ENGINEERING EXPERIENCE IN EASTERN EUROPE

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This paper summarises over a decade of experience in engineering projects in nuclear power plants in countries in Eastern Europe and in the Commonwealth of Independent States (CIS).
It describes the relevant aspects of the great effort made by Western organisations in co-operation and assistance to these countries in order to determine the safety issues that can be improved and to proceed to their implementation. This trend, started by the IAEA, was immediately backed by the European Commission and other international bodies.
It also includes some thoughts on the current state of these types of nuclear projects and the prospects for the future.
Through these projects close collaboration has also been achieved with organisations from other countries of the European Union and the Eastern countries. This has favoured international acknowledgement of Spanish engineering capabilities.

INTRODUCTION

At the end of August 1990 in Vienna, we participated in the launch of the IAEA Extra-budgetary Programme on Safety in VVERs and RBMK nuclear power plants.

This programme consisted of assistance to the countries of Central and Eastern Europe and of the former Soviet Union for the evaluation of the safety of their nuclear power plants. Its main purposes were to identify major design and operational safety issues, to establish international consensus on priorities for safety improvement, and to review its implementation.

This programme signalled the opening up of ex-soviet technology to the Western countries, which applied their knowledge and experience to assess the design situation of these reactors and their operational safety.

This was the initiation of a broad attention to the Eastern NPPs by domestic and international organisations which financed a very wide assessment process of the nuclear sector in Eastern Europe.

The interest, effort and dedication of the European Commission was especially significant, as were those of other international institutions such as the EBRD, the US DOE, OECD/NEA, G-24 NUSAC, WANO, and also organisations from CIS and CEEC countries and other national institutions which reached specific agreements with these countries. This list is not exhaustive and only aims to show the extent of the effort made.

The nuclear safety of these reactors has turned into a true phenomenon of globalisation, given the number of countries and the types of organisations involved. I believe we can safely say that no Western reactor has received as much attention as the VVER reactors.

The reasons for this interest stem, beyond a doubt, from the opening up to the West of this technology following the fall of the Berlin wall and, what is more, to the fear in the West of catastrophes of the Chernobyl kind. Moreover, the lack of knowledge of these reactors in the West meant that a special effort had to be made prior to assessing their safety.

This paper describes the most relevant experiences obtained by our organisation mainly in the area of nuclear engineering, in Eastern projects. These were acquired in projects financed by the European Commission directly or through international organisations such as the European Bank for Reconstruction and Development (EBRD) with its headquarters in London, and direct contracts with local companies.

INITIAL STAGE

Our participation at the start of this programme consisted in the examination and assessment of the design of these reactors, in Eastern projects.

The personnel involved were integrated into groups of specialists from different disciplines, led by IAEA officers. This required the participation of professionals with a high level of experience in their fields and who were able to work independently outside the structure of our organisation. They had to face difficult situations with regard to language, culture, organisation, and limitations to their accustomed standards of living.

It was necessary to combine technical knowledge with human values, in order to achieve communication with other specialists with a different mindset.

It has to be borne in mind that normal work methods in the West, such as abundant well-maintained documentation, systemisation of the development of engineering documents, project management techniques, and others, were not at all usual practice in Eastern organisations. Fortunately, there were very highly qualified specialists who were able to develop sophisticated engineering calculations by hand during a meeting or on a sheet of paper, that we in the West develop from our desks with the aid of computer programs.

We had the opportunity to participate in issues that turned out to be relevant for future improvements like Instrumentation and Control, structural analysis of the containment/confinement, seismic and environmental qualification of electrical components, and probabilistic safety assessments.

The safety issues were classified into categories according to their importance to safety, and the improvements were developed later by the Owners of the plants with the external financial assistance of international organisations.

BASIS FOR DETERMINING WEAKNESSES

How can the weak points of these reactors be determined? Very simply. By comparison with Western codes, standards and practices, performed by highly qualified experts trained to deal with the issues of their specialities internationally.

There has been quite a bit of consensus on the basic criteria (INSAG, IAEA safety guides, international codes and standards, etc), with logical differences over the details of their application but which did not question the

Temelín Nuclear Power Plant

broad conclusions. Against this backdrop, one might wonder whether the harmonisation of safety criteria among countries is or is not necessary. There can be no doubt that such a harmonisation would be welcome, though admittedly difficult to perform at the detail level. A large effort has been made in Europe by way of the EUR requirements project aimed at harmonising safety criteria. Although basic agreements have been reached, we must accept variety when it comes to their application.

Another method used to determine the critical points of these plants has been the Probabilistic Safety Analysis (PSA). A considerable number of these have been performed, financed by different sources (EC, US DOE, local organisations). Different core damage frequency values have been obtained for plants of the same type. This may owe partially to a lack of information and lack of reliability of this information, both at the level of thermal-hydraulic analyses as well as that of plant data. Given the lack of data, extrapolations had to be performed and hypotheses devised that led at times to different results.

Despite the limited validity of the absolute values obtained by the PSA, the results are nonetheless useful from the point of view of determining weaknesses. The main contributors to risk have been determined: large and small LOCA, loss of offsite power, containment sump clogging, realignment of ECCS from high to low pressure, lack of symptom-oriented procedures, common cause failures due to lack of redundancies, etc.

Our first experience of a PSA of Eastern reactors was the Level 1 of Novovoronezh NPP, which we carried out as leader of a consortium of companies from other countries in the EU. We later carried out the Level 2 PSA of Balakovo NPP as member of a similar consortium.

We would like to mention the effort and collaboration shown by a Russian engineering company that participated actively in the work, with whom we have collaborated in different projects involving VVERs as well as RBMKs.

Specific accident analyses performed for these reactors have been used as a third basis for safety assessment. The first step was to draw up a list of accidents to be postulated. There are significant differences with respect to the West. For example, an initial analysis of the oldest reactors discovered that pipe break of the largest diameter pipes of the primary loop had not been postulated. Cases like this led to theoretical discussions on which accidents should be considered. Once the events to be postulated were agreed upon, it was necessary to analyse the validity of Western codes for representing the phenomena and mechanisms that occur in VVER reactors. The results of these calculations gave way to design changes to improve the results: modifications of the main steam isolation valves, upgrading of confinement isolation, etc.

In some very relevant cases, tests to determine the validity of certain design characteristics have been used. This is the case for the validation of the bubble condenser, which has required the erection of test facilities to determine the design margins of this system.

The bubble condenser is a tower adjacent to the reactor building of VVER-440-213 plants, which is used to reduce the pressure generated in the containment after a loss of coolant accident. The physical phenomenon consists of the condensation of the steam through a number of trays with water through which the steam of the atmosphere is condensed. It is a basic safety installation, whose performance needs to be validated.

Our participation in this issue was wide and detailed both in consultations and also developing specifications and calculations and supervising the tests to validate the structural capacity of this installation and its thermo-hydraulic behaviour.

No bubble condenser exists in the first generation reactors (VVER-440-230). They used the concept of confinement which required improvements to reduce the pressure after an accident and to minimise the emissions to the outside. We have reviewed improvements such as the Jet Vortex Condenser, incorporated into some Russian, Bulgarian and Slovak plants.

PROJECT GROWTH

In the beginning, European Commission DG I and DG XI (now RELEX and Environment) played a significant role in the organisation and management of the projects for assistance to the countries of Central and Eastern Europe and of the Community of Independent States (CIS). DG I was responsible for the budget, the definition of the projects and general management. DG XI participated in the safety studies for these reactors with the fundamental collaboration of the regulatory organisations and TSOs and some generic support of the industrial organisations.

Though it has been criticised, the European Commission's performance in this first stage deserves an explicit acknowledgement. It must be said that a small group of the EC staff managed to handle a large volume of projects, thanks to their effort, dedication and skill. As already mentioned, they obviously counted on external support for the definition of an action plan. The projects covered by the EC's scope aim at a more detailed development of safety upgrades, with a view towards the implementation of improvements, in which they also collaborate.

At the beginning of this stage we decided to become actively involved in these projects. This decision led us to participate in over one hundred projects financed by TACIS and PHARE,

EBRD or electrical utilities, basically in the nuclear area, with a few conventional projects.

At the beginning of the 90's, we submitted our first bids individually without integrating in a group. This was the case of the Bulgarian projects proposed by WANO. Despite their success, we considered it convenient for the future to explore the possibilities of participating in projects with other European companies. The European Commission was in favour of promoting groups formed by companies from different countries to help with the consolidation of the European Union.

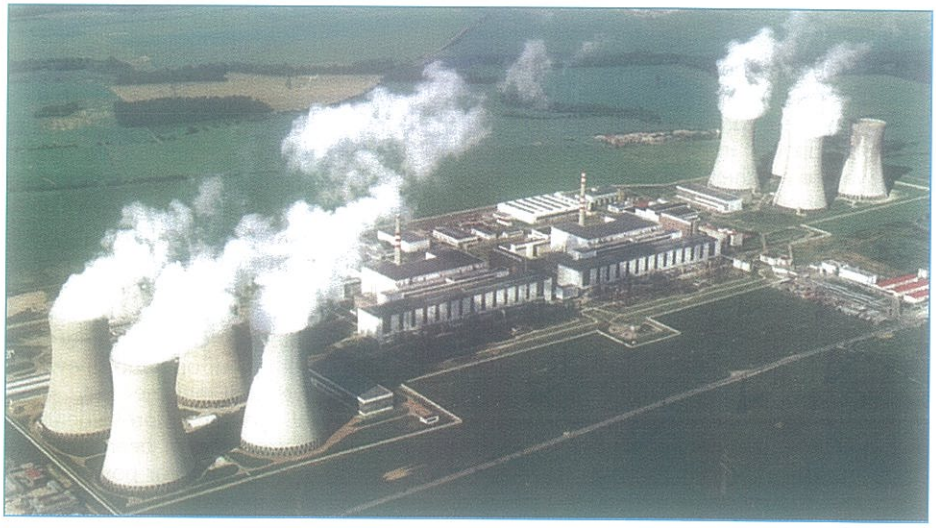
There are two relevant experiences that we would like to mention. At first we participated in a British-Belgian-Spanish consortium in order to bid for the TACIS-91 programme for Russia. The projects awarded covered areas including safety analyses, engineering (modernisation and life extension), quality and training. This set of projects allowed us to consolidate our collaboration with engineering companies from other countries of the EU and to confirm that our experts had homologable international experience. The effort and dedication of our specialists allow us to achieve a high level of quality and to be ranked in excellent positions of the European engineering sector.

These classical values of professionality and responsibility allow us to be members of a multi-national consortium, known as ENAC in which we participated in a significant number of PHARE, TACIS and EBRD projects.

This consortium comprised French, German, Belgian, British, Italian, Dutch and Spanish organisations from the service sector and electrical suppliers and companies. The initial idea of the consortium was to develop the engineering of the standard improvements of the different types of VVER power plants, for subsequent application to specific plants. This systematic approach was not feasible as such due to external considerations of the European Commission.

Priority was given by the EC to the participation of more companies, over the systematic approach that was the initial idea of ENAC. Without a doubt the political considerations of broadening the number of participants were an obstacle to the initial approach of ENAC.

Under these circumstances, ENAC participated in a number of smaller projects along with other bidders. The number of projects awarded and their wide content allowed this organisation to remain in being during a significant number of years.



Dukovany Nuclear Power Plant

Over the course of the years, the European Commission itself concluded that the excessive fragmentation of the projects did not favour an implementation of the safety improvements and it decided to support projects with a greater scope. In a certain way, this conclusion coincides with the initial ENAC approach.

OTHER AREAS OF ACTION

The European Commission's action plan also included the participation of other players in the nuclear sector, ie electrical utilities, safety organisations and waste handling companies.

It is not the purpose of this paper to comment in detail on the activities of these organisations, which also created collaboration groups such as TPEG (electrical companies), RAMG and TSO (Regulatory Bodies) and CASSIOPEE (waste handling).

As these organisations acted in the same area, it was necessary to establish collaboration with them in order to reach a harmonious agreement.

Our organisation stood out on account of the direct support it provided to these organisations on specific issues. This allowed us to obtain a global view of all the actions and improvement proposals made by the different actors.

THE PRESENT MOMENT

The European Commission is continuing with its action plan for the Eastern countries. The management structure for these projects has changed. The Phare projects have been assigned to the General Directorate for the enlargement of the European Union and the funds are used basically in improvement programmes for the nuclear sector of the countries joining the EU.

The programmes for assistance to the CIS countries are continuing separately and cover both supply and service projects.

The current priorities of the nuclear safety programme for CIS countries include the promotion of an efficient safety culture, the development and implementation of spent fuel and waste strategies, and support of international initiatives such as the closure of Chernobyl, environmental protection of the North-west of Russia and the dismantling of first generation nuclear installations.

Although the most intense stage of the design and analysis projects has passed, we are still participating in current projects such as configuration management for Ukrainian plants (with funds from the UK government's Department of Trade and Industry) and application of leak before break criteria in the Medzamor plant in Armenia.

We must mention at this point the recent award of Project Management Unit Consultancy for the start of the decommissioning activities of the Bohunice VI power plant. This project, financed by a Contributors Assembly and administered by the EBRD was awarded to a Spanish-French consortium, comprising EDF, Iberinco, Soluziona and Empresarios Agrupados.

During the course of the project we can apply the experiences acquired in similar cases managed by ENRESA, and through our long trajectory of waste management in projects for Spanish power plants.

RESULTS AND CONCLUSIONS

You may be asking yourselves what the results of this effort have been. They are clear to those of us who have participated in these projects in one way or another, and some of them have undoubtedly been pointed out above in this paper. Two areas can be considered: improvement in safety in power plants, and internationalisation of domestic engineering capabilities.

A pragmatic effort has been made that provided tangible results with respect to safety improvements. Vulnerabilities have been determined and classified by their importance to safety. Logically, priorities have been established for the short and medium-terms with respect to the improvements to be made, some of which have now been implemented, others are being implemented and some are awaiting final modernisation programmes.

Several types of safety evaluations have been performed. The IAEA has carried out a general assessment that encompassed all basic issues. Moreover, at the beginning of this process, German institutions performed a detailed safety analysis of the VVER reactors existing in their country, which served as the basis for deciding their future and helped to extend their conclusions to similar reactors. Although using other methodologies, the Technical Safety Organisations (TSO) have also carried out safety assessments on a selection of the different types of VVER reactors that exist.

It is important to note that the projects carried out have considered both the design safety and the operational safety of these reactors.

The most important design areas analysed, and whose results have been implemented, have arisen from the application of conventional safety criteria such as defence-in-depth, the guarantee afforded by the radioactive product retaining barrier in case of an accident, separation and redundancy of safety systems, fulfilment of safety functions, qualification of safety components in accident conditions, emergency power supply, and instrumentation and control.

Among the many important projects carried out are those related to vessel and primary circuit integrity both regarding materials analysis and testing, upgrading of the integrity and leaktightness of the confinement of the VVER 440-230, structural and thermo-hydraulic qualification of the bubble condenser to operate effectively in accident conditions, the application of the Leak before Break concept and improvement of the detection system of leaks and vibrations, and qualification of electrical and I&C equipment under accident conditions.

Without wishing to wrest importance from a good design, current safety trends place great emphasis on operational aspects. The safety culture, as basic to operation, has received considerable backing in all nuclear forums. Moreover, indicators have been defined and used to monitor NPP operational safety performance. These are structured hierarchically by safety attributes: smooth plant operation, low risk and effective plant management.

Important specific improvements in operational safety have been made in Eastern European nuclear power plants so as to prepare them for the application of new trends. The training of operators using Systematic Approach to Training (SAT) techniques, and the installation of simulators are significant improvements in the field of safety. Moreover, a series of workshops have been conducted to facilitate the transfer of knowledge and know-how to operating personnel. Another area of particular improvement is the development of standard and emergency procedures, the latter being symptom oriented, in accordance with the lessons learned from TMI-2. The direct transfer of operating practices through on-site assistance has been a widely accepted method of know-how transfer. We should not lose sight of the assistance provided in improving in-service inspections, and the training and management of maintenance data, or the Quality Assurance programmes in operation.

The engineering capacities that we initially developed during the Spanish nuclear programme, received an accolade from the international nuclear sector. We have significantly facilitated the formation of alliances with other organisations from other countries. We have become aware of a different technology in the nuclear sector in the East and we have been able to compare and harmonise criteria for the improvement of our methods in favour of nuclear safety and operational efficiency in nuclear power plants.

It is difficult to summarise in this article all the efforts made, and which in economic terms represented a budget of several thousand million Euros. We can safely say that it represents a stimulus that has produced a reaction from all the nuclear organisations in Europe. There is no doubt that participating in this process is worth while from a technological and human point of view.

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