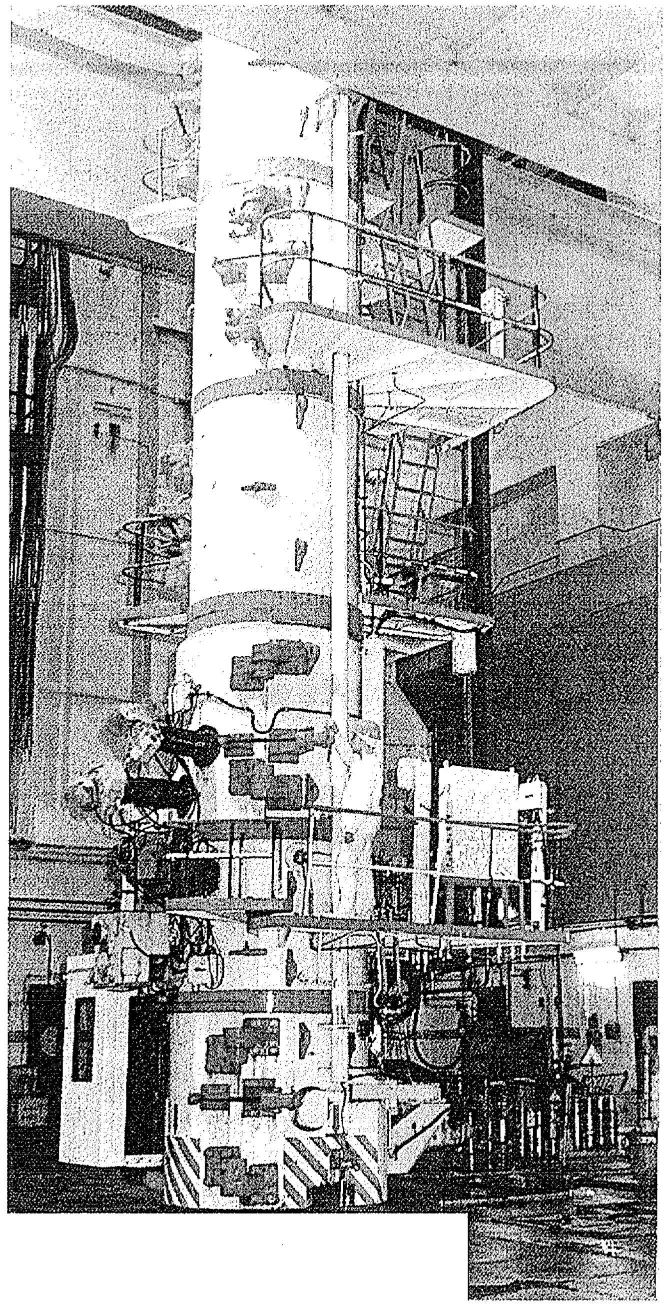
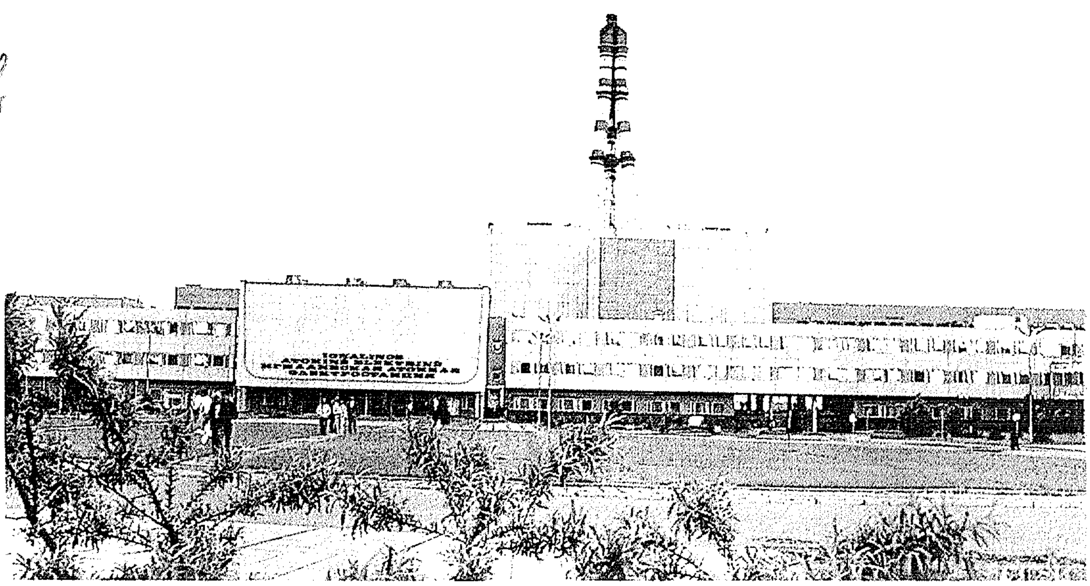
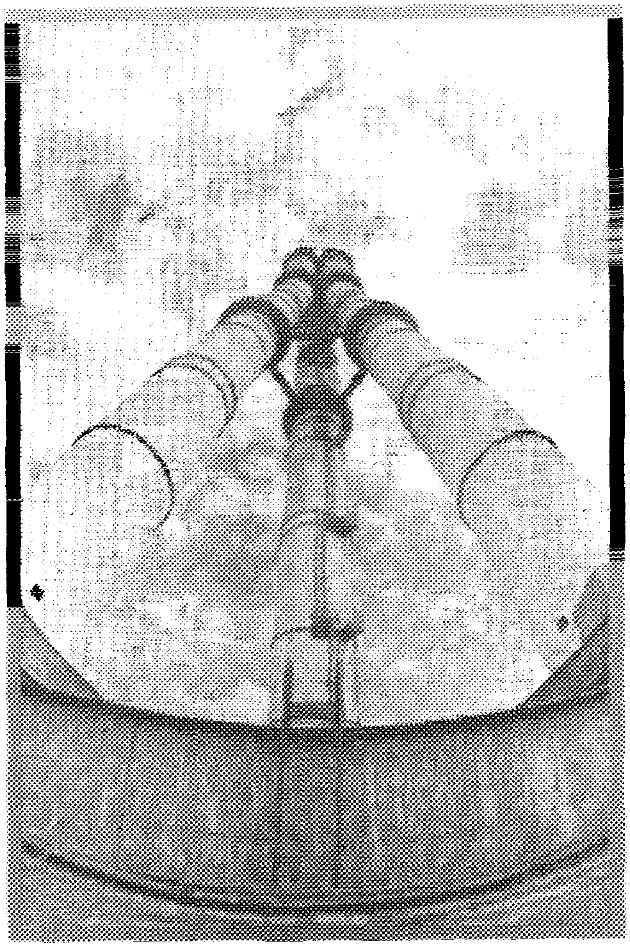
A BRIEF OVERVIEW OF IGNALINA NPP SAFETY ISSUES







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INIS-LT--007

THE IGNALINA NUCLEAR POWER PLANT

The Ignalina Nuclear Power Plant (INPP) consists of two units, commissioned in December 1983 and August 1987. Both units are Soviet designed RBMK-1500 reactors and differ from the RBMK-1000 plants operating in Russia and Ukraine, not only by a higher nominal power level, but also by several improved safety features, one of those being redesigned, more extensive Accident Localisation System (ALS).

The INPP generates power at a cost ~50% lower then alternative electric power sources. In 1993, Lithuania set a world record for the share of nuclear - generated electricity produced in one country, with nuclear energy providing 88.1 percent of Lithuania's power. In 1996 and 1997 the Ignalina NPP generated 85.8 and 81.3 percent of the country's electricity, respectively.

STATE OF KNOWLEDGE OF THE IGNALINA NPP

The INPP is unique among all RBMK type reactors in the scope and comprehensiveness of international studies which have been conducted to verify its design parameters and analyse its level of risk. Right from the start, when Lithuania assumed control of the INPP (after the demise of the Soviet Union in 1991) the plant, its design and operational data has been completely open and accessible to western experts. Initially, effective assistance in the nuclear safety field was provided by Sweden, subsequently, most states having significant nuclear expertise also contributed.

International assistance took several forms. A very valuable mode of assistance utilised the knowledge of international experts in extensive international study programs whose purpose was:

a) collection, systematisation and verification of plant design data,

b) analysis of the level of risk,

c) recommendations leading to improvements in the level of safety,

d) transfer of state of the art analytical methodology to Lithuanian specialists.

The major large scale international studies include:

- **BARSELINA** (1992-1996) – A probabilistic risk analysis study conducted by Sweden, Lithuania and Russia.
- **SAR** (Safety Analysis Report, 1995-1996) – A very extensive international study funded by a grant from Nuclear Safety Account. Its purpose is to provide a comprehensive overview of plant status with special emphasis placed on its safety aspects. Specialists from the Ignalina NPP, Russia (main RBMK designer RDIPE), Canada and Sweden contributed.
- **RSR** (Review of the Safety Analysis Report, 1995-1997) – An extensive review of the SAR by an independent group of international experts. Specialists from the U.S., United Kingdom, France, Germany, Italy, Russia and Lithuania contributed.

The noted studies provide a verified, state of the art base of knowledge which makes it possible to assess the present level of plant safety, compare this level with other reactor plants and plan improvements in plant hardware and operational procedures which enhance the level of safety. INPP is the only RBMK plant for which this information is available. Note, that statements made concerning plant safety in this summary are based on the consensus reached by the international expert community. A significant conclusion stated in the SAR is that none of the analysed safety concerns require the immediate shutdown of the plant.

RECURRING QUESTIONS

The safety of nuclear power plants is of continuous interest to the public and media. Here we review briefly the four most frequently recurring questions concerning the INPP.

1) Can a similar accident to the one that occurred in Chernobyl take place at INPP?

The consequences of the Chernobyl event are unique and were caused by a design flaw in the original RBMK type plants. In a limited operating range the overall reactivity coefficient was positive. It is this flaw which produced the disastrous consequences. Subsequently, hardware changes were implemented to change the neutronic characteristics of the INPP. These include: introduction of absorber rods, alteration of the fuel enrichment and changes in the design of control rods. Therefore, the present INPP reactors ***can not be equated with the unit, which failed at Chernobyl.*** *The implemented changes assure that* ***the total power coefficient of reactivity remains negative under all possible***

circumstances. *This characteristic has been verified by extensive analysis by international experts. Even given the extremely unlikely event that similar operational mistakes are made as those which precipitated the "Chernobyl event", the consequences would be completely different and would injure neither the surrounding population nor plant operators.*

2) Do the INPP units have a containment?

In the safety field what counts is function, not appearance. The function of a 'containment' is to assure that in an unlikely event during which radioactive materials are released from the fuel elements, these materials do not reach the environment. In many (though not all) western reactors this is accomplished by a prominently visible, hemispherical shell. In the INPP, these function is accomplished by an extensive system of interconnected re-enforced compartments called the Accident Localisation System. This system uses the same principle as employed by the BWR's (Boiling Water Reactors) built by GE (General Electric). This is the 'Pressure suppression' approach in which the spaces around the reactor and its piping are divided into two general volumes. When steam is emitted into the inner volume (for example, due to a pipe break), it must bubble through large water reservoirs in order to reach the outer volumes. This reduces the pressure and removes most of the radioactive fission products. The extensive ALS is one of the design characteristics, which distinguishes the INPP from other RBMK reactors.

It should be noted that not the entire primary system is enclosed within the ALS. The pipes, which direct the two-phase water from the reactor to the steam drums *and some part of downcomers, are not enclosed. However, extensive analysis has shown that a break in these pipes will not lead to the overheating of fuel and thus to the release of excess radioactivity.*

3) What are the probabilities and potential consequences of accidents?

Safety is too important a subject to be left to relative judgements which can be influenced by emotions and prejudices. Criteria are required which can be quantified in terms of absolute indexes. In many technical fields (e.g. transportation) such criteria are provided by the statistical analysis of the database provided by past accidents. This approach is not suitable for the nuclear power field – the available number of past accidents is much too small. An approach has been developed which uses component failure data and extensive analysis to determine two aspects of an accident: the ***probability*** *of occurrence and the* ***consequences.*** *A combination of the two indices for all possible accidental events then provides a measure, which can be used to compare the safety of different plants and reactor types.*

For the INPP extensive studies by international experts have determined that in terms of these PRA (Probabilistic Risk Analysis) indexes the modified (post "Chernobyl") INPP is comparable to western reactors. Note, that INPP is the ***only*** *RBMK type plant for which this statement can be made.*

The above conclusions certainly do not imply that the INPP is "identical" to western BWR's. It is a graphite moderated, channel type reactor, and in many constructional aspects differs from the single pressure vessel

BWR's. The documentation of the analysis detailing the consequences of these differences is very extensive. A very brief summary of the conclusions reached in these studies is as follows:

The probability of initiating events (e.g. pipe breaks, valve failures, etc.) for INPP is higher then for comparable western BWR's'. The objective reasons for this are the higher complexity of an RBMK type reactor (a considerably larger number of pipes, valves and associated equipment) and the lower level of quality control for Soviet design and construction.

On the plus side, international analysis agrees that the INPP is remarkably robust and that the vast majority of initiating events will not lead to fuel overheating and the release of radioactivity from fuel (Note – from fuel, not - to the environment. That requires an additional level of failure).

The robustness also has objective reasons. These include: channel construction which limits loss-of-coolant accidents to single channels, the considerably larger volume and thus heat-capacity of the INPP core region (thus lower rate of heat-up), the higher vertical elevations (thus higher driving force for natural circulation), the larger volumes of water in the primary system and above the core region and the high redundancy by which Soviet designers compensated for lower quality control.

When all of these factors are taken into account, the index combining event initiation probability and consequences of events is indeed comparable to those achieved by western plants.

4) *What are the consequences of the closure of the graphite-fuel tube gap?*

This issue has economic, political and judicial aspects. Here is only a brief summary of safety issues is considered.

Operational experience in other RBMK plants has shown that under the influence of fast neutrons and high temperature the gap which initially exists between the graphite blocks and the fuel channel tube gradually shrinks. The consequences of complete gap closure are not fully known. Some negative consequences like increased stresses on the Zr tube and graphite blocks are postulated. Past practice has been to change the Zr tubes once gap closure is observed, this has been accomplished for 3 RBMK units.

Up to 1997 the projected time of gap closure for the INPP units was estimated using data from other RBMK plants. In 1997 an extensive, ongoing program has been initiated which measures the dimensional changes of the Zr tubes and the graphite channels. The response of the graphite-fuel tube gap is thus monitored on an annual basis. Therefore, the time at which the first gaps will start to close will now be determined from actually measured data for each individual unit. On the basis of already obtained measurements it is known that for the INPP the gap closure rate is more gradual then for other RBMK units. This is due to a different operating regime and to somewhat different materials of construction.

SELECTED INSIGHTS FROM THE INTERNATIONAL STUDIES

The extensive studies of INPP conducted by international experts include recommendations for enhancing plant safety. A few excerpts from the lists of recommendations are listed here in order to provide an indication what areas are of concern to the international expert community. Note that most of the recommendations fall in the "human interaction" area:

A) Management

"Fundamental changes are necessary in the attitude of senior management towards its responsibility for safety", (SAR, 1996).

"The recommended improvements in engineered plant safety systems are necessary but are not by themselves sufficient, without corresponding improvements in the plant safety culture", (RSR, 1997).

B) Regulatory

"... the Lithuanian Government should define and establish appropriate division of responsibilities between the Lithuanian State, the INPP, VATESI (Lithuanian Nuclear Power Safety Inspectorate) and the TSO's (Technical Support Organisations)", (Ignalina Safety Panel (ISP) Recommendations, 1997).

C) Operational

"Develop a more systematic approach to training as described in IAEA guidelines and consistent with a formal QA approach", (SAR, 1996).

"Operator training needs to make more use of written procedures and simulators", (ISP Recommendations, 1997).

D) Hardware

"The most important unresolved issues are the ability of the shutdown functions to be initiated and completed irrespective of any single failure, and the integrity of the coolant system.", (RSR, 1997).

"The safety case for the reactor control and protection systems should be completed by the INPP", (ISP Recommendations, 1997).

Priority I suggested system modifications:

1. Installation of a second independent shutdown system.

2. Introduction of an early reactor trip and Emergency Core Coolant System actuation for all break locations in the Main Circulation Circuit and steam system.

E) Additional analysis recommendations

"The Panel holds the view that the most important safety issues needing immediate resolution are the following:

- The safety case for the reactor control and protection system should be completed.
- The safety case for accident localisation system should be provided.
- The safety case for structural integrity of the reactor cooling circuit should be provided.
- A fire hazard analysis for all safety systems should be carried out", (ISP Recommendation, 1997).

Most of the listed recommendations have been adopted, or are being implemented. The Lithuanian Government and its regulatory bodies fully appreciate that concern for safety is an ongoing process and requires constant effort and vigilance. A brief list of the past and ongoing safety improvement projects is provided in the next section.

IGNALINA SAFETY IMPROVEMENT PROGRAMS

After the Chernobyl accident hardware changes were implemented to ensure that a negative power coefficient of reactivity exists at all operating regimes. The changes include the modification of control rods, the introduction of additional absorbers, implementation of a fast reactor scram system and the upgrading of operating regulations with regard to core control.

Efforts to upgrade the Ignalina NPP safety were accelerated when Lithuania assumed control of the plants. A short-term Safety Improvement Program (SIP) has been prepared by the plant with the assistance of Western experts and was approved by VATESI in 1993. To realise this program a Grant Agreement was approved by the European Bank for Reconstruction and Development on behalf of the Nuclear Safety Account. The grant supported 20 projects in three areas: operational safety, technical improvements, and services. Operational safety improvements include non-destructive testing, seals for pressure tubes, routine maintenance instruments and equipment, radiation monitors, upgrading of design and maintenance documentation, upgrading and the design, delivery and implementation of a full-scope INPP specific simulator. Short-term safety improvements include upgrading of the data process system TITAN, low flow and low reactivity margin reactor trip system, engineering study of the second emergency shutdown system, seismic, fire and hydrogen explosion prevention and others.

The follow-up to SIP is the new Safety Improvement Program (SIP-2) of the Ignalina NPP which is based on the recommendation of the Ignalina Safety Panel, the Safety Analysis Report, its independent review and incorporates the experience gained during implementation of the first Safety Improvement Program. The Lithuanian governmental authorities approved the SIP-2 in 1997. It will be continuously up-dated and revised annually and should be completed in three years (1997-1999). All activities within the new Safety Improvement Program are divided into three categories:

- Design modifications.
- Management and organisation development.
- Safety Analyses.

SIP-2 implementation is progressing satisfactorily. The Ignalina NPP, and in particular its Director, have shown a very positive approach regarding the recommended implementation of changes in the safety culture. This applies at all levels of the plant and includes a well-developed plan to employ outside technical expertise for some essential implementation tasks. Several examples of SIP-2 implementation are given below. The work to develop Safety Cases for the Accident Confinement System and Reactor Coolant System is now underway and on schedule. The schedule is realistic, and should provide a sound basis for a VATESI licensing decision. Ignalina NPP has accepted the recommendations related to the required improvements in the Control and Protection Systems (CPS) and has initiated a detailed and comprehensive Single Failure Analysis and for this system. Very detailed analysis has been performed to find out whether failure of a single component could cause a loss of safety function. The effort carried out by Ignalina NPP and their contractors has increased the level of confidence that the CPS/EPPS (Emergency Process Protection System) constitutes a strong line of defense. Ignalina NPP plans to introduce an additional emergency protection system (DAZ) based on a high pressure signal from the steam separators and a low flow indication through Main Circulation Pumps. This is aimed at removing residual concerns about Anticipated Transients Without Scram scenarios during ongoing 1998 outage at unit 1 and during 1999 outage at unit 2. The work for development of the second fully independent diverse shutdown system has been also started this year under PHARE sponsorship.

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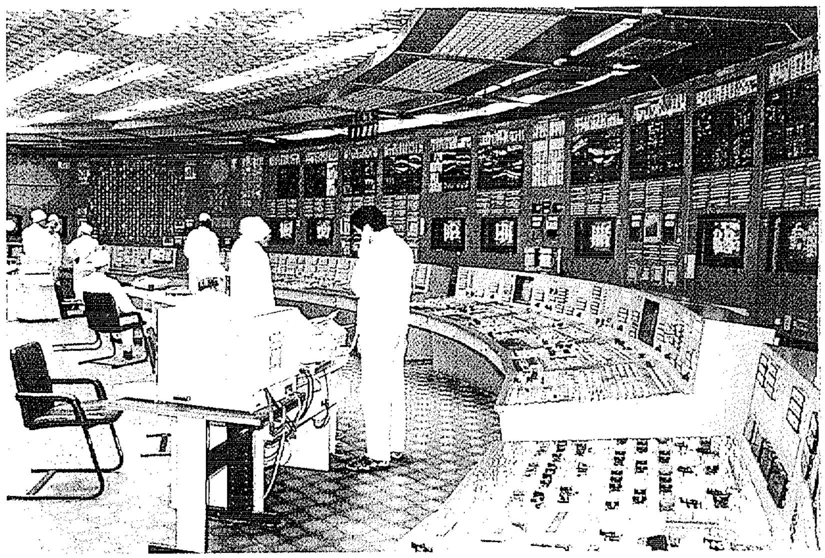

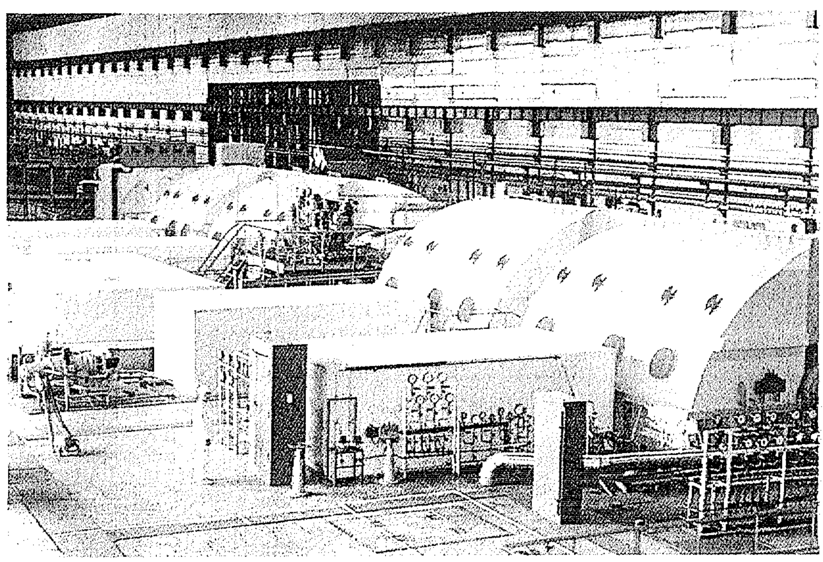

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