IAEA Post Irradiation Examination Facilities Database

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Abstract

The number of hot cells in the world in which post irradiation examination (PIE) can be performed has diminished during the last few decades. This creates problems for countries that have nuclear power plants and require PIE for surveillance, safety and fuel development. With this in mind, the IAEA initiated the issue of a catalogue within the framework of a coordinated research program (CRP), started in 1992 and completed in 1995, under the title of "Examination and Documentation Methodology for Water Reactor Fuel (ED-WARF-II)". Within this program, a group of technical consultants prepared a questionnaire to be completed by relevant laboratories. From these questionnaires a catalogue was assembled. The catalogue lists the laboratories and PIE possibilities worldwide in order to make it more convenient to arrange and perform contractual PIE within hot cells on water reactor fuels and core components, e.g. structural and absorber materials. This catalogue was published as working material in the Agency in 1996. During 2002 and 2003, the catalogue was converted to a database and updated through questionnaires to the laboratories in the Member States of the Agency. This activity was recommended by the IAEA Technical Working Group on Water Reactor Fuel Performance and Technology (TWGFPT) at its plenary meeting in April 2001.

The database consists of five main areas about PIE facilities: acceptance criteria for irradiated components; cell characteristics; PIE techniques; refabrication/instrumentation capabilities; and storage and conditioning capabilities. The content of the database represents the status of the listed laboratories as of 2003. With the database utilizing a uniform format for all laboratories and details of technique, it is hoped that the IAEA Member States will be able to use this catalogue to select laboratories most relevant to their particular needs. The database can also be used to compare the PIE capabilities worldwide with current and future requirements. It is possible that the publishing of this database will provide an incentive for laboratories with limited PIE techniques to increase their own capabilities.

The database work was supported by the IAEA. The authors wish to thank Mr. V. Onoufriev (scientific secretary, IAEA) and Mr. M. Ceyhan (database specialist, IAEA) for coordination and technical assistance during the work of the IAEA database. The database is implemented under the IAEA Nuclear Fuel Cycle Information web site, i.e. at http://www-nfcis.iaea.org/Default.asp.

Keywords: *PIE database, irradiated nuclear fuel, absorber material, non-destructive and destructive PIE, refabrication and instrumentation, storage capability.*

Introduction

The number of hot cells in the world in which post irradiation examination (PIE) can be performed has diminished during the last few decades. This creates problems for countries that have nuclear power plants and require PIE for surveillance, safety and fuel development. With this in mind, the IAEA initiated the issue of a catalogue within the framework of a coordinated research program (CRP), started in 1992 and completed in 1995, under the title of "Examination and Documentation Methodology for Water Reactor Fuel (ED-WARF-II)". Within this program, a group of technical consultants prepared a questionnaire to be completed by relevant laboratories. From these questionnaires a catalogue was assembled. The catalogue lists the laboratories and PIE possibilities worldwide in order to make it more convenient to arrange and perform contractual PIE within hot cells on water reactor fuels and core components, e.g. structural and absorber materials. The catalogue was published as working material in the Agency in 1996. The catalogue was converted to a database and updated through questionnaires to the laboratories in the Member States of the Agency during 2002 and 2003. This activity was

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recommended by the IAEA Technical Working Group on Water Reactor Fuel Performance and Technology (TWGFPT) at its plenary meeting in April 2001.

The proposal to create an international database on PIE facilities/techniques was further discussed at the TM on advanced post-irradiation examination techniques for water reactor fuel held from 14 to 18 of May 2001 in Dimitrovgrad, Russian Federation. The Ministry of the Russian Federation for Atomic Energy and SSC RF Research Institute of Atomic Reactors (RIAR) hosted the meeting. The participants of this meeting agreed to convert the catalogue of laboratories and PIE possibilities to a database. PIE specialists from France, Germany, Norway and Russia volunteered to evaluate the possibility of creating an open database on the IAEA website. The group concluded that the number of PIE techniques has increased and the type of tasks to be carried out have changed significantly since the last TC meeting (arranged in 1995). New materials and design, including mixed oxide fuel, burnable absorber fuel and other additive fuels, together with corrosion resistant claddings have become more prominent. PIE of lead test assemblies is completed with high burn-up test reactor experiments including re-fabricated fuel rods (made from irradiated commercial rods). Changes in composition, structure and properties of fuel and structural materials are to be investigated and understood in order to calculate, validate and forecast fuel operational margins and safety limits. Common approaches in PIE techniques allow results obtained in different countries and different laboratories to be compared, which will improve the trustworthiness of the results to be used for fuel performance, and licensing. The group of PIE specialists agreed upon following basic features of the database: it should not interfer with commercial interests; the database should be regularly updated; and all of the interested IAEA Member countries should have access to the database. All previous activity in the area (e.g. PIE facilities catalogue) should be taken into account and the PIE database should be seen in co-operation with other related programmes and databases on water reactor fuel investigations.

The PIE specialist group worked under the co-ordination of scientific secretary V. Onouvfriev at the department of Nuclear Energy (IAEA), division of Nuclear Fuel Cycle and Waste technology. The consultancy meetings under the PIE database construction were arranged both in Vienna and Dimitrovgrad in Russia. A number of Russian scientists (participants & observers) from several research institutes participated at the consultancy meeting in Dimitrovgrad in 2003 where database maintenance and layout strategies were discussed. One possibility that was discussed on this occasion was the implementation and maintenance of the database by RIAR. RIAR has a database that could be used as a prototype for the PIE database. The consultant PIE specialists and the Russian participants rejected this idea because the database should be maintained and implemented under the IAEA web site as an international PIE database.

The basic structure or skeleton, current user status and possibilities of the IAEA PIE database are discussed in this paper. Some comments related to the process of retrieving relevant input-data from the hot laboratories worldwide are given, e.g. PIE technical descriptions and transformation of the information onto the IAEA web site.

IAEA database specialist Mr. M. Ceyhan implemented and finalized the PIE database for the IAEA Integrated Nuclear Fuel Cycle Information System (iNFCIS) early in 2004 upon recommendations from the PIE specialists.

Basic modules of the IAEA PIE database

The PIE database is organized under IAEA iNFCIS, i.e. the Integrated Nuclear Fuel Cycle Information System at http://www-nfcis.iaea.org/Default.asp. The IAEA operates a number of nuclear fuel cycle related databases and simulation systems for long-term projections of nuclear fuel cycle material and service requirements. Their purpose is to provide Member States, the IAEA, and public users with current, consistent, and readily accessible information for planning activities related to the nuclear fuel cycle. For first time login to this database system, you need a userID and password. The login page is shown in Fig. 1. Here you must click on the Send UserID and Password button that will request you to send your e-mail address. The necessary information you need is then sent to that given e-mail address in a short time. It's possible to login to the database system and to select the Post Irradiation Facilities Database (PIE) after you have received the password from IAEA (after a short while).

All the facilities included in the database are listed at the opening page (see Fig. 2) where it's possible to select one particular laboratory from the list of all laboratories in a region. Under select region or counties

we find the buttons for Eastern Europe, Far East, Latin America, Middle East and South Asia, N/A, North America, South East Asia and the Pacific and Western Europe. We find the associated countries under the continent link. The selection of continent/countries is linked to the various PIE techniques by the Select Technique Query drop list. In this drop list it is possible to choose either all techniques or only one distinct technique from those that are listed in alphabetic order. A database user has the possibility to check which laboratories are performing for instance neutron radiography in Western Europe by first selecting neutron radiography in the Select Technique Query list and then selecting Western Europe. Then all laboratories in Western Europe that are performing neutron radiography will be listed under the facility name column. The number of destructive and non-destructive PIE techniques, continent and country information are included for the various facilities. Listing of techniques linked to the specific laboratories is possible without extra navigations because the searching tools are always displayed at the left corner of the database interface. A user must only choose technique and continent from the searching tool to list this information. The home, help and about buttons can also be reached without extra navigations, i.e. these links or "hand tool" buttons are always displayed in the title bar at the upper part of the database interface.

The database consists of five main areas or topics related to the PIE facilities and techniques: general/cell characteristics; acceptance criteria for irradiated components; available techniques; refabrication and instrumentation capabilities; and storage and conditioning capabilities. Selecting a specific facility leaves the general/cell characteristics topic active and the other four topics inactive. The general topic supplies facility name, the country where the facility is located, contact persons, phone and fax numbers, e-mail address, and the hyperlink to the company/laboratory web page. The cell characteristics topic explains the main purpose of the facility, e.g. the specific materials that are examined in the laboratory. The number of cells and information of gamma activity limits for the concrete, steel and lead cells are supported. The dimension of largest cell and the maximum fuel rod length that can be handled in the laboratory are also given under this topic. And last, there is information about the maintenance procedure, i.e. if it is scheduled or not. The general/cell characteristics details for IFE/HRP hot laboratory are presented in Fig. 3.

Activation of the acceptance Info topic gives information about acceptance type and condition, e.g. fuel rods, assemblies or structural components have to be received at the hot lab facility in dry condition. Transfer mode, maximum cask length and weight are given to support information in relation to external transportations to the facilities. Maximum fuel enrichment and fissile weight, failed rod acceptance and eventual protection packing are also included under this topic. There is also a comment field for inclusion of additional information on the acceptance info detail page that is seen in Fig. 4.

The main difference between the PIE catalogue (released in 1995) and the PIE database is the description of the PIE techniques. Only the names of the actual PIE techniques utilized at the respective facilities were given in the catalogue, while essential technical PIE details are implemented in the new database. There are several predefined fields for detail descriptions of the different PIE methods in the IAEA database. The field layouts are similar for all the different PIE methods that could be selected under the topic of available techniques. This is to ensure a uniform structure of the database. With the adoption of a uniform database format for all laboratories and details of techniques, it is hoped that the IAEA Member States will be able to use the database to select laboratories most relevant to their particular needs. The database can also be used for comparison of PIE capabilities worldwide with current and future requirements. It is possible that the publishing of the database also will provide an incentive for laboratories with limited PIE techniques to increase and improve their own capabilities.

To retrieve information about the different PIE techniques for a specific facility it is necessary to activate the topic of available techniques. A drop list of all DE and NDE techniques will appear under "name of the technique" column (seen in Fig. 5) after choosing a given facility. The next user action will be to activate or double click on one of the techniques to get access to technical details. Easy access to other PIE techniques utilized at the chosen facility is performed by first using the backwards button and then double clicking at the new technique. After this action, the detailed information about the selected PIE technique will be shown in a new window. All detailed information for the PIE techniques is presented with a uniform format, i.e. the description field is the same for all techniques. The type of technique is given in the description, i.e. DT or NDT. This means that each technique is either DT or NDT. There is a field that gives a short description of the techniques. One example of text in the description field under neutron radiography examination can be that neutron radiography is applied on irradiated/non-irradiated fuel rod internal components and material test samples. The "form of data presentation" field gives the format of the prepared data acquired under PIE, e.g. digital images and graphs. This is important information since

it influences the dataflow between the facility and the customer, e.g. digital images are possible to exchange by e-mail immediately after data acquisition while analogue images must be sent by traditional post. There are additional fields for general comments, references (i.e. scientific presentations and articles), equipment (e.g. nuclear reactor, tensile machine, and balance), standards (e.g. weight standards) and test parameters. The decision to choose what content is to be given in the "comment" field is up to the facility staff involved in the description of the techniques. The test parameters are normally related to the ambient conditions under which the examinations are executed, e.g. sample temperature, atmospheric pressure and amount and strength of HNO3 + HCL acid. PIE details for type of specimen (e.g. UO_2 fuel, absorber materials), measured parameters (e.g. LVDT signal, pressure drop), calculated parameter (e.g. diameter, densification) and features (e.g. measurement accuracy, microscope magnifications, etc) are given in the respective fields of the various PIE techniques. Fig. 6 gives an example of PIE details description for density measurements of fuel pellets.

Refabrication/instrumentation possibilities and details are given under more general field descriptions, e.g. fuel centre-line thermocouple, de-fuelling, welding of instrumented endplugs and pressurisation/leak testing. Further information can be given here, e.g. interior of rod is frozen during drilling of centre line hole to ensure that fuel structure is preserved. A similar example of refabrication/instrumentation topic is given in Fig. 7.

The last topic included in the PIE database is about storage & conditioning. Fields for description in relation to intermediate and long term storage and connection to reprocessing plants are implemented. There is a general reference field and also one for description of encapsulation purposes, e.g. in relation to reinsertion of fuel rod. The storage & conditioning details for LHMA-SCK-CEN hot laboratory are seen in Fig. 8.

Conclusion

The PIE database was successfully implemented under the IAEA Integrated Nuclear Fuel Cycle Information System (iNFCIS) early in 2004. The number of visitors that have utilized the IAEA PIE facility database was 621 in February, 484 in March, 629 in April, 472 in May and 223 in June 2004.

The success of the new database depends mainly on the quality of data that IAEA have received from the hot laboratories, e.g. the technical description of the PIE methods and laboratory equipment. The data transfer between the IAEA and the laboratories was arranged by using Microsoft Access software. All relevant laboratories have received an Access template with user instructions included for filling out the PIE data and sending it back to the IAEA. The Access template was not always easy to use according to feedback from some of the hot labs. Some laboratories had problems related to data input through the Access software. Delivering of proper or updated PIE data was sometimes not fulfilled, and some general "Access" user related problems were also reported. These problems should be avoided by utilizing a data input system directly connected to the IAEA PIE database, i.e. the staff of a given PIE facility should be able to modify the information in their PIE facility database directly online through the IAEA PIE web site by utilizing a suitable password protected login procedure. The implementation of the "interactive" data input mode would ensure that the database should develop in a more flexible manner with a minimum of cost and work for both the IAEA and the hot lab facilities. The updating of the IAEA PIE facility database with this new input mode will be performed during 2005.

A similar PIE facilities database is under construction at the LHMA-SCK-CEN hot laboratory in Belgium. However, this database is only implemented with the PIE facilities of European countries. But, the database will be open to everybody and it will be in use during 2005. The work is sponsored under the European Sixth Framework Programme and European Hot Laboratories Research Capacities and Needs. The two databases should develop in a similar manner to ensure maintenance compatibility. Also, some cross references/hypercouplings should be implemented in both databases to make it easy to access information for customer users.