IAEA efforts to improve nuclear power plant operational safety

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Efforts to enhance the operational safety of nuclear power plants consume many hundreds of millions of dollars and thousands of man-years annually around the world. However, most of this work on research and development, studies and reviews, regulation and standards setting is performed in the half-dozen or so advanced Member States which supply nuclear power technology to all the others. The developing countries, on the other hand, cannot devote huge resources to nuclear safety programmes, and they therefore depend on their suppliers for much of this technology. It is in the area of transferring nuclear safety technology to the developing countries that the Agency can be very effective.

The accumulated operating experience of civilian nuclear power plants is currently approaching 3000 reactor-years. Many consider the safety record of the nuclear industry to be superior to that of any other having a comparable hazard potential. Even the most publicized accident – at Three Mile Island – resulted in additional radiation exposure of the general public only a small fraction of that received in one year from natural sources. Although the excellent safety record achieved by the commercial nuclear power industry derives from the combined dedication of researchers, designers, manufacturers, constructors, and regulators, the operating organization is ultimately responsible for the safety of the plant, the general public and the environment. A typical nuclear power plant may have two or three hundred people involved in its daily functioning. Of these, perhaps only five dozen are directly involved with operating the plant hardware; the others carry out vital support functions, such as health physics monitoring, electrical and mechanical maintenance, control of plant chemistry, planning and scheduling, quality assurance, training, and on-going operations analysis.

Background

At the beginning of 1983 there were nearly 300 nuclear power reactors supplying electricity in 25 countries (see Table 1). The electrical generating capacity represented by this investment amounted to almost 174 thousand megawatts, more than 8% of the world's total capacity. By 1985, electricity generated by nuclear power is expected to account for about 17% of the total electricity generated world wide. During the years 1983 to 1987, 200 new units with an installed capacity of nearly 185 thousand megawatts are expected to begin operation.

As may be seen in Table 1, there were 21 units operating in developing countries on 1 January 1983; the number will more than double during the next five years. This will present a challenge to the nuclear community, not only because of the sheer number of new plants, but because operational safety has many facets. One set of problems arises from the inherent complexity of any particular nuclear power plant. Another stems from the fact that a variety of quite different reactor types – pressurized-water reactors, boiling-water reactors, pressure-tube reactors and gas-cooled reactors – have been developed by various vendors.

Further, these design types have been modified through the years in response to lessons learned from experience, the trend to larger capacities, and evolving safety requirements. The result has been not only a variety of designs, but variation in safety approaches adopted in various countries, and differing engineering safety features, containment buildings, siting policies and so on. Difficulties can arise even when a reactor type has become well-established. Since a typical plant takes anywhere from six to twelve years to build, the completed plant may not conform to all the safety requirements that evolved during its construction. Then the question of backfitting the plant and updating its operating procedures must be faced. This is also true, of course, for plants completed some time ago, which have been operating for a relatively long time.

Because the operation of nuclear power plants is so central to safety, and because in the mind of the public nuclear reactor operation poses one of the more serious questions regarding health and environmental quality, the IAEA has for many years supported programmes aimed at strengthening the operational safety of nuclear power plants. It has done this in three ways: by developing Safety Standards and Guides, by sponsoring vehicles for information exchange, and

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Table 1. Operating nuclear power plants, January 1, 1983

Country	Year operation commenced					Total capacity (MWe)	Additional operating units expected, 1983–87	
	Before 1968	1968–72	1973–77	1978–82	Total		Number of units	Capacity (MWe)
Developed countries								
Belgium	1	–	3	2	6	3 463	2	2 012
Canada	2	4	4	4	14	6 686	8	5 064
Finland	–	–	1	3	4	2 160	–	–
France	5	3	3	21	32	23 355	26	28 940
German Democratic Republic	1	–	3	1	5	1 694	7	2 868
Germany, Federal Republic of	3	3	4	5	15	9 831	9	9 411
Italy	2	–	–	1	3	1 232	2	1 964
Japan	1	4	10	10	25	16 589	11	10 289
Netherland	–	1	1	–	2	501	–	–
South Africa	–	–	–	–	–	–	2	1 842
Spain	–	3	–	1	4	1 973	12	11 156
Sweden	–	1	5	4	10	7330	2	2 110
Switzerland	–	3	–	1	4	1 940	1	942
United Kingdom	24	3	4	1	32	6 470	8	5 066
United States of America	6	19	39	16	80	62 376	55	60 368
USSR	10	4	13	13	40	17 876	22	22 420
TOTAL	55	48	90	83	276	163 476	167	164 452
Developing countries								
Argentina	–	–	1	–	1	335	2	1 291
Bulgaria	–	–	2	2	4	1 632	2	2 000
Brazil	–	–	–	1	1	626	1	1 245
Cuba	–	–	–	–	–	–	1	408
Czechoslovakia	–	–	–	2	2	762	8	3 354
Hungary	–	–	–	1	1	408	3	1 224
India	–	3	–	1	4	809	4	880
Korea, Republic of	–	–	1	1	2	1 193	6	5 284
Mexico	–	–	–	–	–	–	2	1 308
Pakistan	–	1	–	–	1	125	–	–
Philippines	–	–	–	–	–	–	1	620
Romania	–	–	–	–	–	–	1	660
Taiwan	–	–	–	4	4	3 110	2	1 814
Yugoslavia	–	–	–	1	1	632	–	–
TOTAL	–	4	4	13	21	9 632	33	20 088
GRAND TOTAL	55	52	94	96	297	173 108	200	184 540

Source: IAEA Power Reactor Information System.

by providing various advisory services. Two relatively new programmes have led to the establishment of Operational Safety Review Teams, and of the Incident Reporting System.

Safety standards, information exchange, and advisory services

The Agency has been active since its inception in developing safety standards in the nuclear field. The major IAEA publications relevant to the operation of nuclear power plants are the Basic Safety Standards for Radiation Protection (Safety Series No.9); and the Nuclear Safety Standards (NUSS) documents on operations (a part of Safety Series No.50). The former deals with the dose-limitation system for occupationally exposed persons and the general public and is based on recommendations of the International Commission on Radiological Protection (ICRP). The latter consists of a Code of Practice and eleven Guides that set out the basic requirements for ensuring the safe operation of nuclear power plants. These deal with safety aspects such as staffing, in-service inspection, operational limits, and effluent control.

One of the most effective ways of improving operational safety is by a continual exchange of information and operating experience. At conferences, symposia, seminars, workshops and technical meetings Member States can constantly update their knowledge of current safety trends and techniques. Safety technology transfer is encouraged also by training courses and fellowships offered to qualified personnel from developing countries. Every year a number of professionals from developing countries are sent to advanced Member States for periods ranging from a month to a year to receive "hands-on", on-the-job training by working on simulators, at laboratories, in industry or in a regulatory agency.

Perhaps the Agency's most direct effort to enhance operational safety is through its advisory services, principally in the form of missions to regulatory authorities, utilities and their consultants. Safety missions on the five aspects of NUSS – governmental organization, siting, design, operation, and quality assurance – visit countries which request assistance. In addition to these general missions, there are also very specialized missions on safety-related subjects to assist Member States with particular problems. Such missions have evaluated steam generator vibration, implemented computer codes, advised on emergency preparedness planning and reviewed technical specifications for a plant. A recent mission to assess the operational safety of a plant as it was being brought up to full power and being turned over from the vendor to the utility was so helpful to the requesting government that it was decided to use this as a pattern for a regular Agency service.

Operational Safety Review Teams

During the 1982 General Conference of the IAEA the Director General announced the availability of a new Agency service, the Operational Safety Review Team (OSART). Under this service, a team of experts will be sent to a Member State which requests it to review the status of a plant and to assess its ability to continue operating safely. A number of requests have already been received from Member States and two or three reviews will be performed in 1983. It is anticipated that when the programme matures, within the next few years, four to six reviews will be conducted annually.

Each OSART will consist of two or three staff members and three or four external consultants with long experience in nuclear power plant safety. The experts will vary from team to team depending on the type of plant being reviewed. The service will be available only to the regulatory authority of a Member State and will act independently of the utility, its consultants, its contractors and suppliers.

The team's advance preparation will be based on the results of the comprehensive safety review and assessment already performed as a prerequisite for licensing the plant. This information should serve as the best introduction to the plant's safety features. It will be supplemented by other relevant documentation related to the plant's operating history, operating procedures, organization, and personnel qualification. The on-site review, which will last about three weeks, will include examination of the plant's documentation, observation of procedures, and discussion with operating personnel.

The following main areas, considered decisive for operational safety, will be sampled thoroughly:

1. Managerial aspects – organizational structure, personnel qualification programmes, quality assurance, document control, safety approach and attitudes.
2. Training programmes – training organization, facilities and equipment for all levels of plant personnel.
3. Operating procedures – for normal and abnormal plant conditions, past operating history, documentation, and tagging procedures.
4. Technical support – engineering and technical groups involved in surveillance, plant modifications, operating experience review, engineering analysis, etc.
5. Maintenance – maintenance organization, procedures and controls, documentation, equipment, and history.
6. Radiation protection – control of contamination, radioactive waste treatment, effluent control, environmental surveillance, employee radiation protection, organizational and administrative controls, and training.
7. Plant chemistry – water chemistry, laboratory activities, instrumentation, waste handling, training and qualification.
8. Emergency preparedness – responsibilities of the operating organization to prepare for nuclear emergencies, both on-site and off-site, including liaison with public authorities.

When the review has been completed, the team will return to Agency headquarters to write its report. This will be submitted through official channels to the government of the requesting country for its exclusive use. The report will contain a variety of findings. An example of the type of detail which might be included in the team's findings is shown in the Box. (This information was taken from a report prepared by the Institute of Nuclear Power Operations, INPO, in the United States. The OSART reviews will be modelled initially on INPO procedures.)

The OSART service is still in a developmental stage. As experience is gained, during coming months, the team's mode of operation will become better defined and guidelines will be established for future use.

Sample Detail of a Safety Review Team's Findings

RADIOACTIVE CONTAMINATION CONTROL

PERFORMANCE OBJECTIVE: Radioactive contamination controls should minimize the contamination of areas, equipment, and personnel.

Team finding:	Personnel are not required to frisk after exiting posted low-level contaminated areas. This could result in low-level contamination of personnel not being detected.
Recommendation:	Establish requirements for performing whole-body frisking after exiting posted contaminated areas with removable surface contamination levels greater than 1000 dpm/100 cm^2.
Company response:	The plant history and policy of maintaining low contamination levels minimizes the likelihood of personnel contamination that would be detectable with conventional frisking techniques. The Gamma-10 portal monitors used are more effective than friskers in determining contamination spread over an area, as opposed to single spots of contamination. Experience has shown that the likelihood for personnel contamination significantly increases when area contamination levels are above 10 000 dpm/100 cm^2. Therefore, we have required frisking when exiting these areas. Our history of personnel contamination and whole-body counting results indicates the present programme to be satisfactory.
Comment:	The present frisking policy that requires personnel to perform a whole-body frisk at the exit of posted contaminated areas only if removable surface contamination levels are greater than 10 000 dpm/100 cm^2 is not consistent with best industry practices. Experience indicates that the majority of skin contaminations in the industry are single spots in the range of 3000–5000 dpm/100 cm^2 that are not detectable by the most sensitive portal monitors currently available.

Source: INPO 1982 Evaluation.

IAEA Incident Reporting System

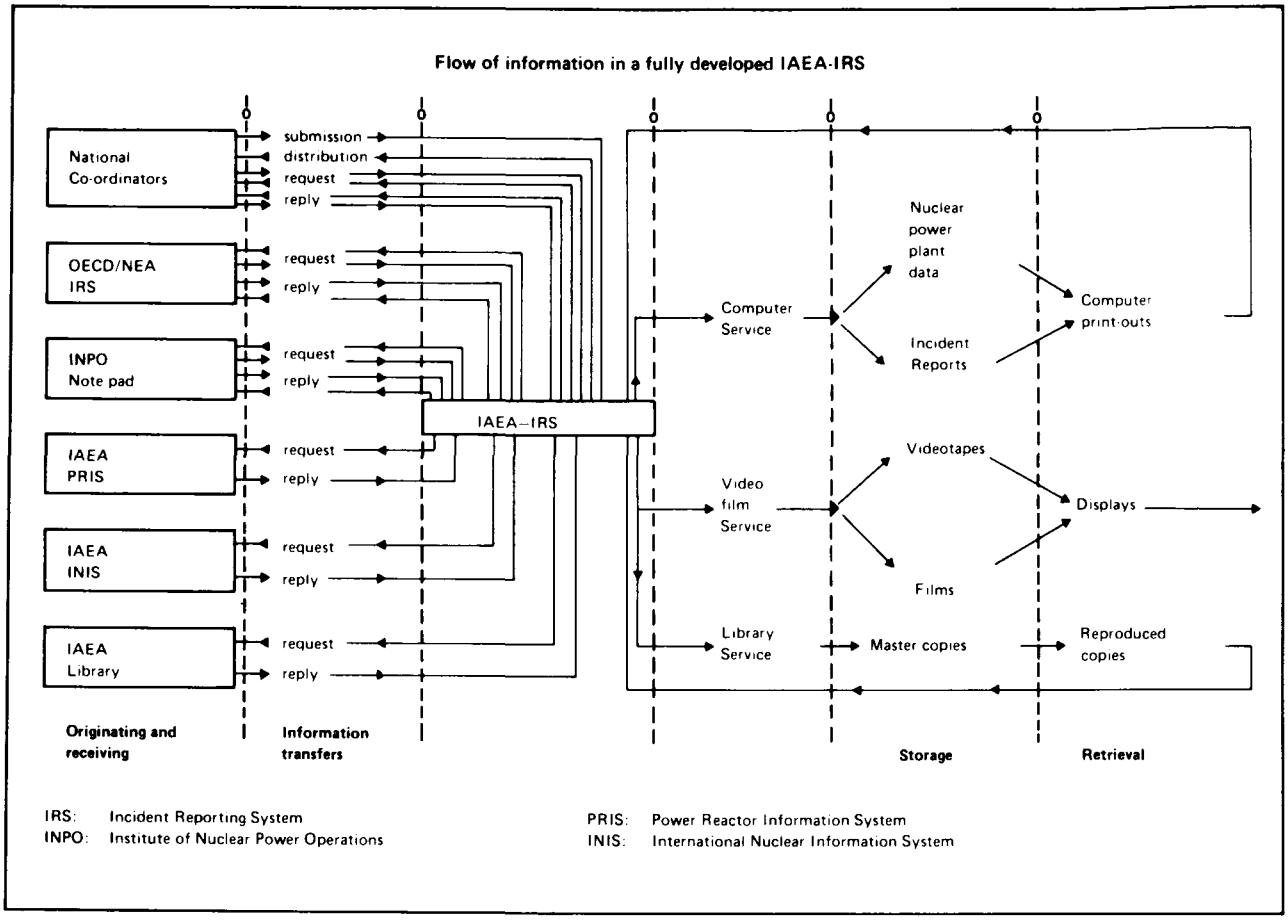
As the investigation into the accident at Three Mile Island made clear, there is a wealth of safety-related information buried in the operating history of the world's nuclear power plants. Unusual events, when analysed within the context of the environment of a specific plant, can highlight general weaknesses in design, construction, and operation. The Agency believes that all Member States with nuclear power plants can benefit from an international exchange of information on nuclear power plant incidents. Since many countries require their operating organizations to report safety-related events to their national regulatory authorities already, the Agency sees its role as that of developing an Incident Reporting System (IAEA-IRS) which will harmonize with national systems, to collect, review, store, and disseminate information on a world-wide basis (see Figure).

Last year, arrangements for the IAEA-IRS were proposed and discussed, and information on them was distributed to Member States. In addition, a Guide on National Reporting Systems was produced and published as a working document. During 1982, the first meeting of the Technical Committee for Assessment of Incidents in Nuclear Power Plants was held in Madrid, and in April of this year official invitations to participate in the IAEA-IRS were sent to Member States.

Because many unusual events occur in nuclear power plants every year, the crucial problem is to select those few that may be significant to safety and of interest to the international community. The Agency has established eight reporting categories, patterned after the incident reporting system developed by the Nuclear Energy Agency (NEA) of the OECD, to identify such events. These are as follows:

1. Exposure to radiation or release of radioactive material.
2. Degradation of items important to safety (structures, systems, components).
3. Deficiencies in design, construction, operation, and quality assurance.
4. Generic problems (recurring events which, taken together, have implications for other similar plants).
5. Significant consequential actions (actions taken by the regulatory body as a result of reported events).
6. Events of potential significance to safety (those during which a protection system operates unnecessarily, or fails to actuate when required).
7. Unusual events, of either man-made or natural origin, that directly or indirectly threaten the ability of the plant to operate safely.
8. Events which, although they have no safety significance, attract significant public interest.

As is true for other aspects of operational safety, regular meetings are also important for reviewing events of interest to the international community. Recommendations which may arise from these periodic review meetings are likely to be those with general applicability to large numbers of nuclear power plants and to many operating and regulatory organizations.



One important problem that may be difficult to overcome is the identification of those events that are not significant individually, but which taken together indicate that a problem of safety significance exists. Reliance will initially be placed on participants identifying such events in accordance with their national systems and alerting the IAEA, so that other countries can be informed. All events which might be precursors to serious incidents must be scrutinized carefully, and sharing of this information among Member States could be especially helpful.

It is believed that world-wide participation in the exchange of information on unusual events with safety significance would make a valuable contribution to safety, particularly if the causes are analysed and the lessons learned are disseminated adequately. The IAEA-IRS can be an essential aid in accomplishing this objective.