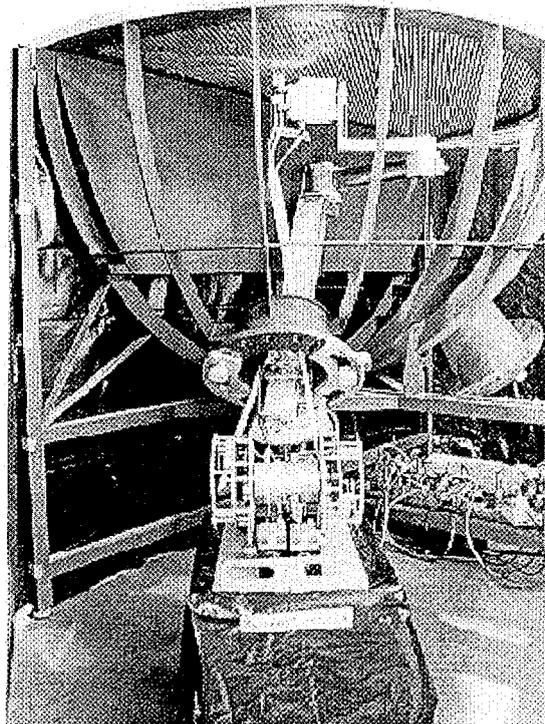
In this graph it is possible to see that even in the inspection between 1990 and 1995 there were some achievements using the same basic tools. This improvements were based mainly on small improvements in the procedures and equipment and in the skill of the inspection crews. In 1999, the 10 years inspection of Vandellos was performed in only 2.8 days due to the continuous improvements in the process and to the change to a new tool.

Steam Generator inspection system

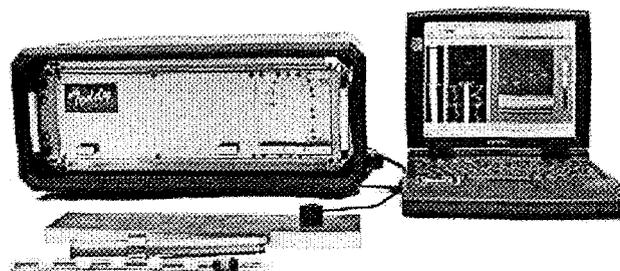
As with the vessel, this inspection is performed many times during the critical path of the outage. The type of work is quite different from the one performed on the vessel. Typically, there are three or more manipulators working at the same time and the amount of data produced is quite important. For schedule considerations, the work on critical path of this activity is the data acquisition, because analysis can be dimensioned to data rate by just increasing the number of analysts or automatic analysis systems. Then, from the point of view of production, acquisition equipment and procedures are essential to increase the inspection speed.

Tecnatom is performing Steam Generator inspections since 1980. In the last three years a new system called TEDDY is in use. This new system integrates all the experience feedback of the inspection crews cumulated during more than 6 million of tubes inspected. The following characteristics are of relevance to the production rate while improving the quality and sensitivity of the inspection:

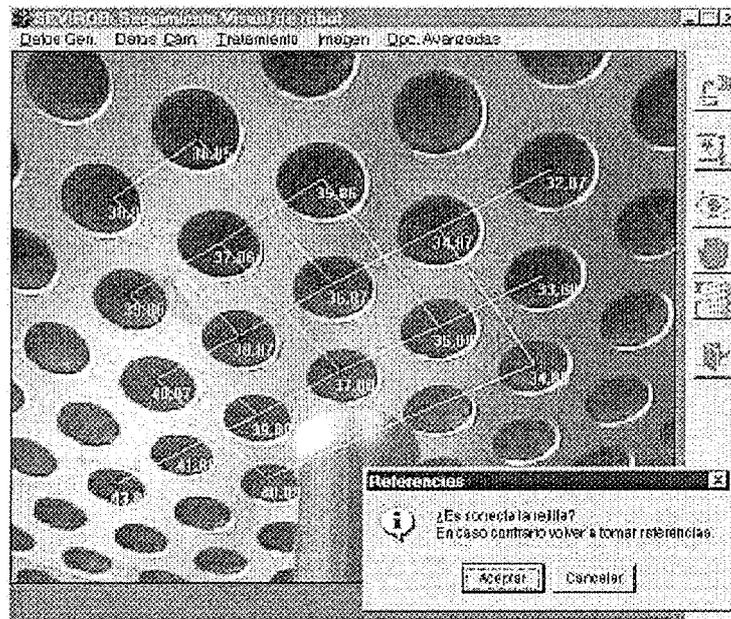
- Dual guide tube. This allows for the inspection of two tubes at the same time using a single manipulator, ET instrument and operator. Some cases even 4 tubes are inspected at the same time. This feature permits almost double the inspection rate with the same resources and with no negative effects on the quality.



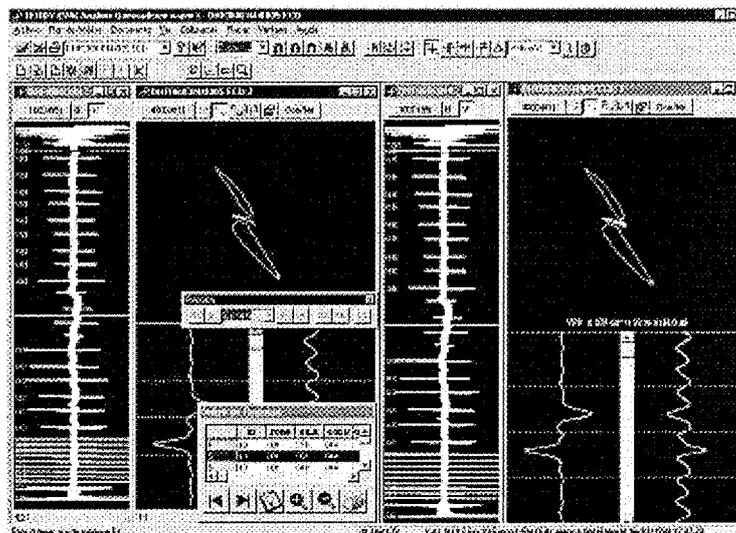
- Other improvement is related to the increase in the scanning speed, that has been doubled. This was achieved thanks to a new pusher/puller with higher speed and a new instrument, the TEDDY, developed at Tecnatom, that gives a higher sampling rate and better bandwidth to allow for inspections at high speed.



- Acquisition software was adapted to the new equipment and improved to provide for almost automatic operation. Typical inspection operations as locating a tube in the tube sheet, inserting the probes and performing the inspection, are fully automatic avoiding waiting time for operator reaction and reducing the fatigue and errors of human operators.
- Artificial vision software takes care of ensuring correct location of the tubes, then permitting faster operation without errors.



- Historical data recall module, presents historical information to the analysts avoiding the time to review past data.



- A full workflow system was developed to automatically handling the inspection management. This task, specially at the end of the inspections, is very delicate and time consuming. A good organization of retests with different probes is essential to reduce time and avoid errors.

Conclusions

The two inspection systems presented are just examples of how the inspection time is been reduced during the last few years. This improvements are in line with the general efforts of plant NPP owners to reduce outage durations while reducing costs and maintaining the required safety and quality of the different tasks.

The examples presented are not at all unique. Other inspection systems as the new control rod inspection tool that allows for a 100% inspection with RPC and encircling coil of around 54 control rods in less than 2 days, condenser and piping inspection systems, just to mention a few, are following exactly the same trend.



In the next future, improvements in computer systems will allow for a generalization of the use of cost effective automatic systems that will reduce even further the schedules of the inspections.