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**THE IN-DEPTH SAFETY ASSESSMENT (ISA) PILOT PROJECTS  
IN UKRAINE\***

by

C. A. Kot and C. E. Dickerman  
Argonne National Laboratory  
International Programs  
9700 South Cass Avenue  
Argonne, Illinois 60439

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M. G. Stamatelatos  
Scientech, Inc.  
191 Calle Magdalena, Suite 290  
Encinitas, CA 92024

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C. A. Kot and C. E. Dickerman  
Argonne National Laboratory  
International Programs  
9700 South Cass Avenue  
Argonne, IL 60439-4842  
Phone: (630)252-6151  
Fax: (630)252-3361

M. G. Stamatelatos  
SCIENTECH, Inc.  
191 Calle Magdalena, Suite 290  
Encinitas, CA 92024  
Phone: (760)436-1131  
Fax: (760)436-1151

**Abstract**

Ukraine operates pressurized water reactors of the Soviet-designed type, VVER. All Ukrainian plants are currently operating with annually renewable permits until they update their safety analysis reports (SARs). After approval of the SARs by the Ukrainian Nuclear Regulatory Authority, the plants will be granted longer-term operating licenses.

In September 1995, the Nuclear Regulatory Authority and the Government Nuclear Power Coordinating Committee of Ukraine issued a new contents requirement for the safety analysis reports of VVERs in Ukraine. It contains requirements in three major areas: design basis accident (DBA) analysis, probabilistic risk assessment (PRA), and beyond design-basis accident (BDBA) analysis. The DBA requirements are an expanded version of the older SAR requirements. The last two requirements, on PRA and BDBA, are new.

The US Department of Energy (USDOE), through the International Nuclear Safety Program (INSP), has initiated an assistance and technology transfer program to Ukraine to assist their nuclear power stations in developing a Western-type technical basis for the new SARs. USDOE sponsored In-Depth Safety Assessments (ISAs) have been initiated at three pilot nuclear reactor units in Ukraine, South Ukraine Unit 1, Zaporizhzhya Unit 5, and Rivne Unit 1. USDOE/INSP have structured the ISA program in such a way as to provide maximum assistance and technology transfer to Ukraine while encouraging and supporting the Ukrainian plants to take the responsibility and initiative and to perform the required assessments.

## Background

Ukraine operates three kinds of pressurized water reactors of the Soviet-designed type, VVER-440/213, VVER-1000/302 (the older, so-called "smaller" 1000 series), and VVER-1000/320, their most modern 1000 MWe nuclear power plants. There are two VVER-440/213 and one VVER-1000/320 at Rivne, two VVER-1000/302 and one VVER-1000/320 at South Ukraine, six VVER-1000/320 at Zaporizhzhya, the largest power station in Europe, and one VVER-1000/320 at Khmelnitskyy. All Ukrainian plants are currently operating with annually renewable permits until they update their safety analysis reports (SARs). After approval of the SARs by the Ukrainian Nuclear Regulatory Authority, which is currently part of the Ministry of Environment, the plants will be granted longer-term operating licenses.

In September 1995, the Nuclear Regulatory Authority (NRA) of the Ministry for Environment and Safety (MINECOBEZPEKA) and the Government Nuclear Power Coordinating Committee of Ukraine (DERZHATOM) issued a new contents requirement for the safety analysis reports of VVERs in Ukraine. It contains requirements in three major areas: design basis accident (DBA) analysis, probabilistic risk assessment (PRA), and beyond design-basis accident (BDBA) analysis. The DBA requirements is an expanded version of the older SAR requirements. The last two requirements, on PRA and BDBA, are new.

The schedule for submitting and approving the updated SARs is tight and the US Department of Energy (USDOE), through the International Nuclear Safety Program (INSP), has initiated an assistance and technology transfer program to Ukraine to assist their nuclear power stations in developing a Western-type technical basis for the new SARs. The INSP is managed on behalf of DOE by the Pacific Northwest National Laboratory (PNNL) and Argonne National Laboratory (ANL) is responsible for the technical integration of all plant safety evaluations and specifically for the management and coordination of the in-depth safety assessments (ISAs). USDOE sponsored ISAs have been initiated at three nuclear reactor units in Ukraine, South Ukraine Unit 1 (SUNPP1), Zaporizhzhya Unit 5 (ZNPP5), and Rivne Unit 1 (RNPP1) which are the plants selected by Ukraine to be the pilots for the SAR effort. SUNPP1 is the selected pilot for VVER-1000/302s, ZNPP5 the pilot plant for VVER-1000/320s, and RNPP1 the pilot plant for VVER-440/213s.

### Objectives of the DOE-sponsored In-Depth Safety Assessments (ISA)

The objectives of the DOE-funded plant-specific ISA program have been to:

- Provide the technical basis to meet the requirements for Safety Analysis Report (SAR) upgrades in Ukraine as outlined in the document entitled "Requirements on Safety Analysis Reports for Ukrainian Nuclear Power Plants with Reactors of the VVER Type" issued by MINECOBEZPEKA and DERZHATOM in 1995;
- Develop a documented plant-specific safety basis; provide a basis for prioritizing plant upgrades and for evaluating effects of changes in plant operation;

- Develop indigenous capabilities in Ukraine to perform in-depth safety assessments for nuclear power plants (NPPs) and capabilities at each NPP to use up-to-date methods for controlling the plant configuration to keep it within its safety envelope;
- Provide models, data bases, computer programs, and computer program input decks which are readily adaptable to establishing the safety basis for the VVER NPPs of similar design.

### **Principles for DOE Support of ISA Projects**

An ISA provides valuable input for safe plant operation as well as the technical basis for plant safety assessment. In order to achieve the goals of technology transfer and to build an indigenous safety culture, DOE's support of in-depth safety assessment projects is based on the following principles:

- *Plant leadership:*

Since the NPP is responsible for safety, it must assume the responsibility for the project. Involvement of NPP personnel in the project and the use of plant-specific data in the analyses are essential.

- *Contractors:*

The NPP is responsible for the identification of their proposed subcontractors. DOE provides technical and financial assistance to the identified contractors as necessary.

- *Project Management:*

While DOE provides the funding, the NPP must provide a project manager and support staff at the site. DOE INSP selects and funds a US contractor to provide technical and management project assistance.

- *Quality Assurance:*

The US will fund a separate team to conduct quality assurance and peer review of the work. The work products must be able to pass international peer review.

- *Regulatory Review:*

It is the NPP's responsibility to obtain regulatory review of the safety assessment and to ensure that the safety analyses are acceptable to the in-country regulatory authority.

- *Computer Programs:*

Commonly used, non-commercial, validated computer programs are used to ensure ease of technology transfer with no residual obligations for program maintenance payments to contractors.

- *Maintenance:*

The NPP and the host country designated support organizations are responsible for the maintenance and upkeep of the safety analyses and the safety analysis reports after their completion.

Thus, USDOE/INSP has structured the ISA projects in Ukraine in such a way as to provide maximum assistance and nuclear safety technology transfer while encouraging and supporting the Ukrainian plants to take the responsibility and initiative and to perform the required assessments. In order to accomplish this, INSP has selected SCIENTECH, an experienced US nuclear safety contractor, to assist in the management and performance of the ISA tasks for all three pilot plants, to transfer US nuclear safety technology, and to mentor and review the technical work of the projects. Nevertheless, the management and performance of all technical work in each project rests with the Ukrainian nuclear power plant which selects Ukrainian companies, organizations and consultants to perform the work.

In order to provide top-level guidance to the ISAs in Ukraine, a Steering Committee was formed with representatives from the following organizations:

- DERZHATOMATOM
- USDOE
- All four NPPs operating VVERs in Ukraine, namely Rivne, South Ukraine, Zaporizhzhya and Khmelnitsky

This committee meets several times per year to provide overall direction and oversight, to review important projects progress and milestones, to resolve important programmatic issues, and to provide the necessary coordination necessary to ensure uniformity of quality and purpose for all ISAs in Ukraine.

### **ISA Scope of Work**

The ISA scope of work for the three Ukrainian pilot project have followed some general technical guidelines but the efforts have been specialized at each NPP to meet the needs of the NPP and its stage of individual capability and progress in performing an in-depth safety assessment.

The general topics covered by an ISA are as follows:

1. Project planning;
2. Assembly, documentation and evaluation of safety analysis work completed by or for the NPP prior to initiation of the DOE funded effort;
3. Development of project guidelines for the performance of the project technical tasks; This is a very important task because it serves as the initial standard for performing a world-class ISA. It also serves as the initial tool for on-the-job training of the Ukrainian team under the guidance of the selected US expert contractor which, in this case is SCIENTECH, Inc..
4. Project-specific data collection and analysis;
5. Probabilistic risk assessment (PRA) containing the following subtasks:
  - Level 1 internal-events PRA;
  - Limited Level 1 external events and internal hazards (fires and floods) PRA;
  - Limited Level 2 PRA;
6. Design-basis accident (DBA) analysis which constitutes an update and expansion of the deterministic DBA analyses typically performed in support of a safety analysis report;
7. Limited beyond-design-basis accident (BDBA) analysis.

The specific efforts for each of the three ISA projects have varied to some extent from the original general workscope.

Specifically, a major portion of the Rivne 1 Level 1 PRA was completed by the NPP prior to initiation of the DOE funded project. Completion of this Level 1 PRA will be included in the Rivne Unit 1 ISA project. In addition, the NPP expressed interest in analysis assistance to support the development of emergency operating procedures (EOPs). DOE therefore decided to add this task to the overall Rivne 1 effort.

In the case of South Ukraine Unit 1, the PRA effort had only been initiated by the NPP when the DOE effort was put in place. Therefore, the PRA effort for this plant is greater than that for Rivne 1.

For Zaporizhzhya Unit 5, no PRA had been initiated prior to the DOE effort and therefore the fully intended scope of the Level 1 PRA is being performed.

### **Status and Conclusions**

The three ISA studies in Ukraine have been at different stages of progress since they were initiated at different times. The South Ukraine Unit 1 project was started almost one year ago and it therefore has shown the most progress. The initial tasks have been completed including the development of a major portion of the Project Guidelines, and considerable progress has been made on the Level 1 Internal Events PRA and the

supporting thermal-hydraulic work. The Zaporizhzhya Unit 5 project was started next but it has suffered some delays because not all of the NPP subcontractors were selected and integrated into the project. The Rivne Unit 1 project was started only very recently and only the overall project planning effort is complete.

Although early in the life of all three projects, some general conclusions can be drawn at this time:

- All three projects are supported by the NPPs who find them essential for performing the necessary safety analyses for developing updated SARs;
- The nuclear safety technology transfer process between the US and Ukraine is working well and in-country safety analysis expertise is being developed at a reasonable rate;
- The relationship among the Ukrainian project personnel, the US project coordination (ANL), and the US trainers and technical mentors (SCIENTECH, Inc.) has developed successfully and it fosters good project progress;
- No major technical or programmatic impediment for successfully meeting the overall ISA objectives set forth by DOE appears to exist.