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CSNI Specialist Meeting on Operator Training and Qualifications

Charlotte, N.C., USA / October 12-15, 1981

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CSNI Specialist Meeting
on
OPERATOR TRAINING
AND QUALIFICATIONS

Charlotte, N.C., United States
12-15 October 1981

Co-sponsored with the
UNITED STATES NUCLEAR REGULATORY COMMISSION
and the
INSTITUTE OF NUCLEAR POWER OPERATIONS

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PROCEEDINGS

Volume 1

Committee on the Safety of Nuclear Installations
OECD Nuclear Energy Agency
38, boulevard Suchet
75016 Paris
France

Nuclear Energy Agency
of the
Organisation for Economic Co-operation

The Nuclear Energy Agency (NEA) is a specialised Agency of the Organisation for Economic Co-operation and Development (OECD) in Paris. The NEA committee on the safety of Nuclear Installations (CSNI) is an international committee made up of scientists and engineers who have responsibilities for nuclear safety research and nuclear licensing. The Committee was set up in 1973 to develop and co-ordinate the Nuclear Energy Agency's work in nuclear safety matters, replacing the former Committee on Reactor Safety Technology (CREST) with its more limited scope.

The Committee's purpose is to foster international co-operation in nuclear safety amongst the OECD Member countries. This is done essentially by:

i. exchanging information about progesss in safety research and regulatory matters in the different countries, and maintaining banks of specific data; these arrangements are of immediate benefit to the countries concerned.

ii. setting up working goups of task forces and arranging specialist meetings, in order to implement co-operation on specific subjects, and establishing international projects; the output of the study groups and meetings goes to enrich the data base available to national regulatory authorities and to the scientific community at large. If it reveals substantial gaps in knowledge or differences between national practices, the Committee may recommend that a unified approach be adopted to the problems involved. The aim here is to minimise differences and to achieve an international consensus wherever possible.

The main CSNI activities cover particular aspects of safety research relative to water reactors and fast reactors; probabilistic assessment and reliability analysis, especially with regard to rare events; siting research; fuel cycle safety research; various safety aspects of steel components in nuclear installations; and a number of specific exchanges of information.

Institute of Nuclear Power Operations

The Institute of Nuclear Power Operations (INPO) is a non-profit, independent organization created in 1979 by the nuclear utility industry. INPO is dedicated to promoting safety in operations in nuclear power plants.

Every U.S. utility with an operating license, a construction permit or a limited work authorization for a nuclear power plant is a member of the Institute. INPO's membership is broadened further with the inclusion of utilities that are co-owners of nuclear power plants. Participation is also extended to non-U.S. nuclear organizations and to domestic nuclear suppliers and engineering firms.

INPO was founded to assist nuclear utilities in achieving a high level of excellence in safety of nuclear power operations. Offices are located in Atlanta, Georgia.

OECD

INPO

NRC

The CSNI Specialist Meeting on Operator Training and Qualifications Proceedings have been printed in two volumes. Volume I contains the conference agenda, introductory remarks, and proceedings of Sessions I and II. Volume II contains proceedings of Sessions III-VI, the Program Group, and the List of Participants.

Additional copies may be obtained by writing the Institute of Nuclear Power Operations, 1820 Water Place, Atlanta, Georgia 30339.

VOLUME I

Table of Contents

CSNI SPECIALIST MEETING ON OPERATOR TRAINING AND QUALIFICATIONS

SUNDAY, OCTOBER 11

4:00 p.m.	**Registration**
6:30-8:00	**Reception**

MONDAY, OCTOBER 12

9:30 a.m.	**Opening Remarks** J. Kramer, Deputy Director Division of Human Factors, NRR United States Nuclear Regulatory Commission E. P. Wilkinson, President Institute of Nuclear Power Operations K. B. Stadie, Head Nuclear Safety Division OECD Nuclear Energy Agency **International Collaboration to Improve Operator Qualifications** **Session I - National Approaches and Practices** **Chairman** E. L. Zebroski - United States **Assistant Chairman** P. M. Lienart - France
10:00	**Training of PWR Operators in Electricite de France** J. J. Mira and J. J. Martin - France
10:35	**On- and Off-site Training of Technical Staff in the UK Nuclear Power Stations** P. B. Myerscough - United Kingdom
11:10	**Break**
11:30	**The Picket Engineer Concept in Swiss Nuclear Power Plants** W. Steffen - Switzerland

12:05 p.m.	**Philosophy, Practices and Experience in Operator Training and Licensing in Finland** M. Friberg, J. Laaksonen and L. Reiman - Finland
12:40	**Lunch**
2:00 p.m.	**Operator Training and Qualifications in the Netherlands** C. J. Lobbezoo - Netherlands
2:35	**The Nuclear Power Plant Operator- A Safety Barrier: Regulatory Requirements in the Federal Republic of Germany** J. B. Fechner - Federal Republic of Germany
3:10	**Experience Gained in Spain in Licensing Reactor Operators** A. Alonso, R. Gutierrez and P. Villajos - Spain
3:45	**The U.S.N.R.C. Perspective on Operator Training and Qualifications** J. J. Persensky et al. - United States
4:30	**Break**
4:50	**Panel Discussion** Chaired by E. L. Zebroski - United States
6:00	**End of Session I**
6:30-8:00	**Cocktails**

TUESDAY, OCTOBER 13

	Session II - Training **Chairman** A. Alonso - Spain
	Assistant Chairman A. M. Mangin - United States
8:30 a.m.	**Training Centre in Reactor Physics at the Grenoble Nuclear Research Centre** M. Destot - France

9:00	**The Role of INPO in Improving Training in the U.S. Nuclear Power Industry** A. M. Mangin - United States
9:30	**Academic Training for Nuclear Power Plant Operators** D. W. Jones - United States
10:00	**A Program to Improve Educational Qualifications of Reactor Site Technical Personnel** J. M. Christenson and L. E. Eckart - United States
10:30	**Break**
11:00	**Operator Training and Requalification at GPU Nuclear** R. L. Long, R. J. Barrett and S. L. Newton - United States
11:30	**Training and Requalification of Operation Personnel for RWE Nuclear Power Plants** K. Distler and D. Kallmeyer - Federal Republic of Germany
12:00	**Accountability in Power Industry Training** R. C. Evans - United States
12:30 p.m.	**A Command Role - Stress Decision Program** H. J. Worsham and J. L. French - United States
1:00	**End of Session II - Lunch**
	Session III - Simulators **Chairman** P. O. Myerscough - United Kingdom **Assistant Chairman** G. M. Grant - United States
2:00	**Implementation of a Basic Principle Simulator** J. F. deGreef - Belgium
2:30	**Application of Compact Simulators in Training Programs** P. E. Blomberg - Sweden

3:00	**Improvements in Simulator Training for PWR** E. Lindauer, M. Simon and D. Reppmann - Federal Republic of Germany
3:30	**Break**
4:00	**Training Simulators - Major Issues Remain** G. M. Grant - United States
4:30	**Advanced Techniques for Real Time Simulation of Reactor Loss of Coolant Accidents** F. C. Luffey, J. H. Murphey and J. R. Hill - United States
5:00	**End of Session III**
7:00	**Cocktails**
7:30	**Banquet** Address by Mr. William S. Lee, President Duke Power Company

WEDNESDAY, OCTOBER 14

	Session IV **Selection and Requirements** **Chairman** J. B. Fechner - Federal Republic of Germany **Assistant Chairman** R. L. Wilson - United States
8:30 a.m.	**A Method for Operator Competence Development in Nuclear Power Plants** J. Wirstad and H. Andersson - Sweden
9:00	**Plant Operator Selection Battery - A New Procedure to Aid in Evaluating Employment Candidates for Electrical Power Plant Operating Positions** M. D. Dunnette - United States
9:30	**Human Factors Society Study Group Progress Report** R. C. Sugarman and R. R. Mackie

10:00	**The Associate Degree in Nuclear Engineering - What Does It Offer to the Training of Reactor Operators** A. J. Baratta, J. L. Penkala and W. F. Witzig - United States
10:30	**End of Session IV - Break**
	Session V - Performance Measurement **Chairman** R. M. Koehler - United States
	Assistant Chairman J. R. Hale - United States
10:45	**Human Factors Research Using the EPRI Performance Measurement System** E. J. Kozinsky - United States
11:15	**Safety-Related Operator Actions in Nuclear Power Plants** P. M. Haas and T. F. Bott - United States
11:45	**A Report on the Pilot Test to Determine the Feasibility of Implementing the Comprehensive Occupational Data Analysis Program (CODAP) for the Nuclear Power Industry** J. R. Hale - United States
12:15 p.m.	**Analytical Techniques for Creating a Job Design Basis for a Nuclear Power Plant Operating Crew** D. J. Shea - United States
12:45	**End of Session V - Lunch**
	Session VI - Human Factors Aspects **Chairwoman** A. Carnino - France
	Assistant Chairman S. San Antonio - Spain
2:00	**Evaluating Human Reliability in the Execution of Routine NPP Tasks - Designing Procedures to Improve It** A. Carnino and M. Stephens - on behalf of a CSNI Group of Experts

2:30	**Advanced Diagnosis Graphics** M A. Bray and O. R. Meyer - United States
3:00	**Patterns of Shift Work in the Power Industry: The Need for Circadian Chronohygiene in Bioengineering at the Man-Machine Interface** C. F. Ehret and A. L. Cahill - United States
3:30	**Implementation of an Automated Status Analysis System in an Operating Nuclear Power Plant** J. Christenson, T. Graae and H. Roggenbauer - OECD Halden Reactor Project, Sweden and Austria
4:00	**End of Session VI - Break**
4:15	**Panel** chaired by K. B. Stadie - (OECD) "The Future: Man's Role in the Nuclear Power Plant"
5:00	**End of Formal Sessions**

THURSDAY, OCTOBER 15

8:00	**Technical Visit at the Invitation of the Duke Power Company:** **R. M. Koehler - Manager, Technical Training Services - Duke Power** **Introductory Presentation on Duke Power Company and its Operator Training Practices** **Tour of the McGuire-2 Nuclear Power Plant - Turbine & Reactor Buildings** **Tour of the Duke Power Training Simulator Facility**

INTRODUCTION

The events during the accident at TMI-2, along with others identified in retrospect at other nuclear plants, re-emphasized the critical role of the reactor operator. Many countries are focusing greater attention on the capabilities of control room operating staff and on the problems they face.

In view of the importance to safety of the subject, the CSNI Subcommittee on Licensing decided in November 1979 that a specialist meeting should be held on the broad aspects of operator selection and training and the functions and organization of operating staff. After CSNI endorsed the proposal, arrangements for it were undertaken in collaboration with the United States Nuclear Regulatory Commission and the Institute of Nuclear Power Operations.

The meeting focused on the following specific topics:

1. functions, role, and organization of control room personnel as a crew and as individuals (including job function descriptions and methods of analysis, basis for manning, abnormal conditions)

2. selection and qualifications of personnel (including psychological requirements, technical requirements, criteria development)

3. operator training and requalification (including use of simulators, skill development, and knowledge procedure training)

4. evaluation of crew and individual performance (including performance measurements, knowledge and procedure testing, circadian desynchronization)

5. professional and career alternatives for control room personnel (including standardization, career pathways)

6. "concepts for the future" (e.g., implementation and impact of computer technology, advanced simulator concepts, off-site monitoring and support)

In the event, there were 103 participants from 14 countries and 3 international organizations. A panel discussion on the first afternoon discussed current approaches and practices in several NEA countries. A second panel, on the third afternoon, debated the more general question of the role of the human in power plant control rooms in the future.

On the second evening, the participants were addressed by Mr. William S. Lee, president of the Duke Power Company, and visited the company's McGuire-2 Nuclear Power Station and Training Center on the fourth day.

REMARKS OF JOEL KRAMER

U. S. NUCLEAR REGULATORY COMMISSION

Good morning, ladies and gentlemen. On behalf of the Committee on the Safety of Nuclear Installation of the OECD Nuclear Energy Agency in Paris, the Institute of Nuclear Power Operations, and the United States Nuclear Regulatory Commission, I am pleased to welcome you to the United States; Charlotte, North Carolina; and our truly international CSNI Specialist Meeting on Operator Training and Qualifications.

At dinner last night with Mr. Stadie, it occurred to me that having our meeting begin on such a special day as Columbus Day brings added significance to our important work over the next three and one-half days, because without the efforts of the forefathers of our friends and colleagues, who are here with us from Europe today, we would not be here.

I would like to spend a few moments to thank the many people who have made significant contributions to the program that you see before you.

To my meeting vice chairmen, Bob Smith and Michael Stephens, who share things across the ocean, and to the other members of the program committee and meeting coordinators - A. Carnino, J. B. Fechner, K. L. Rawley, P. M. Lienart--without their efforts and long hours of work, this meeting would not have been

possible. Most of all, I would like to thank the authors and presenters of the papers you see in the program. The six paper sessions and several panel discussions aim right at the heart of important national and international nuclear power plant issues concerned with operator training and qualification. We at the NRC strongly endorse and support work in these areas and believe that this meeting will enable a better understanding of the complex technical challenges that lie ahead of us in these areas.

I would now like to introduce Mr. E. P. (Dennis) Wilkinson, president of the Institute of Nuclear Power Operations. As the former commander of the U.S.S. Nautilus and now as president of INPO, I can think of few other people as energetic, enthusiastic and dedicated to excellence in the safe generation of nuclear power.

REMARKS OF E. P. WILKINSON
INSTITUTE OF NUCLEAR POWER OPERATIONS

I join Mr. Kramer in welcoming you to this meeting on operator training and qualifications. The Institute of Nuclear Power Operations, INPO, is honored to be co-sponsoring a conference that has attracted so many top-notch participants.

We all have an important mission to accomplish: international cooperation to improve qualification of nuclear operators. Obviously this meeting alone will not do that. The process of sharing knowledge and experience and putting that to good use must be on-going. The leadership and experience found in all nuclear utilities--regardless of national boundaries, plant design, governmental or other differences--must be tapped if the future of the nuclear power industry is to be ensured.

Since I came to INPO early in 1980, I have had the opportunity, at 42 different nuclear stations, to talk with nuclear personnel at all levels from the operators to the chief executive officers.

I have found that one of the most serious problems facing the industry in the United States today is the lack of an adequate number of properly trained operators and supporting work force. Through INPO's international contacts, we are getting the

same message--the manpower problem is a worldwide problem, and it threatens the safety and therefore the viability of the technology.

This disturbs me. I have seen nuclear facilities that are the Taj Mahals of the industrial world. I have seen companies spend $1 billion--or $2 billion--or even more--to produce a marvelous facility capable of safely and economically producing electricity for generations but, unfortunately, with no accompanying action to provide a trained force to man it.

There is much work to be done to correct this situation. Each operating organization needs to make a strong commitment to training--a commitment requiring many of you to make available more resources, manpower, and facilities for training than is currently the case.

You who are involved with training in the nuclear industry can help ensure that we have the qualified people required. To do this, we all have something to offer--we all have something to learn. A wise man once said the more you learn, the more you find out you don't know. That is especially true in this business of training and qualifying people. No one country, no single organization, has all the solutions for improving operator training. That is why we must work together. That is why this type of meeting is so important. This meeting is another step in the right direction.

At INPO, we intend to demonstrate that sharing information on an international scale can be of benefit to all. And as more operating experience is gained, an even greater data base will be available for information exchange. INPO will help to serve as a mechanism to distribute this knowledge.

Meetings such as this offer an excellent opportunity to exchange information that will help the nuclear industry world-wide to maintain safety in its operations. That is an important consideration for each of us today, so I welcome you and thank you for being involved at this meeting.

REMARKS OF K. B. STADIE

NUCLEAR SAFETY DIVISION

OECD NUCLEAR ENERGY AGENCY

Admiral Wilkinson, Mr. Kramer, Admiral Smith, ladies and gentlemen.

I am pleased to welcome you to the CSNI Specialist Meeting on Operator Training and Qualifications. This meeting is an important new venture for CSNI. It is the first time that the committee has provided a forum for the discussion of human factors in nuclear safety. Until now, CSNI specialist meetings have all been devoted to safety technology and regulatory questions.

This meeting is also the first attempt to broaden our circle of participants, which in the past has been limited to nuclear safety and licensing experts representing member governments. Thanks to the cosponsorship of the Institute of Nuclear Power Operations, we welcome experts from industry and, in particular, from operators of nuclear power plants. It seems to us that the topic of our meeting here in Charlotte is exceptionally well suited for and in need of an exchange of ideas between regulators and operators.

Ladies and gentlemen, I am certain that you will need no explanation about what NRC and INPO stand for, but I am less

certain that you are familiar with NEA, OECD, and CSNI, which play a major role in the organization of this meeting. I, therefore, should like to take a few minutes to briefly describe to you their objectives, particularly in regard to our meeting here.

The Committee on the Safety of Nuclear Installations, or in short, CSNI, is a permanent body of the OECD Nuclear Energy Agency in Paris. The committee consists of senior experts in nuclear safety technology and licensing from OECD member countries, which include all western European and countries, Canada and the United States, as well as Japan and Australia. The OECD countries - 23 in all - cooperate through CSNI to ensure a uniformly high level of nuclear safety in the OECD area. With this aim in mind, CSNI has developed a major collaborative program, which in addition to specialist meetings, such as this--by the way, this is its forty-second meeting--covers several information systems and shares safety research through a number of permanent working expert groups.

Particularly revelant to our meeting here is the CSNI group of experts on human error data and assessment. This group has recently developed a classification scheme for human error that is intended to render data being collected in several national incident reporting schemes more compatible, thus expanding our data base in this respect. The group also examines analytical methods used to determine the causes of man-induced incidents and

good practices in writing routine procedures. This guide will be presented in our meeting in Session 6 by Madame Carnino, chairman of this group.

The work of the Human Error Group closely relates to the CSNI Incident Reporting System, IRS, which has recently completed its two-year trial period. During this time, some 120 incident reports were exchanged between our member countries; many of these incidents had human causes. This system, which will now become permanent, has already led to safety improvements in several member countries based on the insights gained from incidents elsewhere, reported under the CSNI system.

Beyond these collaborative efforts, CSNI sponsors an operational program. This program consists on the one hand of preparing state-of-the-art reports that consolidate joint knowledge in areas of nuclear safety technology, and on the other, covers a series of international standard problem exercises. As these standard problem exercises are the most effective means of international collaboration within the CSNI program, I should like to describe them briefly to you. The objective here is to compare the diverse tools that we employ to assess the safety of nuclear installations. These tools may be complex computer codes, experimental facilities and their instrumentation, special measurement techniques, or methods for testing material. In these international standard problem exercises, these tools are gauged against one another and/or an agreed standard. There can

be no doubt that the method is highly effective in increasing the confidence in the validity and accuracy of these complex and vitally important tools. At present, CSNI is carrying out a series of ISPs on predicting the physical conditions in a water reactor during a LOCA and the performance of ECCS. Similar exercises are underway on reactor containment response during a LOCA, on modeling the consequences and dispersion of radionuclides following their release from an accident and on the critically codes used for assessing the safety of spent fuel transport cask. A similar kind of comparison is currently being conducted on ultrasonic non-destructive tests, carried out on a number of heavy steel plates from which reactor pressure vessels are fabricated. These sections, weighing between 4 and 20 tons, are shipped to 15 OECD countries where identical tests are performed. The test results will be compared with each other and with the information gained from cutting up these plates afterwards. These exercises will lead not only to more uniform testing, but also to improved safety.

Returning to the topic of this meeting, I will have the opportunity on Wednesday afternoon to moderate the final panel, which has the ambitious title "Man's Role in a Nuclear Power Plant." In order to prepare yourselves for this debate, we have distributed copies of a thought-provoking paper by Dr. Courvoisier, who has long been recognized in CSNI as the foremost nuclear safety philosopher. Dr. Courvoisier raises a number of fundamental questions, some of which you will have asked yourselves

before. At this point, I will only urge you to study this paper so that we may conclude our meeting with a far-reaching debate addressing some of the basic questions in this area, which I am afraid divide us at present.

Until then, I wish you an informative and interesting exchange of your experiences in selecting, training and licensing nuclear power plant operators.

To conclude, ladies and gentlemen, I would not want to vacate this spot before thanking both NRC and INPO for cosponsoring this meeting with CSNI and for having invited us to Charlotte. Our particular thanks are due to Mr. Smith and his collaborators at INPO, who have worked so hard to make this meeting a success from the administrative point of view. It will now be for you to make the meeting professionally rewarding.

Thank you.

Session I

Remarks of

Dr. E. L. Zebroski

A key ingredient to the safe operation of nuclear power plants is people. The Reactor Safety Study, Wash 1400 and the German Safety Study of a similar type, as well as some subsequent probabilistic risk analyses, all conclude that in some of the dominant sequences operator error can be 60-70 percent of the contribution to risk. This is especially so in sequences which involve severe damage to that plant. The training and selection of good people is obviously one of the main objectives for good power plant mangement.

Today there is an acute shortage of trained nuclear operating personnel in the United States, and a similar shortage is developing in many countries in the rest of the world. This shortage will even worsen as more and more plants come on the line. The U. S. civilian nuclear power industry shortage is estimated to be about two thousand trained people as approximately sixty more plants come on the line in the next decade. This has led to a hot market in trading people from one place to another which doesn't increase the supply, of course. I wouldn't be surprised to see a certain amount of such trading to develop even country to country.

In the United States, the Institute of Nuclear Power Operations is trying to solve the questions of supply and quality of operators. We are establishing comprehensive criteria for the management and curriculum content of training programs, and by means of job and task analysis, we are trying to establish both the educational and personal attributes which contribute to good operations capability. This conference helps us to share international training efforts. We can share those things which are most effective in improving the quality and eventually the number of trained and nuclear personnel throughout the world.

We are all aware of the concept of a pyramid of experience. At the base of the pyramid you have the personal experience of a single engineer or operator, at the next level you have the experience of his immediate organization, at the next level you have the experience of the entire parent organization or operating utility, at the next level you have the experience of the whole family of similar plant designs and their operations and finally you have the family of all plants operating in the world. For problems which occur frequently and have relatively small impact, it is appropriate and practical to rely primarily on local experience for deciding how to treat and solve the problem. For events which are less and less frequent, but which have larger and larger impacts in terms of outage costs and apparent threats to public safety, it is obviously prudent to go further up the experience pyramid and ideally to draw upon the entire world's experience to whatever extents are practical.

As many of you know, the Institute of Nuclear Power Operations is helping to do its part to ensure that practical operating experience is shared thoroughly within the United States and that the analysis and remedies are understood by all utilities. We have established for this purpose the Nuclear NOTEPAD system to speed the daily and direct exchange of operating experience and remedies being considered utility-to-utility. Seven countries outside the United States are also participating in this program. The objective is very simple. A mistake in operation or maintenance or design or implementation of any kind which has troublesome consequences should not have to be repeated several times in one country or several times in several countries before it is recognized and the preventative measures identified and put into practice. The system to achieve this is now growing on the operating experience level. The purpose of this conference is to share similarly the experience in the operator training area.

Summary

Dr. E. L. Zebroski

This morning's presentations were illuminating, enjoyable, and informative. There are important elements of similarity in the practices in every country reporting here, but also some extremely interesting and provocative differences. I will try to remark briefly on just the key highlight from each of the panelists' presentations.

The French Program has the striking level of investment of three dollars a kilowatt or roughly one half percent of project cost in the training area. An impressive investment indeed.

The United Kingdom presentation as well as the French presentation emphasized the use of concept simulators as part of the training and education process. The concept simulators or function simulators are used to ensure comprehension of how the system functions before the heavy use of a full-scope simulator is made in training. In fact, Mr. Myerscough commented that premature use of full-scope simulators was even dangerous to attain the necessary levels of understanding by operators.

Mr. Steffen addressed the interesting question of how much training is enough, that overtraining can be counterproductive.

The Swiss Program also has included the concept of the use of graduate engineers as "picket engineers," generally similar to the role of the shift technical advisor which has recently been adopted in the U. S. Program. He also noted the license assessment by several independent bodies not primarily from a paper regulation standpoint. He characterized the danger of overtraining, in that too little training can subject the operator to stress when he encounters situations he doesn't understand fully. Whereas on the other side, too much training can lead to boredom and resentment. The experience of 24 reactor-years and 120 man-years of experience with the "picket engineer" and particularly the low turnover which has been achieved in this job and in a shift supervisor job has some important lessons for the U. S. Program.

Mr. Laaksonen covered the Finnish Program for Training and Organization for two pressurized water reactors and two boiling water reactors. Especially interesting was the relationship to the prior educational levels of the operators and the adjustment of the training program accordingly, and also the interesting binational operations at Lovisa and TVO.

The presentation from Holland indicated a classical and somewhat conventional training program without the noticeably unique features, but one that was obviously polished and executed with great skill, as evidenced by the excellent operating experience of the plants in Holland.

The presentation from Germany covered a transition to a graduate engineer for the shift supervisor function by 1984. At present, 40 percent are graduate engineers, 40 percent are called "master craftsmen" and 20 percent are at technician levels, whereas with control room operators, 40 percent are "master craftsmen," 40 percent are craftsmen and 20 percent are technician level. They are also looking at a program for an additional shift engineer who is responsible for recognizing potential conditions leading to severe accidents, a process including, "severe accident or catastrophe training."

The presentation from Spain was unique in the high diversity of plant types covered involving five overseas and one domestic supplier. The emphasis on criteria for specific knowledge requirements and also on physical requirements and psychological requirements is instructive. Their training program covers 187 different types of malfunctions and is somewhat unique in a well defined 43-month training sequence conducted in five phases. It would be interesting in another circumstance to learn of the evolution of this program from its early stages. Mr. Persensky noted the pre-occupation in this country with the question of degree as a requirement for the shift technical advisory or the senior reactor operator. The possible use of task analysis may help resolve this question. He also noted the probable use of concept simulators as a potentially ideal tool for training for

severe accident responses. He further observed the "moving target" nature of the requirements and perhaps the need for stabilizing the situation using both the job and task analysis objective measures of operator performance.

Since these are only my personal reactions to the highlights in these presentations, I've asked each of the panelists to recount what appeared to be the highlights of one of the other presentations in respect to his own experience or the needs of his own country.

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C S N I SPECIALIST MEETING
ON
OPERATOR TRAINING
AND QUALIFICATIONS

Charlotte, N.C., United States
12-15 October 1981

TRAINING OF PRW OPERATORS IN ELECTRICITE DE FRANCE

J.J. MIRA - Chief of Operations Department
J.J. MARTIN - Chief of Training Division

SERVICE DE LA PRODUCTION THERMIQUE
EDF - DIRECTION PRODUCTION TRANSPORT
3, rue de Messine - PARIS 75008

I - INTRODUCTION

ELECTRICITE DE FRANCE is today operating 29 nuclear units, including 5 natural uranium gas cooled reactors, with powers between 200 and 540 MWe, 1 heavy water reactor of 70 MWe, 1 PWR unit of 300 MWe, 1 breeder reactor of 230 MWe and 21 PWR units of 900 MWe.

Eight PWR units of 900 MWe were started up in 1981, and five or six more will be commissioned in the course of each of the next few years.

Such a programme will require an unprecedented effort of recruitment and training by the company.

New staff will be recruited partly by taking on young school leavers and partly by internal recruitment within EDF of staff working in conventional thermal or nuclear power stations operated by the Thermal Production Service.

The personnel employed in this Service will increase from 16,000 in 1981 to 23,000 in 1985. Taking into account losses through retirement, the Thermal Production Service will have to cope each year :

- with the mass recruitment of 2,000 persons,
- and the recycling or promotion of a little more than 2,000 persons,

and consequently will have to provide training each year for 4,000 staff, about one third of whom are operating personnel (see Appendix I).

In what follows, we shall confine ourselves to the problems raised by recruiting and training operating personnel for PWR power stations.

We shall deal successively with the following points :

- organizing the operation of a power station with 4 PWR units of 900 MWe,
- the criteria for personnel selection,
- training programmes suited to the origin and function of operating personnel,
- training staff to carry out a given function,
- the training resources at present existing or being provided.

II - ORGANIZING OPERATIONS

The Operation Service of a power station of 4 PWR units comprises, under the responsibility of the Plant Superintendent and his Assistant (see Appendix II) :

- a Operation Supervisor,
- three Operation Engineers,
- six shifts for 2 units.

Each shift comprises, for twin units of 900 MW :

- a Shift Supervisor,
- an Assistant Shift Supervisor,
- two Control Room Operators,
- two Assistant Control Room Operators,
- two Plant Technical Men,
- three Roundsmen.

The experience and responsibilities under normal operating conditions of the persons operating these various posts are as follows :

The Operations Supervisor is generally a graduate engineer with 4 to 8 years experience in power station operation. This post may be held by a person promoted from the ranks with experience of more than ten years acquired successively in the different shift functions.

The Operation Engineer is generally a graduate engineer with 2 to 4 years experience. He participates in the recruitment, training and administration of shift personnel. He is responsible for updating operating procedures, recording the results of periodical tests and proper application of the safety rules.

All the posts in the shift are occupied by persons who have moved up the different function grades in the shift. Thus their experience, which may have been acquired partly in a conventional power station, varies between a minimum of 10 years for a Shift Supervisor to a minimum of 2 years for an Assistant Control Room Operator at the time they take up their duties.

The Shift Supervisor is responsible for exploiting the units. He is also responsible for training the personnel in his shift. He delivers work authorizations and issues the instructions for all work on the power station equipment. He records all events occuring during operation.

The Assistant Shift Supervisor helps the Shift Supervisor in his duties, and especially in the delivery of instructions and the co-ordination of periodical tests. He is qualified to carry out the function of Control Room Operator.

The Control Room Operator operates all the equipment from the control room. He is helped in this function by the Assistant Control Room Operator.

The Plant Technical Man operates locally-controlled equipment and especially the various elements of equipment in the nuclear-auxiliary building.

The Roundsman carries out checks and local handling operations under the responsibility of the Control Room Operator.

The Shift Supervisor may, in abnormal operating conditions, call on the services of a stand-by Operating Engineer outside his working hours. He may be available for duty within less than 30 minutes.

After the Three Mile Island accident, it was considered necessary to reinforce the potential of the shift personnel. EDF decided to make available continuously to each shift the services of an engineer known as the Safety and Health Physics Advisor. The duties of the engineer, who has no hierarchical function in the shift, are to provide technical advice to the shift Supervisor in exceptional situations outside the latter's competence. Our objective is that, even in such circumstances, the Shift Supervisor should retain responsibility for directing his shift. The engineer will also provide co-ordination during the first moments of an accident in respect of problems of radio protection and environment.

In normal operating conditions, the Safety and Health Physics Advisor will have the additional duties of organizing continuous training for the shift personnel and analysing significant operating events.

This function will be carried out either by graduate engineers with 2 to 3 years training and practice, or by former Shift Supervisors with long experience, who have received special training.

The Safety and Health Physics Advisors will be on duty in the PWR power stations now being operated as from October 1981.

III - SELECTION CRITERIA (see Appendix III)

III.1 - Preselection : School training - Experience

During recruitment, EDF has to deal with two types of candidates :

- those that already have operating experience acquired in an EDF power station, whether conventional or nuclear;
- those that have not this experience, and who in general are just out of school.

The candidates of the first category are personally known to the management of the power station where they work. Those who are already working in a nuclear power station also have an individual training book in which is summarized the training they have received. The profile of each candidate is thus clearly defined and graded according to the following criteria :

. the level of school education,
. training received in EDF,
. experience acquired and length of service in the preceding post,
. the opinion of his superiors.

For candidates in the second category, on the other hand, the only criterion that may be taken into account in the "level of school education". These criteria constitute the basis for preselection of candidates.

III.2 - Selection = Tests

The selection criteria are first of all based, depending on the origin of the different candidates, on criteria of school education and experience.

Candidates who satisfy the training and experience criteria, and in respect of whom no unfavourable opinion is given by their superiors, are subjected to an additional written and oral examination.

This examination, which is given by two power station engineers, includes tests whose purpose is to find out whether the candidate is capable, technically and psychologically, of adapting himself to his future duties and whether in particular he can successfully complete the corresponding training.

Particular attention is paid to human qualities. Our engineers are given special training for this.

We also use the services of psychologists more and more in the selection of young school leavers.

Engineers are recruited nationally, naturally of course on the basis of their university education, but also after a series of tests and in particular psychological tests.

It is by no means uncommon that after this two-stage selection only 5 or 10 % of candidates are accepted.

This explains to a large extent why the percentage of failure after training is so low.

IV - TRAINING PROGRAMME (see Appendix 4)

IV.1 - Main guidelines for training

A person who has been accepted for operating duties is only recognized as suitable to carry out such duties after he has first been through specific training.

Depending on the person's profile (training/experience) and the position he will occupy, a training plan is prepared by the Operation Supervisor and submitted for the approval of the Plant Supervisor. This training programme lays down the training he must complete before being declared suitable to occupy the post for which he has been chosen. This training programme is described in the staff member's personal training book.

The training programmes are designed to ensure :

. preadaptation of new recruits to the environment in which they will carry out their operating duties,
. adaptation to the technical methods used in PWR stations,
. training specific to the duties,
. maintenance and upgrading of knowledge;

and to cover the following needs :

. recruitment of school leavers,
. recycling of operating staff who have been working with other techniques (conventional or nuclear other than PWR),
. promotion of PWR operating staff.

The training takes place either in national or regional specialized training centres, or locally in the power station. In the latter case, the training is provided by senior staff from the power station who, quite apart from the necessary technical training, have received special instruction in teaching.

IV.2 - Content of the training

IV.2.1 - Programme for new recruits

Each new recruit receives first of all, for a period of one week, a course of adaptation to EDF which will inform him of the function and organization of Electricité de France, of his role within this Company, the career developments that are open to him, and the social and statutory structures of the Service.

The job familiarization course depends on the recruitment level.

For persons who will be employed as Roundsmen or Plant Technical Men, a training period of 16 weeks, including 6 weeks working in a shift, enables them to take up their duties as Roundsmen. This training details the principal circuits in a PWR power station and through description of the technology and behaviour of the essential equipment enables them to understand how it works.

For engineers, a training period of 6 weeks gives them basic knowledge of nuclear techniques, with the help of which they can acquire a general picture of the problems of operating a nuclear power station. This training is given in an institute of the French Atomic Energy Commission. A second period of training of 9 weeks, at the Le Bugey training centre, provides them with more detailed knowledge of the circuits and operating methods of a PWR power station.

Training for the specific duties takes place essentially by doubling up the trainee with existing personnel for approximately 24 weeks. In particular, in a power station that is being started up, the whole phase of testing and commissioning is used to increase the competence of staff in their duties.

IV.2.2 - Recycling programmes

A recycling training programme of a duration that varies according to staff level is given to enable the special features of PWR power stations to be understood (principal circuits, technology of the principal equipment, systems operation). The duration of this training period varies from two weeks for Roundsmen and Plant Technical Men to four weeks for Control Room Operators, and nine weeks for Shift Supervisors and Engineers.

Training for the specific function then follows on the same basis as for new recruits, i.e. by performance of the job in parallel with an existing staff member.

Essential additional training is provided by the courses that every person employed in a PWR station must follow when he changes his job.

IV.2.3 - Specific training programmes for PWR staff changing jobs

A PWR Plant Technical Man who moves up to the post of Assistant Control Room Operator must study the procedures and instructions for normal operation before following a course of 2 weeks on the simulator (module 1) on which he learns the procedures for start-up from cold, work-up, work-down and load variations around nominal power.

An Assistant Control Room Operator who takes a job as Control Room Operator studies the procedures and instructions for operation in incident and accident modes before following 2 x 2 weeks courses on the simulator (modules 2 and 3); one of these weeks concerns procedures in incident circumstances (for instance islanding), and the other procedures in accident circumstances (for instance, rupture of a primary-circuit pipe), (Appendix 5).

A Control Room Operator who becomes an Assistant Shift Supervisor must follow a course of 3 weeks, in which his knowledge of the operation of a PWR power station is updated and he acquires the full dimension of his new function.

This training is completed by local training, in the form of refresher courses and updating of knowledge, and by a week of annual recycling on the simulator.

For example, a PWR Control Room Operator who was engaged as a Roundsman or Plant Technical Man in a PWR power station will have worked in a power station for 5 to 8 years depending on his level on entry. During this period, he will have been through formal training in the form of courses with a total duration of nearly 40 weeks, excluding the training he will have received in the power station, (see Appendix VI).

IV.3 - Practical measures for helping training

It is obvious that such a training structure, to be really efficient, must provide a certain margin in order to be able to provide for the unexpected replacement of a staff member in any circumstances. This kind of situation is in fact far from rare in a Company operating a rapidly growing number of power stations. There is a natural and understandable tendency for staff to look for promotion in a new power station when this is recruiting its own staff.

To allow for this, we have significantly reinforced the staff in certain operating functions; this is the case of Roundsmen, Control Room Operators and Assistant Shift Supervisors.

These extra staff are included in the shifts and double up with the titular staff. This period, which lasts between 6 months and 2 years depending on the case, constitues an excellent form of additional training.

V - LICENCING

On completion of training and after a period of parallel shift work, the duration of which varies according to the competence and experience of the staff in question, the Plant Superintendent issues them with licences.

Such a licence, which is under the Plant Superintendent's sole responsibility, authorizes a person to carry out a given function, i.e. to perform a precise task excluding all others.

The licence is valid for two years. It is granted at the proposal of the Operation Supervisor :

. if the person has acquired the requisite knowledge;
. and if the person's superiors (Shift Supervisor, Operation Engineer) give a favourable report on him after his trial period in parallel shift work.

Proof that a staff member has the desired level of training is provided by regular checks on his knowledge carried out through out the training period by the instructors. This takes the form of :

. collective tests during the training sessions; in this way it can be ascertained whether the training action has achieved its purpose and certain parts that have not been properly assimilated can be revised;

. by individual tests at the end of the training period. Persons who do not attain the required level are then required to undergo additional training periods.

At the end of the period of validity of the licence, the Plant Superintendent renews it on the proposal of the Operation Supervisor and after a favourable report by the person's superiors.

This licence can be suspended at any moment.

We consider that delivery of a licence on the basis of the results of a single examination does not provide sufficient guarantee. The behaviour of a staff member in his previous post is a most important element to take into account, as is also his real progress in knowledge during training.

For indication, we should add that the above arrangements are applied to all the technical functions of a nuclear power station : operations, maintenance and technical supervision.

VI - MEANS USED FOR TRAINING

The means used are either the training structures organized outside power stations, or educational resources provided to supervisory staff within power stations for local training.

VI.1 - Training structures

The formal training courses may take place either in the national Schools under the responsability of the Personnel Division of Electricité de France, or in regional training bases managed by the Training Department of the Thermal Production Service.

At present, the school principally used for the training of operating personnel in PWR power stations is the Le Bugey training centre, which in particular has two PWR 900 MW power station simulators and will acquire a third 900 MW simulator in 1983.

Another school is under construction at Paluel. It will be equipped in 1983 with two PWR 1300 MW power station simulators.

A school is planned for training Assistant Shift Supervisors. It will be equipped with a fourth 900 MW simulator in 1984.

Whereas the schools are used for training Assistant Control Room Operators, Control Room Operators, Assistant Shift Supervisors and Shift Supervisors, the training bases are used for job familiarization and recycling for Roundsmen and Plant Technical Men. There are at present five of these bases, situated in the following nuclear power stations : Fessenheim, Gravelines, Tricastin, Saint-Laurent "B", and Blayais. These bases have permanent instructors, supplemented by persons from the supervisory staff of neighbouring power stations.

VI.2 - Teaching resources

The teaching resources made available to supervisory staff for local training include :

- technical notices,

- audio-visual displays in the form of video-films or "diaposons" (slide projections synchronized with a sound track), whose cumulative available time is at present of the order of 50 h,

- slide transparencies, boards for back projection, boards on adhesive backing,

- models made to show the operation of equipment that is sensitive or inaccessible during normal operation,

- teaching notes designed as aids to the instructors and giving an organization pattern for the training programmes.

Apart from the bulky teaching resources such as the simulators used in the Schools, the Thermal Production Service is at present developing functions simulators, training by computer assistance and an accident simulator.

The purpose of the functions simulators is to allow staff to follow up the various physical phenomena that occur during operation of a system, to register the changes in the different parameters, and to assimilate the corresponding operational instructions. These simulators will be used in the schools, but also in the power stations themselves, for which mobile equipment is being planned.

A trial of computer-assisted training is in course in four power stations, which are connected to a computer in the Paris region. Each power station may thus have access to more than 600 hours of courses on circuits, on the status of these circuits in different conditions of operation, on equipment supervision and the corresponding rules.

EDF is also planning a simulator for installation on each site. Its design should make it possible to simulate accident situations which present simulators cannot reproduce or simulate badly. This simulator is undergoing feasibility studies with the collaboration of the Atomic Energy Commission and Framatome.

On further teaching aid may be mentioned. It is a direct consequence of the studies carried out by EDF after the accident at Three Mile Island to improve the presentation of operating procedures used in incident or accident situations.

These studies, which are being carried out with the help of companies specialized in time-and-motion studies and human behaviour, have in particular led to the conclusion that it is necessary to strip away from the operating procedures everything that is not basically essential for the operator's action.

Each procedure thus stripped to its essentials, described as action procedure, must then in all cases be completed by a document which explains and justifies the action to be taken.

These documents, which are known as teaching documents, constitute a basic tool for continuous operator training.

VII - CONCLUSION

This note will give an idea of the considerable effort that Electricité de France has already carried out and must still further develop in order to create the competences necessary for operating PWR nuclear power stations and for ensuring that such knowledge is maintained. This effort goes considerably beyond the context of operations, which is the object of this meeting.

We have always felt very strongly that the training of operating personnel forms one of the essential components in the safety of a nuclear installation. The greater part of the training programme which has been summarized above, together with the teaching resources that go with it was laid down and applied before our first PWR units were started up.

Operating experience on the one hand and the lessons learned from incidents or indeed accidents such as that at Three Mile Island on the other hand have shown us that though the essential requirement had been carried out, improvements were desirable, especially in respect of the teaching equipment used.

Among the many guidelines that we have developed and are continuing to develop, we may recall in particular the following :

- training must be adapted to the profile of each staff member, i.e. to his level of theoretical and practical knowledge. This implies that each member of the operations staff must be personally known ; this is the reasoning behind the personal training record;

- training must be organized and structured at national level, and in particular given principally in specialized training centres;

- training must be realistic and practical; for this, it is essential that the teaching programmes and tools should be designed with the active co-operation of those who are to use them; this participation is just as necessary in the training actions proper;

- the instruction given in each training action must encourage the acquisition of knowledge, but also develop a spirit of analysis, criticism and deduction. We should not lose sight of the fact that the operator is there to compensate for machine failure under all circumstances, including unpredicted situations;

- recognition of the competence of a staff member must be a synthesis of several components :

. *the level of knowledge acquired*, checked on throughout the training programmes;

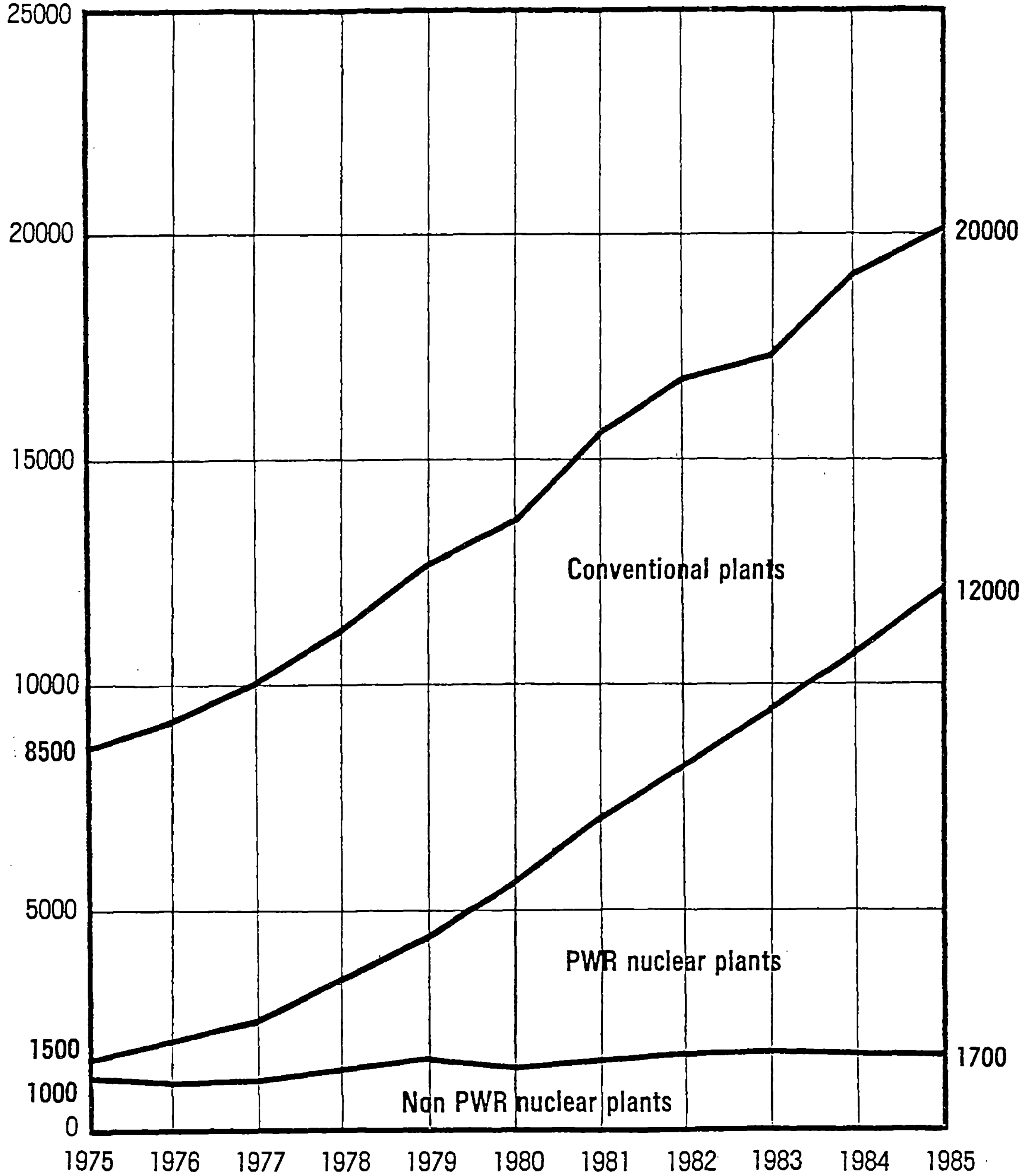
. operating *experience*;

. the *opinion* of the person's superiors.

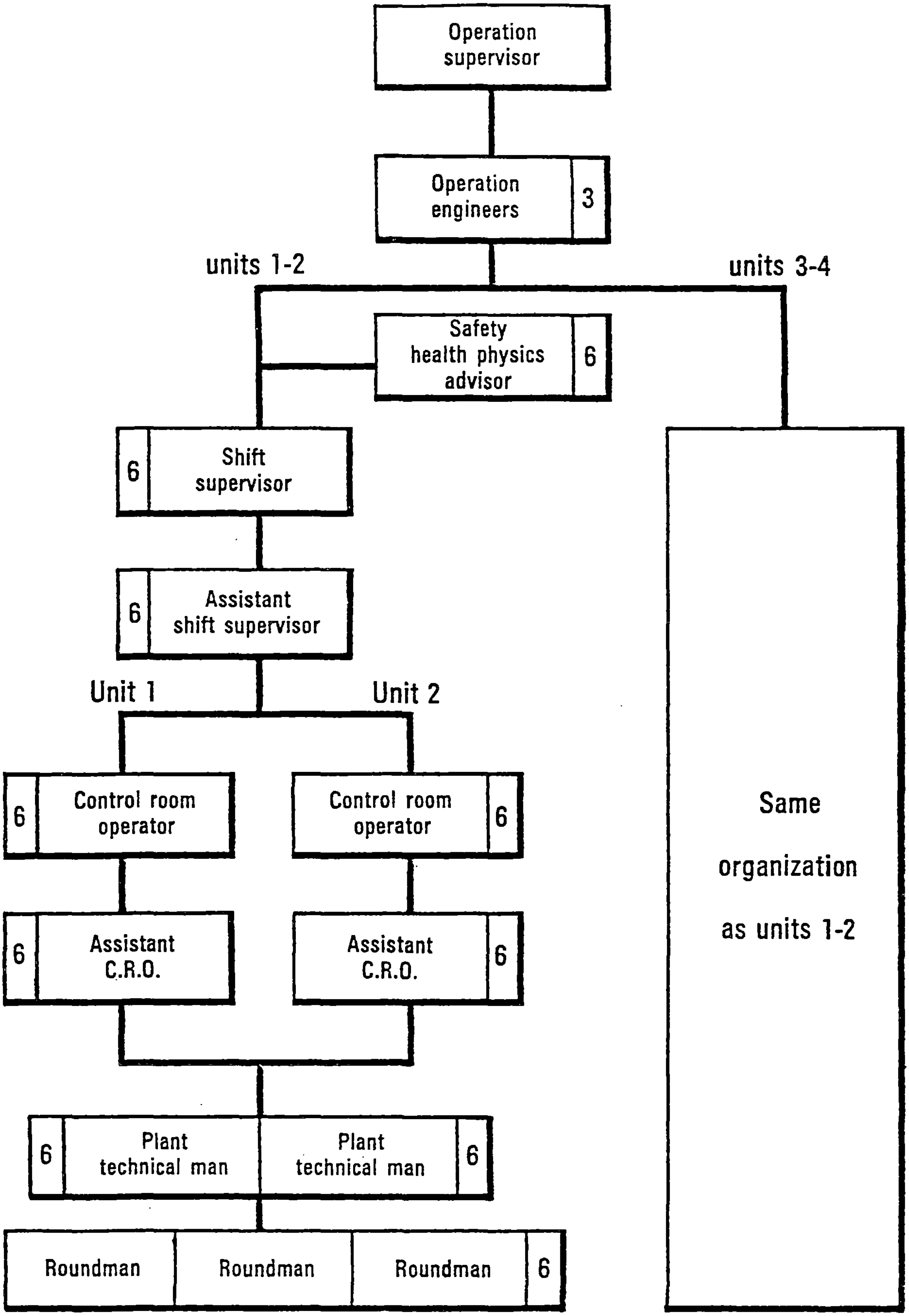
- the organization must encourage *group training*. It is in fact essential to develop a team spirit so that in the face of a critical situation each member can carry out his function in an atmosphere of confidence and under the responsibility of a single man : the Shift Supervisor.

In conclusion, we may note that we are more and more convinced that training must give considerable emphasis to concrete programmes met in operational situations, and especially to comments on the lessons learned from significant incidents that have occured in units of a similar nature (whether french or foreign). We also plan to reproduce the most significant incidents on our future on-site simulators, so that each shift can have the opportunity of testing the behaviour of each one of its members and the cohesion of the whole group.

Evolution of number of people in EDF thermal plants



Operating staff twin units organization



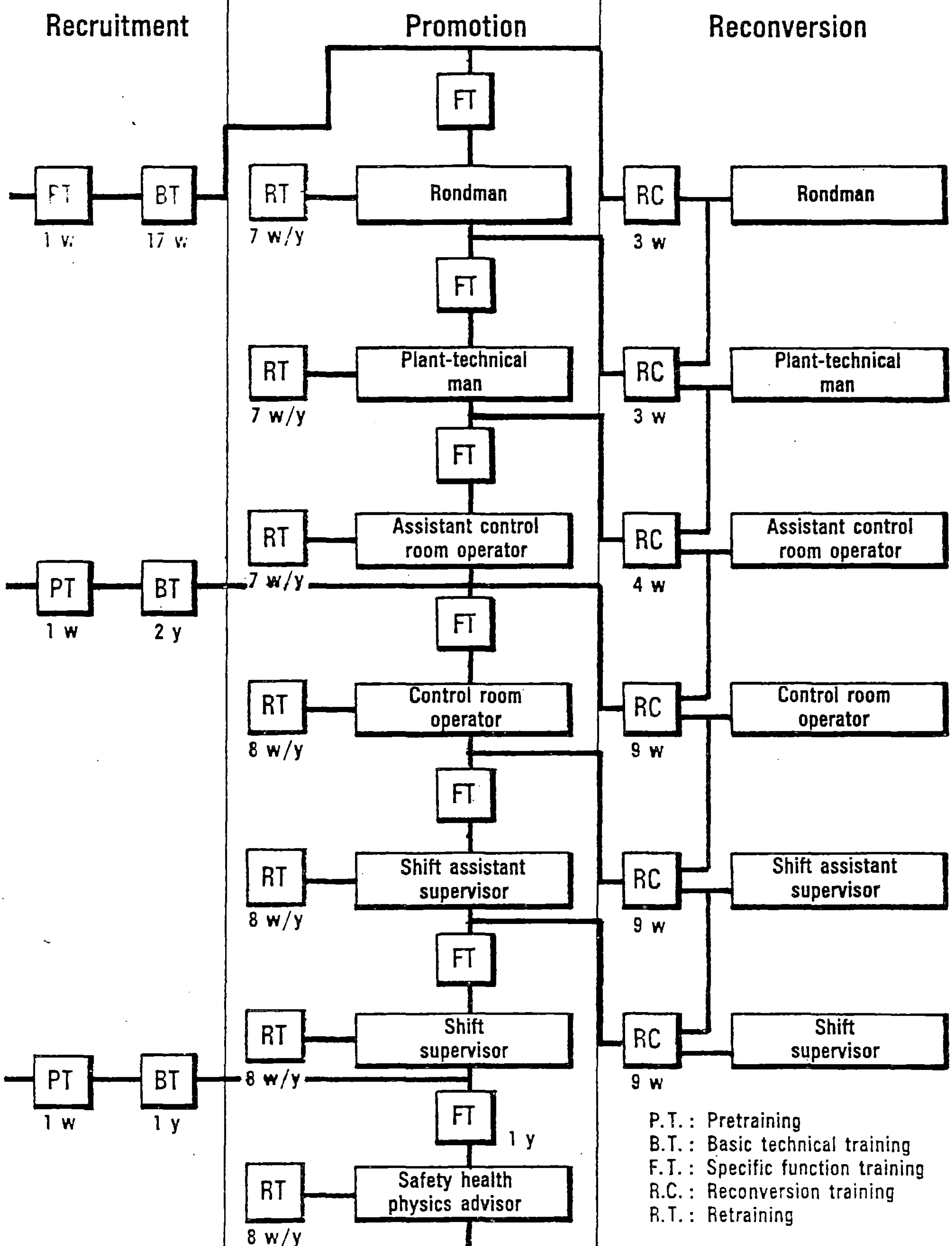
PRESELECTION REQUIREMENTS

SELECTION REQUIREMENTS

Function	Education (number of years after elementary school)	Minimum experience required
Roundsman (operation worker)	5 years	2 to 3 years E + T
Plant technical man	7 years	2 to 3 years + E + T
Assistant control room operator	7 years	2 to 3 years + E + T
Control room operator	7 years Bachelor of technology 9 years	3 to 4 years + E + T
Assistant shift supervisor	»	2 to 3 years + E + T
Shift supervisor	»	11/16
Safety and health physics advisor	Graduate engineer 12 years	> 3 years + E + T

E = Examination T = Training

Training program for PWR operating staff



P.T. : Pretraining
B.T. : Basic technical training
F.T. : Specific function training
R.C. : Reconversion training
R.T. : Retraining

APPENDIX V

SIMULATOR TRAINING

	DURATION	PROGRAMME
INITIAL TRAINING	1st part : 2 weeks 40 hours	Normal conditions operations
	2nd part : 2 weeks 40 hours	INCIDENTS Ex: Transients With safety injection
	3rd part : 2 weeks 40 hours	ACCIDENTS Ex: Primary pipe leakage
RETRAINING	1 week/year	- Studies of incidents and accidents - Comments about significant events

CONTROL ROOM OPERATOR TRAINING

	PRETRAINING	BASIC PWR TECHNICAL TRAINING	SPECIFIC FUNCTION TRAINING	RETRAINING
RECRUITMENT	General information about EDF 1 w	PWR operator technical training (simulator 1st, 2nd and 3rd level) 2 y	Health physics 1st, 2nd level Quality assurance 1st, 2nd level Parallel shift work Plant studies Procedures studies 24 w	On site training (7 w/y) Fundamentals review Procedures review Operating experiences Equipment and procedures modifications Simulator retraining (1 w/y) 8 w/y
RECONVERSION		Basic operation training 9 w	Health physics 1st, 2nd level Quality assurance 1st, 2nd level Parallel shift work Plant studies Procedures studies Simulator 1st, 2nd, 3rd level 30 w	
PROMOTION			Health physics 2nd level Parallel shift work Procedures studies Simulator 2nd, 3rd level 18 w	

QUESTIONS TO J. J. MIRA

C. F. Ehert

Q: Please describe the ROTAS (length and direction of rotation) in Electricite de France. Do the shift schedules rotate through slow rotation by phase advance or by phase delay?

A: At EDF, in all plants there are six shifts. The EDF's management doesn't impose a rotation system. Each plant, after an operator hearing, decides the rotation type. The most frequent decisions are:

7 days - morning

7 days - normal timing (8:00 a.m. - 5:00 p.m.) used for site or off-site training

7 days - afternoon

7 days - normal training (used for site or off-site training or rest)

7 days - night

7 days - normal timing

Warren Witzig

Q: Please distinguish between a Bachelor of Technology and a Bachelor of Engineering degree.

A. A Bachelor of Technology receives the same education as a Bachelor of Engineering throughout his first 13 years of schooling. After which, an exam will decide which level he will have to pursue for his degree.

If the student is at the top level of his class, it is possible for him to pursue an engineering degree by branching into a higher level of mathematics and scientific courses with emphasis placed on design. This student then is called an Engineering Bachelor.

On the other hand, if the student is not able to follow the higher level of mathematics, he may become a major technician

after completing two or three years of technologically oriented studies. This student then is called a Bachelor of Technology.

On and Off-Site Training of Technical Staff in the U.K. Nuclear Power Stations

by

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Introduction

The training requirements necessary to provide the staff for the operation of a utility's nuclear power station depend upon a number of factors including:

(a) the proportion of generating plant in the utility which is nuclear;

(b) the variety of the nuclear plant types, e.g. Magnox, AGR, PWR, BWR. Standardization within the utility on a single type of nuclear steam supply system, for instance, will simplify the training facilities to be provided, in particular the variety of full scope training simulators required. It could also reduce the degree of retraining necessary when staff transfer to other generating units within the utility;

(c) the statutory requirements imposed upon the utility for the safe operation of the nuclear plant. Of particular importance in this context is the method of licensing plant for safe operation and whether this includes the examination of individual plant operators by the external licensing authority or if the responsibility for the training of staff to ensure safe operation lies with the utility. For instance if examination standards are determined as part of the licensing requirements by an authority covering a number of utilities, the necessary training could be wider than that designed specifically for one utility. It might then be more appropriate for the relevant aspects of training to be covered by a national training centre rather than provided by individual utilities.

The nuclear training needs of the utility must be regarded as distinct from the training required for fossil fuelled plants, in particular that required for operational staff. The potential hazards of nuclear plant must make safety the primary aim of the training. Although economic operation must be of secondary importance to safety, the economic penalties of maloperation are more severe than with coal and oil-fired plant because of the comparatively low fuel costs of nuclear generation and the resulting incremental replacement fuel costs which will increase as oil and coal costs escalate. In addition, the essential base load mode of operation of nuclear plant and the distinctive characteristics of their design reduces the opportunities for on-plant training which generally form the principal content of fossil fuelled plant training schemes. The nuclear training requirements of the CEGB are appropriate to a utility with approximately 56000 MW total capacity with an installed nuclear capacity of 4800 MW of Magnox plant and 5200 MW of AGR plant operating or under construction. Thus the current training facilities are applicable to a gas-cooled technology with the possible introduction of PWR stations in the near future.

CEGB nuclear station operating staff are drawn principally from

engineers who have completed one of the Board's internal training schemes. The latter recruit directly from schools at sixteen or eighteen years with 'sandwich' type training or provide two year post graduate training courses for graduates direct from universities or polytechnics. The training of staff for the operation of all types of stations follows this pattern and this policy is carried through to the nuclear stations with special emphasis on safety aspects. Fig 1 shows a typical technical staff organization for a CEGB nuclear station. The shift operational staff have direct responsibility for the safe operation of the plant and are the only personnel who operate the nuclear plant items. The shift charge engineer/shift manager has overall responsibility for the day to day station operation under all normal and fault situations. An assistant charge engineer is responsible for the control room operations with 1 or 2 assistant engineers as desk operators. The level of basic nuclear training is essentially the same for all the technical operating staff (this is discussed in detail later), promotion to senior grades being based upon ability and experience. Depending upon the work involved shift engineers will be separately authorised to control work in radiological zones. Following the incident at the Three Mile Island Plant a review of nuclear training was carried out within the Board and whilst the current pattern of training was considered to be adequate, certain recommendations were made to strengthen the existing arrangements. These included an extension of the training in dealing with plant abnormalities and multiple failure accidents. It was noted that the report following the T.M.I. incident recommended that additional training emphasis should be given to fundamental nuclear physics and kinetics, subjects which have always received high priority in the CEGB training programmes. (Reference to technical operating staff indicates staff of graduate, diploma or the equivalent level engaged in a range of duties from reactor desk operation to power station management.)

U.K. Training Requirements

The formal training requirements for U.K. nuclear power station operators are comparatively small and great reliance is placed upon the licensee to maintain his own training programmes and standards. Thus the Board maintains a full and comprehensive nuclear training effort, as outlined elsewhere in this paper, which covers all the staff involved. This is in contrast to the practice in several other countries who lay down formal licensing procedures including written and oral examinations and periodic re-licensing.

Training of the nuclear station operating staff in the United Kingdom is conditioned by the requirements of the Nuclear Installations Act of 1965 as amended which places a responsibility on the CEGB (and the SSEB) for the safe operation of the nuclear stations within their area of management. The licence to operate the plant is issued to the Boards as Corporate Bodies and direct responsibility for the safe operation is vested with the Station Manager. Thus Station Managers are directly responsible for the standard of all training received by their staff. This training is

provided both on-site and at the Board's training centre although the content and standard of both types of training are carefully co-ordinated and are complementary.

On Site Training

There are no specific training requirements detailed in the nuclear site licence but there is a duty on the CEGB to give instruction to all persons employed, and authorised to be on the site, on the radiological risks associated with the plant and its operation, and the precautions and actions in the event of an emergency. There is also a requirement for persons with duties in connection with the emergency arrangements to receive instruction. The nuclear site licence conditions require that the CEGB appoint persons to carry out functions specified in the licence, one of these is to control and supervise the operation of the plant. Such people are designated as "Duly Authorised Persons" and details of their nuclear training, technical qualifications and previous positions are furnished to the NII. Although the licence does not contain specific training requirements, training forms a basic element in the Board's procedures and the following are some examples of these:

(a) The Board issues Radiological Safety Rules to give the necessary controls for radiological protection in their nuclear power stations. These are furnished to the NII and contain implicit training requirements. Where it is necessary to carry out maintenance work in radiation or contam ination zones and to gain access to plant in the higher classified zones special authority in the form of a 'Permit-to-work' is necessary. A Permit-to-Work' may only be issued by a 'Senior Authorised Person' who has been specifically authorised following an oral examination by a panel consisting of senior station management/ personnel plus an independent representative from the Headquarters Health and Safety Department. The authorisation refers specifically to one station and re-authorisation is necessary if the engineer moves to another station.

In order to give the necessary health physics advice to the Senior Authorised Person for the preparation of the 'Permit-toWork' the safety rules procedure includes a Health Physics Certificate which specifies the radiological safety precautions required in specified radiation and contamination zones. The Health Physics Certificate is issued by an 'Accredited Health Physicist', who is a person with the necessary qualifications, knowledge and experience to assess the health physics measures required for that particular establishment, and who has been appointed to issue such certificates. Each Accredited Health Physicist is subject to independent consideration by a senior Health and Safety Department officer prior to Accredition.

(b) Emergency arrangements for each station are provided in two parts - the first part, the Emergency Plan contain the general principles of the emergency arrangements, health physics

procedures, duties of staff involved and collaboration with outside authorities such as the police, fire brigade etc., and is formally approved by the Health & Safety Executive. The second part, the Handbook, is of much greater volume, containing detailed information on every aspect of operations connected with the emergency arrangements. The Handbook and any subsequent changes are sent to the Health and Safety Executive for information.

In order to maintain a high level of training and to demonstrate the effectiveness of the emergency arrangements the nuclear stations adopt the practice of an annual rehearsal based on a postulated serious accident to the plant such as a pressure circuit rupture and escape of radioactivity. This is designed to test every facet of the emergency arrangements under the most realistic conditions possible. This frequency of rehearsal has been accepted by the Nuclear Installations Inspectorate and each demonstration is witnessed by Inspectors from both the Nuclear Installations Inspectorate and the CEGB's Health & Safety Department. Details of the postulated accident, release levels and, where possible, the exact time of the emergency are kept confidential in order to provide the maximum degree of realism. To maintain a continual state of preparedness specialised training is given to individual groups with special responsibilities such as damage control, fire fighting and first-aid teams.

The licence condition contains a specific requirement that all persons with duties in connection with the emergency arrangements shall be properly instructed in such duties. There is also a requirement to maintain a register recording details of this training. In the CEGB this duty is fulfilled by the stations preparing a comprehensive training programme and detailing this in a training schedule. Records of all training completed are maintained.

This training, which is separate to, and in addition to, the training off site at a Training Centre includes first aid and fire fighting measures, assembly point procedures, and the use of breathing apparatus. In addition instruction is given on specialist duties such as VHF radio operation and off site data plotting, health physics Control Room Duties, and damage control measures.

Off Site Training

The United Kingdom was one of the first countries to operate commercial nuclear power stations and the early staff training schemes relied upon the experience gained by the Atomic Energy Authority in developing, commissioning and operating the prototype at Calder Hall upon which the design of the present Magnox commercial stations have been based. As the number of staff required for the commercial stations increased, the basic theoretical training of approximately six weeks was transferred to the universities with the continuing use of the Operations School reactor simulator at Calder Hall for the practical aspects of plant operation.

As the CEGB gained operational experience with the commercial

stations it assumed an increasing amount of direct responsibility for the nuclear training of station operating staff commencing in 1959 with the acquisition of a reactor simulator. This analogue machine together with a later model has been used primarily to supplement other types of training and also for revision training of experienced operating staff. Since 1972 the off site nuclear training of CEGB technical staff has been at the Board's national Nuclear Power Training Centre at Oldbury-on-Severn on a site adjacent to one of the latest Magnox prestressed concrete pressure vessel stations. The Centre is administered directly by the CEGB and staffed almost exclusively full-time and part-time by Board technical personnel with a small proportion of part-time lecturers from UKAEA, British Nuclear Fuels, the Nuclear Installations Inspectorate and plant manufacturers. The principal role of the Training Centre is to provide three essential training functions for the Board:

1. the training of operational staff following their initial appointment in a nuclear station;

2. the revision training of experienced operating staff in nuclear stations;

3. the training of 'non-operational' staff from the stations and supporting nuclear departments.

The Centre also provides a forum for short seminars and conferences on nuclear subjects of immediate interest to specialist groups within the industry, e.g. asymmetric fault studies, gas and waterside chemistry, health physics, reactor physics.

The full-time staff at the Centre consists of a manager and ten tutorial staff with technical and administrative support. The tutorial staff are of graduate level with recent experience in the nuclear activities of the Board. Emphasis is placed upon the close involvement in and co-operation with the management of the nuclear stations and in a flexible approach to the needs of the stations to be continually staffed by fully trained engineers. The tutorial staff are provided with opportunities to keep up to date with nuclear operational requirements of the Board and for short secondments to the nuclear stations.

An essential ingredient in ensuring that the training meets the industry's safety responsibilities is an Advisory Committee. This consists of managers from a cross section of the CEGB (and SSEB) nuclear interests and advises the Centre manager on the content of courses, the current nuclear operational requirements and the methods of assessing the competence of the operating staff on completion of the training.

The ability of the Training Centre manager to call upon the advice of the full range of technical expertise available in the industry has been a major factor in enabling the training staff to meet the nuclear training requirements of the Board. These requirements could not have been met so effectively if the Centre had not been administered directly by the Board.

Content of Training Courses

Initial training

The staff requiring initial training will be of graduate diploma or equivalent standard principally in mechanical or electrical engineering or physics with little previous knowledge of nuclear technology but having completed at least one of the Board's training schemes. The primary purpose of this phase of training is to give a thorough understanding of the gas cooled reactor plant technology. The initial appointment after the off and on site training is usually as a reactor plant desk operator, the engineer's subsequent career depending upon his technical ability.

It is important to emphasize the attention paid to ensuring that the engineer understands the underlying design philosophy and dynamics of the plant which he is to operate rather than using only a 'mechanistic' approach to detailed plant operating techniques. This philosophy is continued throughout the full training programme.

The overall pattern of initial training is shown in Fig. 2.

Introductory Course

This is a four week course with emphasis on basic nuclear technology, the syllabus including nuclear and reactor physics, reactor kinetics, reactor heat transfer and reactor chemistry. A typical course is shown in Table 1.

The lecture periods are supplemented by practical demonstrations in the laboratory and, where applicable in an operating nuclear station. A limited amount of instruction is given on the reactor training simulator, although at this stage in the training the simulator is used primarily to give an analogue demonstration of reactor kinetics lectures, e.g. temperature effect on reactivity. The maximum number of engineers being trained on each course is 20 with sub-division into small groups of 4-5 for tutorial and practical project sessions.

Plant Familiarization

This takes place over a period of 4-6 weeks at the station to which the engineer has been appointed. The pattern of training for this period will vary according to the needs of the individual and the type of station and will be determined after consultation between the Training Centre and station managers. This period of station training is essentially an extension of the total training programme and, to ensure a degree of continuity, the engineer is required to complete a written project. The details of the project are determined by the tutorial staff after consultation with the station management and are designed to provide an objective to be achieved during the plant training period. (Typical project subjects are shown in Table 2).

Operational Courses

(See Tables 3,4 and 5). Two separate parallel courses are provided for Magnox and AGR staff after completion of the introductory course and the period of plant familiarization. For Magnox station staff this stage of training is completed in 4 weeks. AGR staff continue with a 4-week AGR technology course followed by a 2-week operational course, the latter being exclusively on the plant simulator for a specific station. This phase of training concentrates principally on the operational aspects of the engineer's responsibilities. As with the introductory course, emphasis is always upon obtaining a through understanding of the dynamics of the plant, with the primary objective of ensuring its safe operation and a secondary but very desirable objective of improved commercial performance. At this stage an increasing proportion of the training is given by experienced operating engineers, providing the student engineer with the opportunity to discuss current operational procedures and problems which he is likely to experience when his training is complete For the AGR technology course, in particular, plant designers are employed as part-time lecturers to ensure that operating engineers are fully conversant with the plant design philosopy and kinetics.

In presenting the lecture material to the engineer a minimum amount of time is given to proving mathematical equations, sufficient mathematics being used to obtain an understanding of basic principles. Experience has shown the value of demonstrating kinetics in an analogue form, particularly if the engineer can be involved in operating the analogue device as a project. Projects of this nature provide a useful addition to the demonstrations on the training simulator. In a number of situations the use of a large complex simulator may prove to be unsatisfactory tool for demonstrating specific aspects of reactor kinetics. This is particularly so when demonstrating the interactions of say two reactor parameters only e.g. the effect of temperature upon reactivity, or when the time scale requires acceleration, e.g. rate of xenon poisoning after reactor shut down. A large number of projects have been constructed by the Training Centre staff and Figs. 3 and 4 show typical fuel channel temperature distributions and reactor xenon poisoning.

At each phase of the initial training the engineer is assessed and his progress reported to the station manager. The assessement takes the form of a written examination together with an in-depth project on a specific item of plant or the operating procedures. The content of the examinations are monitored by the Training Centre Advisory Committee, the examination being set and marked by the Centre tutorial staff. This assessment is applicable to his progress during the training period only and is not intended as an assessment of his competence to operate the plant safely. The latter rests with the station manager who remains responsible for appointing his staff to an appropriate post within the station and ensuring the operational safety of the plant.

Continuing assessment is made on the station by senior members of the station technical staff before the engineer assumes his operational duties with further assessments as additional levels of safety and radiological protection authorizations are granted to the engineer. This arrangement ensures that the Station Manager remains responsible for the overall training of his staff and that both training and assessment are relevant to the local plant environment and to the personal characteristics of the individual within an overall national level of competance.

Revision Training

The base load operating pattern of nuclear stations limits the opportunity for operational staff to experience start-up and shut-down procedures and to remain familiar with the significance óf the major departures from normal operating conditions. This limited degree of involvement in non-routine operating procedures is more pronounced as an increasing amount of automatic control is provided in AGR stations, compared with the early Magnox stations.

Technical operating staff are required to satisfactorily complete a period of revision training at least every two years commencing after their initial appointment and emphasis is given to the importance of operating staff being continually updated with the problems related to the recovery from accident situations, multitude failure response, etc. The principal purpose of the revision training has always been to ensure that operating staff can regularly review the operating procedures required for safe and efficient operation under start-up and shut-down, load changing and fault conditions. The training is currently for one week dealing exclusively with one operational shift group of 5-8 engineers from a specific station, the reactor simulator being programmed with the appropriate station operating parameters. Simulator training, however, forms only a proportion of the revision course programmes typical review subjects include emergency schemes, automatic control, design philosophy, reactor kinetics, radiological safety, operating rules, fault studies, post trip logic.

Other Training

The Nuclear Training Centre provides a wide spectrum of training for technical staff other than those involved directly in the operation of the nuclear stations. The type of course is changing continually to meet the current needs of the industry and includes nuclear safety, reactor technology courses for chemists and for maintenance engineers, reactor physics, health physics, reactor instrumentation and radiological protection.

Simulation Techniques

The provision of simulation facilities for any type of nuclear station training is essential because of the problems of providing 'on the job' training on an operating nuclear reactor.

Simulation of the basic dynamics of a gas cooled reactor is by means of an analogue computer driven simulator representing the major operating parameters at each of five planes in a single fuel channel thus demonstrating the effects of various operating manoeuvres on the detailed temperature and flux patterns. This basic simulation is being further developed to include the dynamics of the boiler and turbine plant in Magnox stations.

The dynamics of the AGR system are more complex than the Magnox designs with higher operating pressures and temperatures and the use of 4-8 once-through boilers, the dynamics of which are closely coupled to the gas dynamics of the reactor core. Simulation of the interaction of even a single reactor channel with the boiler and turbine on a real-time basis requires the use of a large digital computer with several interface computers to process the information required to be displayed on the replicate control desks. The major technical problems involved in constructing a simulator for this purpose occur in the development and solution in real-time of the mathematical models and computing software to represent the operating conditions necessary for this type of training. The mathematical model necessary in terms of the number of equations to be solved is significantly larger than has been used in any previous training simulators. Replicate simulators for each of the AGR station designs have been constructed.

Although the use of simulation techniques is essential it should be emphasized that they form only a part of the overall training required by the operating engineer. Experience on a full scope simulator can only benefit the student if he has previously acquired a good knowledge of the fundamentals of plant kinetics. 'Mechanistic' training only on plant procedures is not enough to ensure that the operator can understand and deal with the multi-failure type of incident.

Experience within the CEGB has shown that simulators of varying degrees of complexity each have a role to play in the overall training programme. The small analogue device can simulate the effect of the variation of a single reactor parameter and produce the type of graphs shown in Figs 3 and 4 enabling the student to understand discrete sections of the reactor characteristics.

The basic 'generic' simulator (based upon the Magnox design) enables the student to interact with the major operating parameters of the reactor without the necessity for complete replication of the station control desk. With this design a limited number of faults can be inserted by the tutor, e.g. a gas circulator failure, and the student is able to control the single channel power by means of simulated control rods.

The full scope AGR simulators go beyond complete replication of the station control desk and provide the operator with additional information to that obtained from the desk displays. For instance, the display illustrated in Fig. 5 shows the variation in feed/steam, gas and metal temperatures in the AGR boilers as major parameters

are changed from the simulator control desk. This information is not available in the station control room but enables the engineer to understand the effect of changes in feed flow rates etc., on major boiler design constraints.

Simple simulation of operating procedures with a minimum of operator interaction can also be useful for frequent procedural training. An example is the Reactor Shutdown Sequence Equipment (RSSE) simulator which has been installed at Hinkley B and Hunterston B AGR stations. This type of simulator is probably most usefully located on the station where frequent refresher sessions on procedures can be performed without the necessity for skilled tutors and computer software teams which are essential for the more sophisticated simulators.

Conclusion

The U.K. Nuclear Installations Act 1965 etc. places total responsibility for nuclear safety on the Nuclear Licencee. The CEGB fully accept this responsibility and maintain the highest standards of safety at every stage of its nuclear programme. Within this policy great importance is attached to nuclear training and whilst the U.K. is not subject to the rigid and formalised regulatory training requirements prevelant in other countries the necessary standards have been maintained by the CEGB from the begining of its nuclear programme.

Overall responsibility for training rests with the Station Manager who arranges "on-the job training" on-site and utilizes the comprehensive training facilities provided at the Board's Nuclear Power Training Centre. In addition to providing an integral and essential part of an engineer's nuclear training the Centre ensures a common national training standard. In order to maintain effective levels of training continual review is undertaken by an independant Advisory Committee.

By the clear definition of responsibility for training and the mixture of local and national training together with the ongoing review the CEGB is well organised to meet the training needs of existing nuclear stations as well as the requirements of future nuclear systems.

TABLE 1 Introduction to Nuclear Power Course (4 weeks)

Subject	Time (Hours)
Nuclear Physics	9
Reactor Physics	9
Reactor Kinetics	18
Reactor Management	9
Reactor Systems	19½
Heat Transfer	7½
Chemistry and Metallurgy	10½
Health Physics	9
Tutorials and Assessments	12

TABLE 2 Typical Projects completed during initial training

Cooling Ponds

Control Rod Systems

Burst Can Detection Systems

Reactor Guard Lines

Gas Circulator Control and Monitoring

Reactor Control

TABLE 3 Magnox Operations Course (4 weeks)

Subject	Time (Hours)	Subject	Time (Hours)
Reactor Physics	5	Reactor Incidents	4
Chemistry	6	Emergency Schemes	5
Reactor and Plant Kinetics	4	Operating Experience	3
Simulator and Projects	18	Magnox Fuel	2
Assessments	3	Health Physics	3
Reactor Plant	15	Legislative Requirements	3
Control and Instrumentation	9	Tutorials and Discussion	3
Reactor Operation	12		

TABLE 4 AGR Technology Course (4 weeks)

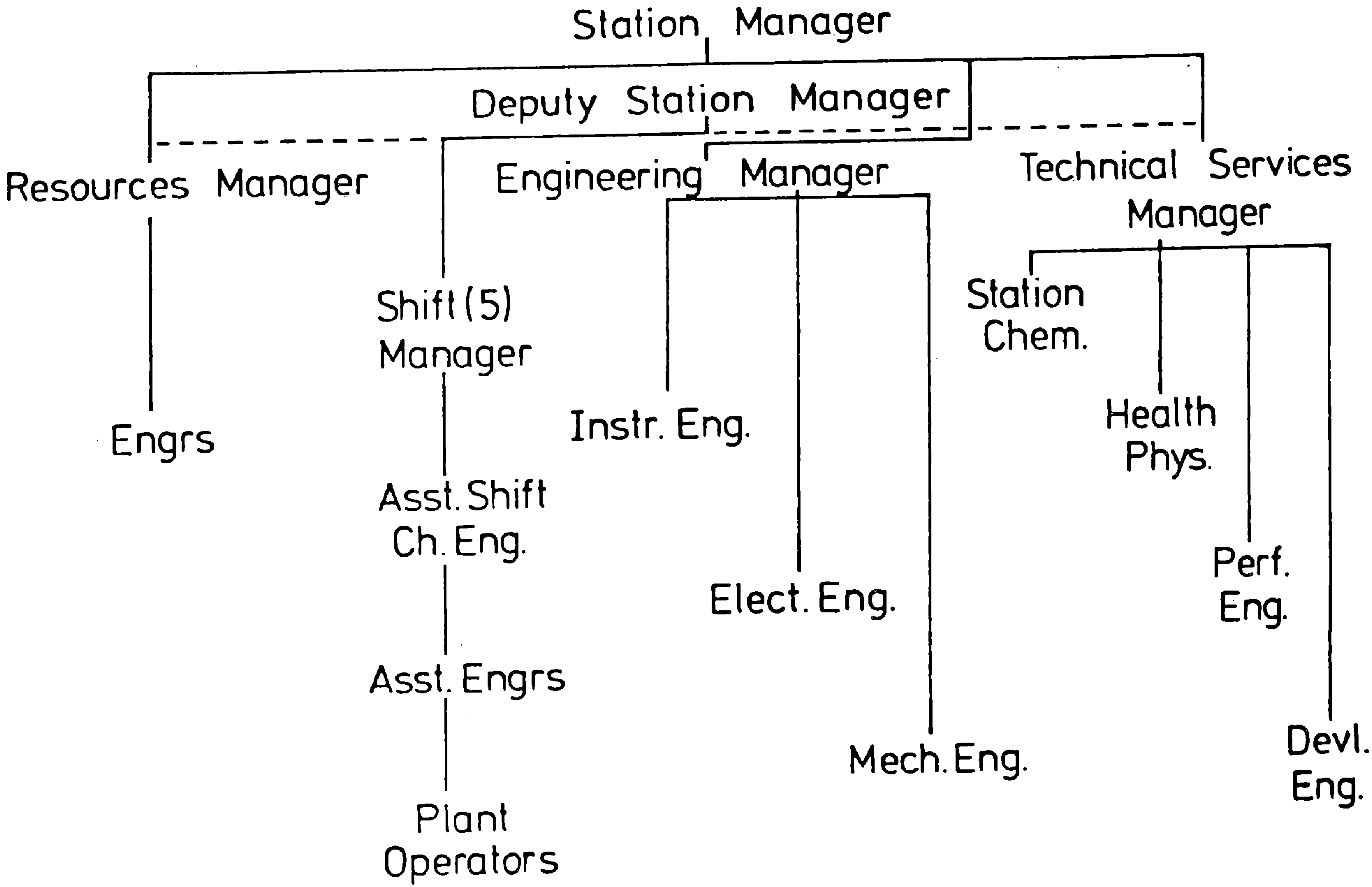
Subject	Time(Hours)	Subject	Time(Hours)
Reactor Physics	5	Computers/Application	10
Reactor and Plant Kinetics	8	Safety Systems	4
Reactor Instrumentation	2	Legislation	5
Reactor Plant Design	16	Reactor Performance	8
Chemistry	5	External Visit	6
Commissioning	5	Health Physics	4
Fuel and the Fuel Route	6	Tutorials and Projects	20
		Assessment	3

TABLE 5 AGR Operations Course (2 weeks)

Subject	Time (Hours)
Simulator (unit start up)	3
(limit loading)	3
(auto control)	3
(boiler transients)	3
(major incidents)	5
(fault operation)	5
(operator action at power)	5
(post trip logic operation)	3
(operator action post trip)	5

Subject	Time (Hours)
Physics Revision and Performance	3
Reactor Plant Kinetics	5
Normal Operation and Start Up Requirements - Discussion	3
Alternative Start Up Procedures	2
Safety Systems	3
Chemistry	3
Fuel and Post Irradiation Examination	2
Incidents at Other Stations	2
Project Work and Tutorials	5
Assessment	3

FIGURE 1



Station Manager
Deputy Station Manager
Resources Manager
Engrs
Shift (5) Manager
Asst. Shift Ch. Eng.
Asst. Engrs
Plant Operators
Engineering Manager
Instr. Eng.
Elect. Eng.
Mech. Eng.
Technical Services Manager
Station Chem.
Health Phys.
Perf. Eng.
Devl. Eng.

FIGURE 2

Training of Operations Engineers in Magnox and AGR Stations

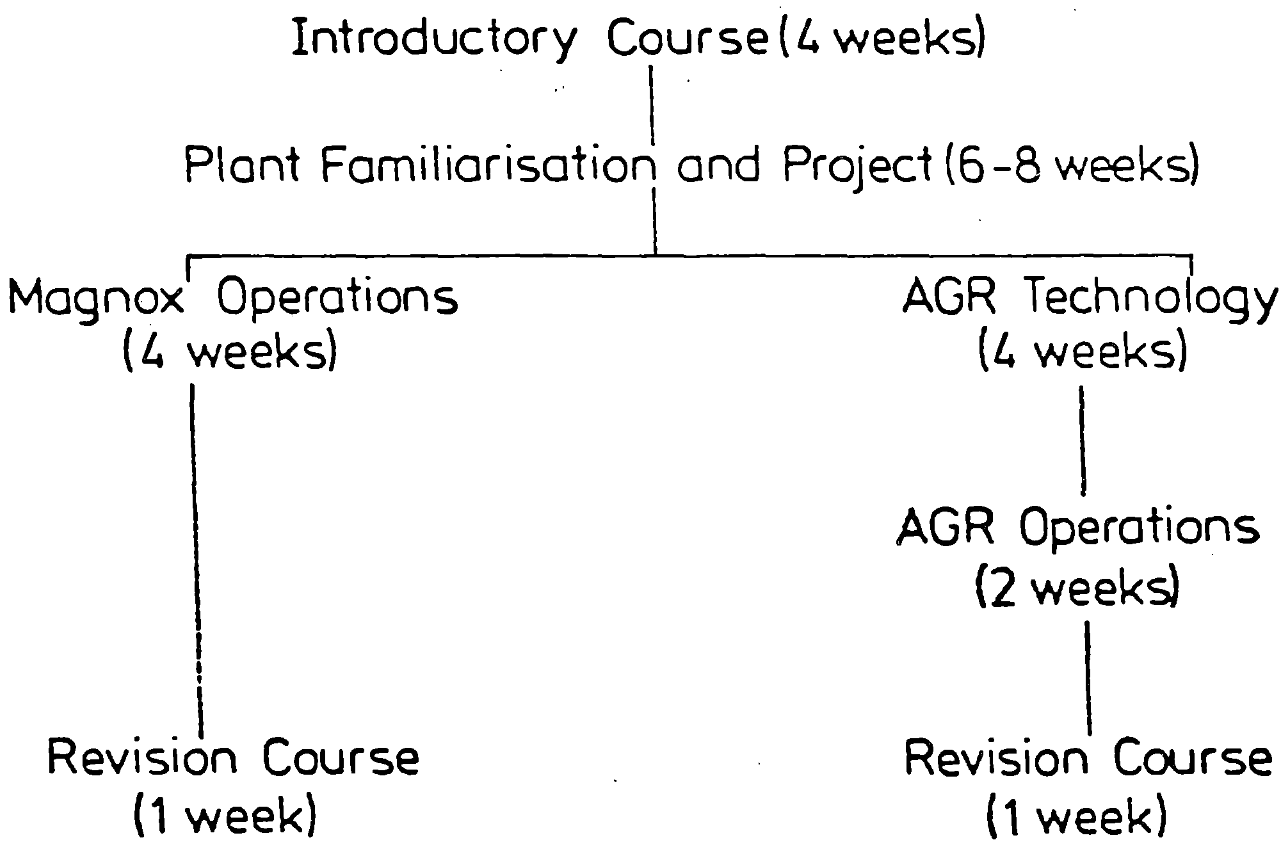


FIG. 3 TEMPERATURE AND FLUX PATTERNS IN FUEL CHANNEL

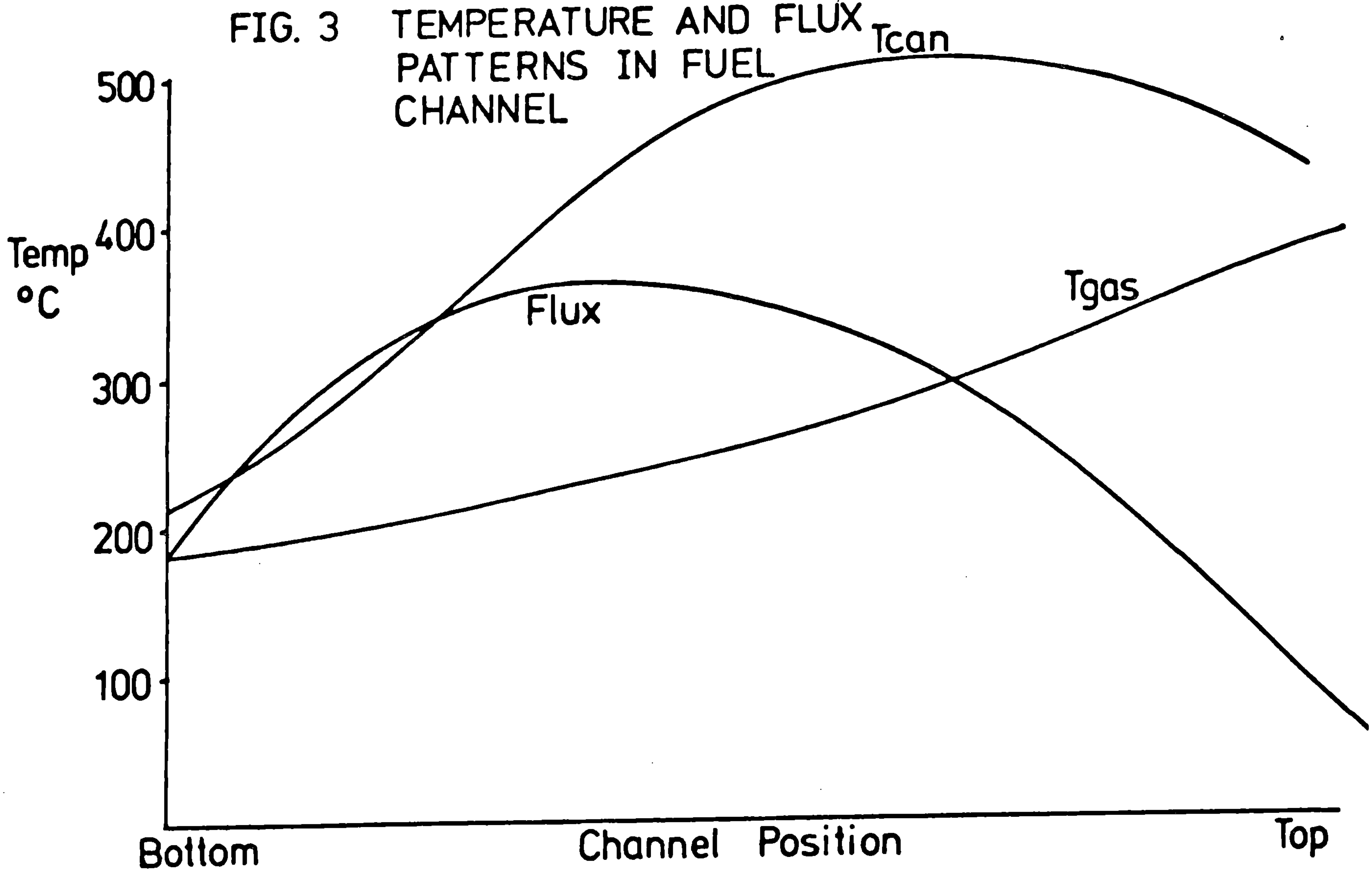


FIG. 4 VARIATION OF XENON-135 AND IODINE-135 CONCENTRATION WITH TIME

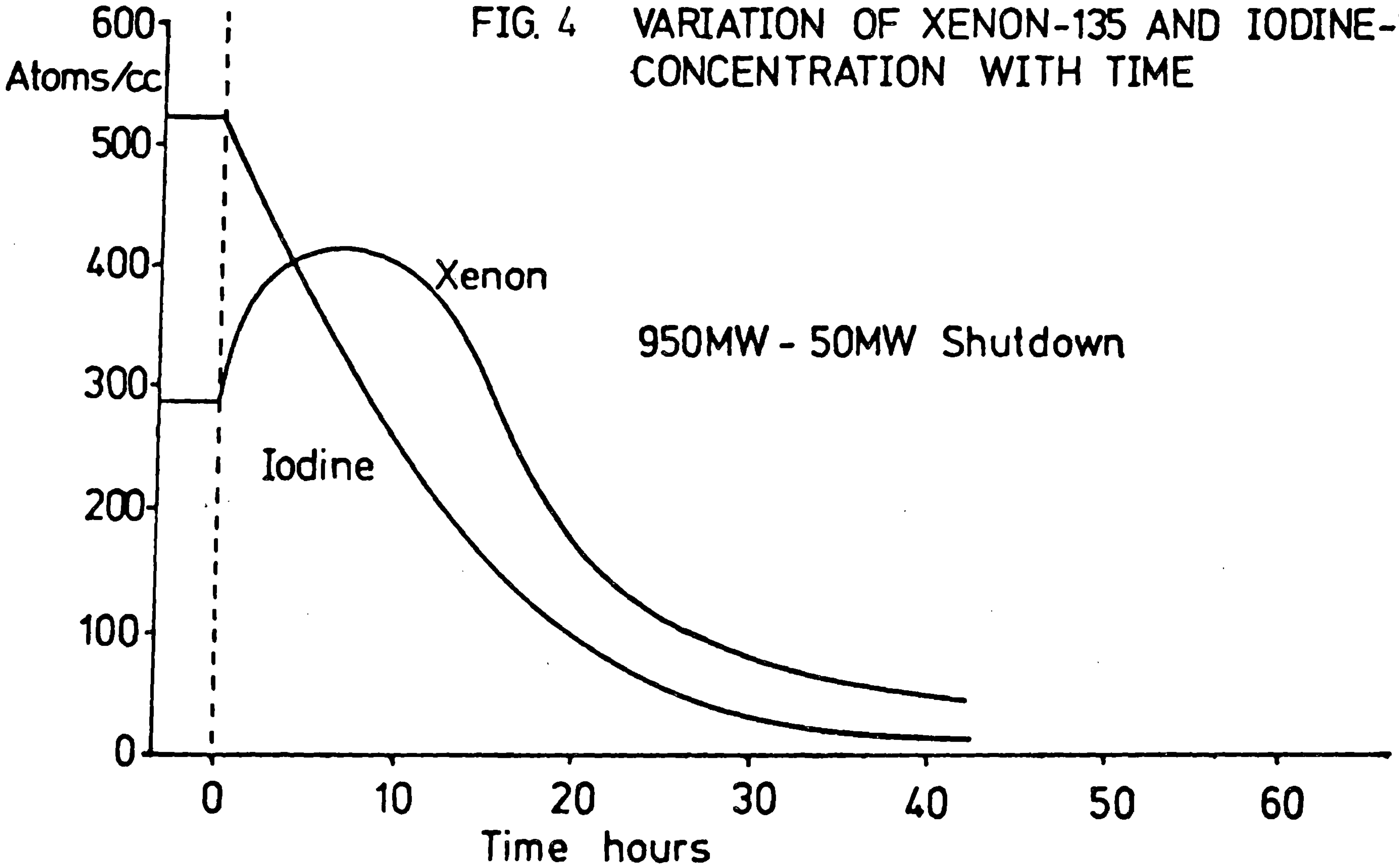
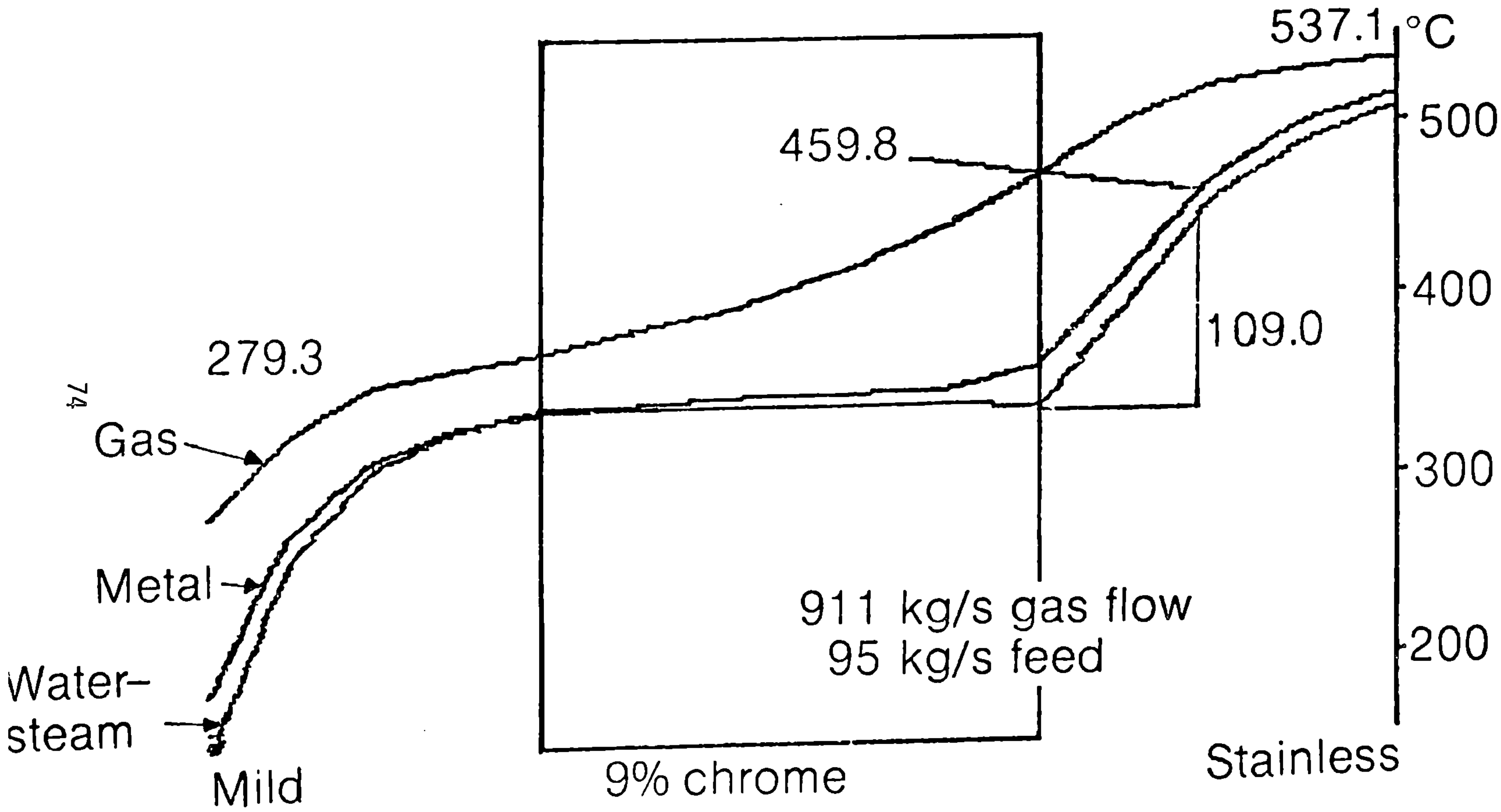


FIG. 5



537.1
°C
500
400
300
200
459.8
109.0
279.3
Gas
Metal
Water-
steam
Mild
9% chrome
911 kg/s gas flow
95 kg/s feed
Stainless

QUESTIONS TO P. B. MYERSCOUGH

R. L. Long

Q: Would you verify that the "revision training" includes one week every two years at the simulator? How much additional time is given to revision training?

A: Two weeks per year.

Warren F. Witzig

Q: How many personnel on each shift have a graduate degree (i.e., B.S.) in engineering or science?

A: A typical shift consists of shift manager (one), assistant shift managers (two), assistant engineers (four approximately). Each engineer must have graduate-level qualifications usually in engineering. These are the only shift personnel who are allowed to operate a nuclear plant.

THE PICKET ENGINEER CONCEPT IN SWISS NUCLEAR POWER PLANTS

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1. Introduction

On a worldwide comparison of nuclear energy producers, Switzerland is a small country. We have four plants already in operation, three of the 300 MW Class and one of 1000 MW, with a further 1000 MW plant under construction. Nuclear energy is of vital importance to the country, in 1980 it accounted for almost 30% of the year's total electricity production. Great economic and political importance is attached to the safety and availability of our nuclear power plants.

The first Swiss nuclear power plant (Beznau) started commercial operation in 1968. At that time one of the qualifications required for a shift supervisor, by the Safety Authority (ASK), was training as a mechanical or electrical engineer to at least college diploma level (HTL). In subsequent years, when two further plants had come into operation, the shift supervisors became increasingly dissatisfied - the interesting start-up phase and the varied first years of operation were being replaced by monotonous routine. Under normal operation conditions these well-qualified and dynamic personnel felt unable to realise their full potential. Shift work was seen as boring and socially limiting. Valuable employees left the operational staff or refused to perform further shift work. With their training and experience they were able to take up managerial posts in industry without any problem.

For safety reasons neither the plant owners nor the Authority were willing to dispense with having a qualified engineer in permanent attendance at the plant, particularly during incidents, accidents or emergencies. For this reason the concept of picket engineer was introduced in 1972, through the initiative of the plant owners and with the approval of the Authority.

Through the various inquiries from authorities and plant owners in other countries, we have become aware of the general interest in the scheme and agreed to report our knowledge and experience to this Meeting. As requested by the CSNI Programme Group, this report aims to provide in addition a general review of our training concept.

For simplicity, in the following text PE denotes picket engineer.

2. Definitions

For clarification, some specific and frequently used terms are explained:

ASK	Nuclear Safety Division. The Swiss Authority supervising safety and radiation protection in nuclear power plants.
EIR	Federal Institute for Reactor Research. The EIR is linked with the Federal Technical College and runs a reactor and radiation protection school.
A-Operator	Experienced reactor operator with the ability to stand in for the shift supervisor for short periods.
B-Operator	Reactor operator

C-Operator	Mechanic able to carry out routine inspections and operate local control panels, but may carry out switching operations only with instructions from the main control room.
HTL Engineer	Technical College engineer with extensive practical background, as opposed to an engineer (FIT, Federal Institute of Technology) with a higher theoretical education.
Normal operation	All operational conditions within the defined operating limits and specifications, particularly concerned with power generation, starting-up or shutting down the plant, maintenance, or refueling.
Incident or accident	Conditions outside normal operational conditions; suitable precautions render these harmless to plant or personnel, e.g., loss of auxiliary power, rod malfunction, turbine trip, etc.

Emergency — Low probability serious incident which threatens environment, personnel or plant, e.g., primary system pipe break, fire, serious earthquake, unacceptable release of radiation, flooding, etc.

3. Organisational Structure and Typical Practices in Swiss Plants

Our nuclear power plants are organised according to the general outline in Fig. 1. The organisational structure during normal operation differs from that during an emergency. The structure in individual plants may vary in minor details.

Normal Operation

Under normal operation the plant is run by the Operations Division, and in practice the shift crew on duty operates the plant according to a predefined daily schedule under the direction of the shift supervisor. The PE in attendance stands ready to act as advisor to the shift crew or to assume direct control during an incident or accident and during complicated operational procedures. He also acts for the plant management in all matters, whenever they are not available. Each PE also has primary tasks which fail within the field of activity of either one of the divisions or a staff officer. Typical examples will be given later. In performing these tasks, the PE is directly responsible

to his corresponding division head and works normal office hours. If on duty however, the PE is responsible to the Head of Operations and is on call, usually for a one-week period. In practice, this means that a PE is on duty at the plant outside normal working hours for one week every six to eight weeks. For this he is available from 18.00 to 8.00 h on week days and for 24 hours over one weekend. During his period of duty, and assuming incident-free operation, he performs his supervisory and primary tasks for eight hours daily. For the rest of the time, a studio inside the plant is at his disposal, where he can work, watch TV, sleep, etc.

As Fig. 1 also shows, questions related to training and further education/training are the responsibility of the training supervisor, usually a staff officer.

Safety problems are dealt with by all divisions depending on their area of specialisation and the nature of the problem. The so-called Plant Safety Commission meets as an advisory board for specific problems, if the divisions are not in agreement or at the request of one of the members.

Emergency

The shift supervisor can call the PE at any time for information or assistance. When an incident or accident occurs, the shift supervisor is obliged to call on the PE, who must be in the control room within 5 to 10 minutes. This delay can be tolerated because of extensive automation and the general observance of the 30 minute rule* for manual intervention. In the control room the PE is briefed on the incident and makes an independent judgement. He then decides, as necessary, whether to take over control himself or to act simply as an advisor to the shift supervisor. In an emergency he is, however, obliged to take control and to call the emergency staff. Until they arrive, which in extreme cases could be hours later, his decision concerning plant and personnel is final. During this time he represents the plant owner, even externally, and decides, if necessary, to warn the Authorities or alert the public. He is assisted in this by the precisely defined criteria in the emergency regulations.

General Training Aspects

A general review of Swiss training practices is given in Fig. 2 and Fig. 3. These show the training programme for shift supervisors and licensed operators in operational plants. A more detailed review is presented later in section 6.

Our basic principles:
At all stages the aim of the training is to ensure an understanding of plant interactions and physical processes, so that personnel are also in a position to interpret and control situations not specified in the "text books".

* Manual intervention in the working of the safety systems, by operational personnel, may be considered only if it can be undertaken following pre-defined instructions and without undue time pressure (guide-line 30 minutes).

In operational plants, where the candidate has not taken active part in the initial start-up programme, training usually includes three levels of practical licencing, after an initial basic theoretical licence has been obtained, i.e.

for trainee operators	1st. licence	B-operator
	2nd. licence	A-operator
	3rd. licence	Shift supervisor
for engineers	1st. licence	A-operator
	2nd. licence	Shift supervisor
	3rd. licence	PE

The procedure is slightly different for training the first operating crew for a new plant. If a candidate has participated actively in the construction and start-up programme and has several months practical experience in an operational plant of similar type then, after obtaining the basic theoretical licence and depending on examination results, there are 2 or 3 levels of practical licencing, i.e.

		3 level	2 level
for trainee operators	1st. licence	B-operator	A-operator
	2nd. licence	A-operator	Shift supervisor
	3rd. licence	Shift supervisor	
for engineers	1st. licence	Deputy	Shift supervisor
	2nd. licence	Shift supervisor	PE
	3rd. licence	PE	

In the initial operational period of a new plant the absence of experienced crew and the lack of sufficient PEs has, as a rule, to be compensated by an experienced picket crew provided by the reactor supplier.

4. Job Description of the PE

The job description and tasks of the PE can be envisaged from what has already been said. He has two main fields of activity.

1. As a specialist engineer: During his normal working days (and partly during picket duty), he is responsible for tasks within a technical or operational Division, and has the appropriate position in the organisational hierachy. These tasks form some 70% of the PE's job. Typical examples of these tasks are:

   - Head, deputy or assistant in the operations or maintenance divisions
   - Training supervisor or assistant
   - Project management of plant expansion, backfitting and changes
   - Head of special services, such as, regulations and specifications, supervision of information systems, supervision of periodic tests, evaluation of experiences, etc.

2. In PE assignments his aim is to maintain the safety and availability of the plant. Here his main tasks are:

   <u>during normal operation</u>

   - Acting for the nuclear power plant management in all matters, whenever they are not available
   - Advising the shift supervisor in all operational questions
   - Checking the smooth running of the shift, the guards and also the safety tests and specific regulations
   - Assuming supervision of the shift in serious operational incidents or accidents. Coordination and instigation of the necessary measures according to operational instructions
   - Production of incident/accident reports
   - Training the shift crew by discussion of incidents and measures to be taken, by amplification of incident and emergency instructions and by broadening their understanding of systems, etc.

- Preparing and conducting emergency drill
- Deputising for the shift supervisor as necessary

during emergencies

- Deciding whether an emergency exists
- Assuming control of the emergency and supervision of the shift until the emergency staff is available
- Informing or alerting, as necessary, the proper offices and Authorities
- Directing the emergency services eg. fire services, guards, radiation protection, ambulance. Coordination and instigation of measures according to safety regulations.

5. Requirements and Selection

The minimum qualifications accepted for training a PE candidate are:

9 years primary/secondary school

3-4 years apprenticeship with technical schooling in a mechanical or electrical engineering field. Final examination with qualifying certificate

3-4 years technical college with a diploma (HTL Eng.) in the field of mechanical or electrical engineering.

The average age on completion of the HTL diploma course is about 24 years. Normally at least 1 or 2 years practical engineering experience in an appropriate field are required for selection.

Before taking on a candidate the nuclear power plant considers his suitability i.e.

physical health - general condition, radiation fitness (blood count) and sensory organs are checked by the plant's company doctor.

psychological health and personality fitness are checked by the nuclear power plant with the cooperation of a psychological institute. The following are evaluated: intelligence/learning ability; way of thinking; technical understanding; ability of verbal expression; working conduct; ability to make decisions; self-reliance; social behaviour; leadership qualities; behaviour under pressure/stress; and as far as possible proneness to drugs or criminal behaviour.

professional qualifications and background. There are no professional entrance examinations, the HTL Diploma is recognised throughout Switzerland.

By aiming to guarantee the suitability of candidates, this selection procedure helps to protect the nuclear power plants from resignations during or shortly after training.

6. Training Programme for Operational Personnel, particularly PEs

As a general principal the nuclear power plants undertake to train the PE in cooperation with officially recognised schools. The Authority acts simply in a supervisory capacity and participates in licence examinations.

The PE receives his basic training in the form of shift supervisor training (Fig 3). As already mentioned (in section 3) this differs in operational plants and new plants. The additional training up to PE is, however, the same in both cases.

The following are the most important stages of training, with a brief description of content:

Basic theoretical course at EIR (27 weeks, full time) (A)

The course is designed to suit the standard of the participants. This means that the basic course for engineers differs from that for operator trainees. The course aims to explain the physical processes in a nuclear plant, particularly in the nuclear section. 'Programmed' instruction is given in the following subjects - mathematics, core physics, reactor design, radiation protection, energy technology, nuclear power plant safety, together with a practical course. Homework, exercises and various tests enable the trainee to apply and check his work.

Successful completion of the final examination, written and oral, enables the candidate to continue with further training, regardless of the type of plant. (Basic theoretical licence).

Plant's internal basic courses (Duration varies, see Figs.2 and 3) (B)

Adjusted to the standard of the participants, these courses provide specific information about the plant. These courses take place at the plants, in some cases in cooperation with the main suppliers.
The main aims are to provide:

- information specific to the plant, to supplement the theoretical training
- design & construction characteristics of the individual plant together with their safety aspects
- thorough systems training, including control techniques
- measures to be taken during normal operation and shut-down and during an incident or accident
- regulations.

On site training, together with theory, plays an important role here. Individual study, regular discussions and on the job training also form an important part of the course. In this way for example the PE candidate performs the duties of an A operator for at least one year.

Shift supervisor course (about 10 weeks) (C)

This training programme consists of an internal course at the plant and, for operators, a training course at EIR. The internal course lasts about 6 weeks and broadens the knowledge gained in the basic course. It enlarges upon themes relevant to managerial posts: shift management, employee qualifications, radiation protection on shift, manpower protection, fire precautions.

The 4 week course at EIR is taken by operators only. It refreshes the basic theoretical course and adds the following:

- reactor safety, specific operational and safety limits, incident/accident analyses, risk analysis, radiation release, hypothetical incidents
- energy economics, fuel cycle
- employee supervision.

PE course (about 8 weeks) (D)

The PE course includes further internal training at the nuclear power plant, mainly through individual study and joint discussion. It deals particularly with emergency situations and problems linked with safety instructions, such as:

- emergency procedures
- technical specifications, emission limits, environmental monitoring
- specific safety analysis aspects of the plant type but also managerial tasks, such as:
- guard, police action, alarm systems
- radiation protection.

In addition EIR runs a theory course of about 4 weeks length, dealing with specific themes, such as: hypothetical incidents/accidents, diffusion models and calculations.

Simulator courses

At all levels simulator courses are an important pre-condition for licencing and further training. They generally last for 7 to 10 days. In new plants a 6 to 8 week basic simulator course usually serves as an introduction for the first operational crew. The main areas of interest, according to field of activity, are:

Operators	- normal operation - operational problems
Shift supervisors	- operational problems - incident/accident conditions - communication and management
PEs	- accident conditions - communication and management - stress behaviour

Depending on the plant type simulator courses take place in Essen-KWU/PWR (BRD), Zion-Westinghouse PWR (USA), Chattanooga GE-MkI/BWR (USA) or Confrentes GE-MkIII/BWR (E).

From this rather elementary outline, it can be seen that the minimum training period for a PE is 4 to 5 years. By this time (if he enters an operational plant) he has completed three simulator courses and as well as the basic theoretical licence holds two practical licences. All this is necessary before he may even sit the PE licence examination. A further requirement for prospective PEs is the supervision of an emergency drill. This drill is observed by representatives of the Authority.

The PE licence examination is superintended by the Authority and lasts about 1/2 a day. It is oral and usually includes the following:

- discussion of the plant behaviour and what action would be necessary during a design basis incident/accident
- discussion of a beyond design basis incident/accident
- discussion of an incident with radiological consequences for the environment
- theoretical treatment of a simulated emergency in the central control room.

Together the Authority and the plant owners evaluate the professional capability and personal performance of the candidate. The plant owners must also provide the candidate's practical assessment and simulator qualifications. This procedure presupposes a relationship of trust between the Authority and the nuclear power plants, fortunately in our country this is the case. With only four plants and short distances it is still possible to get to know each other and create good working relationships.

Periodically all licence holders are re-licenced i.e.

- medically by the company doctor
- professionally by the management and training supervisor
- psychologically by the management, doctor and training supervisor.

This description of the processes of selection, licencing and re-licencing personnel clearly illustrates another principle: the assessment by several independent bodies.

Finally it should be noted that all the licence examinations, except the basic theoretical examination, are valid only for current plants.

7. Continued Education of PEs

A PE licence is obviously something which should be 'maintained'. A table is given in Fig. 4. The most important conditions are:

- regular PE work
- several weeks per year as shift supervisor
- revision courses for basic theory, as necessary
- simulator courses every two years
- participation/supervision of emergency drill.

This programme tries to account for the human failing - to overlook infrequent occurrences and routine behaviour.

A few general remarks to end all this 'dull theory'.

We believe that there is an optimum to be reached both in the initial and further training and in the licence examinations. Too little training leads to uncertainty and increased stress, too much over-taxes and causes declining interest, high personnel and monetary expenditure and dissatisfaction amongst personnel in the lower ranks - they feel unable to utilise the qualifications they have gained. Corresponding symptoms arise from too many or too few examinations. Our problem can be expressed - 'Where are we now?'.

Because of this uncertainty our requirements for personnel training and qualifications can not yet be laid down in the form of official guide-lines. Although perhaps approaching the end, we are still in the experimental stage.

8. Evaluation of the PE Concept

Since the introduction of the PE concept, we now have available 120 man-years or 24 reactor operating years of experience. The expectations of the concept have been realised:

> The nuclear power plants have been able to combine low personnel fluctuations in PE and shift supervisor groups with high availability and safe operation.

On the whole the advantages of the concept outweigh the disadvantages. The most important points according to the Authority, the power plants and the personnel are listed again:

Advantages

- satisfied and motivated shift personnel, fewer personnel changes and therefore increased operating safety and availability (retention of experience/fixed crews)
- routine operations are carried out by a shift supervisor who is qualified craftsman, for a skillful operator this is a career worth striving for and offers a satisfying job
- the shift is supported in special situations by an experienced engineer. This operational support or even change of leadership during an incident or accident provides a certain planned redundancy in manpower to analyse and diagnose the situation
- the PE is at a distance and not prejudiced by the initial events of a situation

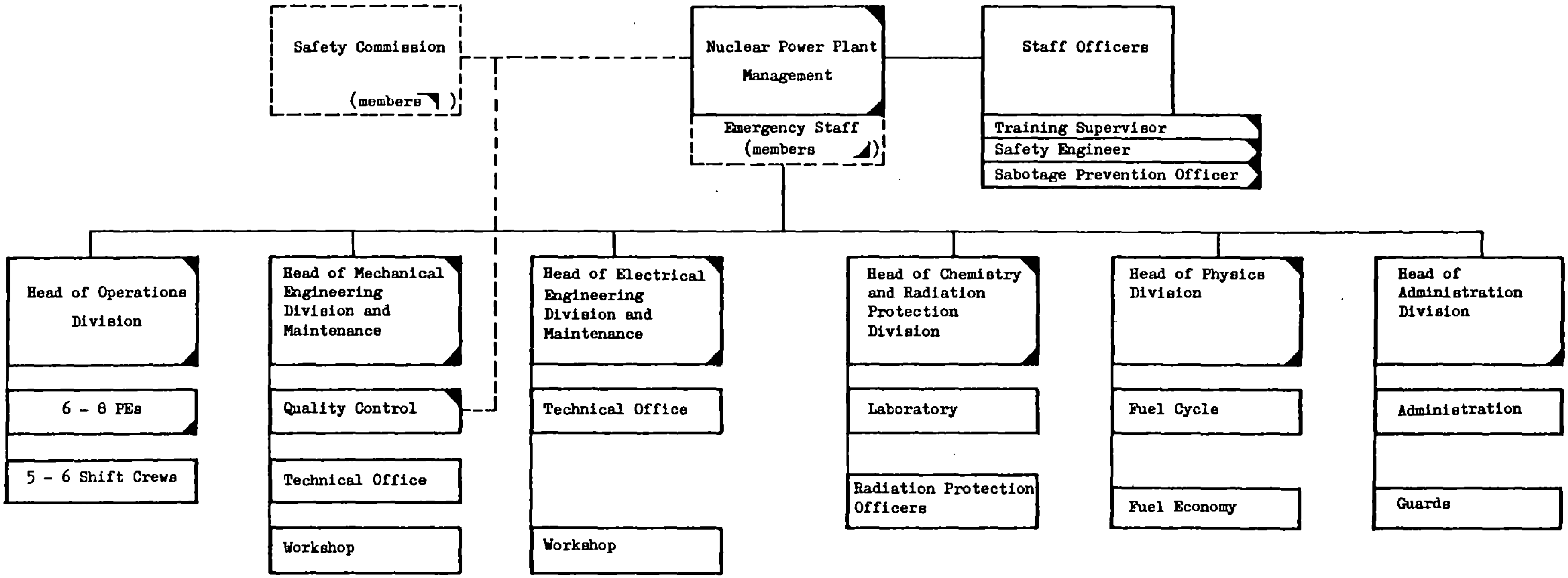
- permanent and continuous education of shift crews by the officiating PE, discussion of problems with a variety of specialist opinions (the PE duty rota is not synchronised with shifts)
- in depth connection of operational, shift and technical problems between all Divisions where PEs are active
- the PEs form a reservoir of well-qualified and experienced potential managers

Disadvantages

- the delay of 5 to 10 minutes before a PE is available at an incident or accident
- continuous availability means shift work for the PEs and even though this is relatively 'humane', with increasing age PEs find shift work increasingly burdensome
- devaluation of the position and competence of the shift supervisor
- additional personnel and expenses for the plant owners

In conclusion:

The concept described here has proved successful and is now required by the Authority as a standard solution in all operational and new plants, as a pre-requisite for granting an operating licence. The excellent figures for availability of Swiss plants in top positions on a world rating, serve to confirm our statement.



Operating Personnel Required on Shift

	1000 MW	300 MW
PE (outside normal working hours)	1	1
Shift Supervisor	1	1
Deputy Supervisor	1	–
A Operator	1	1
B Operator	1	1
C Operator	5	3

Total Personnel per Plant Unit

		1000 MW	300 MW	
Total including guards	approx.	290	140–170*	approx.
of these Licenced Personnel	approx.	30	25	
Academic or Engineering	approx.	45	20–30*	approx.
Technical or Professional		210	100–120*	approx.
Auxiliary Personnel	approx.	35	20	approx.

* Lower value for 2 Unit Plants

Fig. 1 ORGANISATION CHART FOR POWER PLANTS

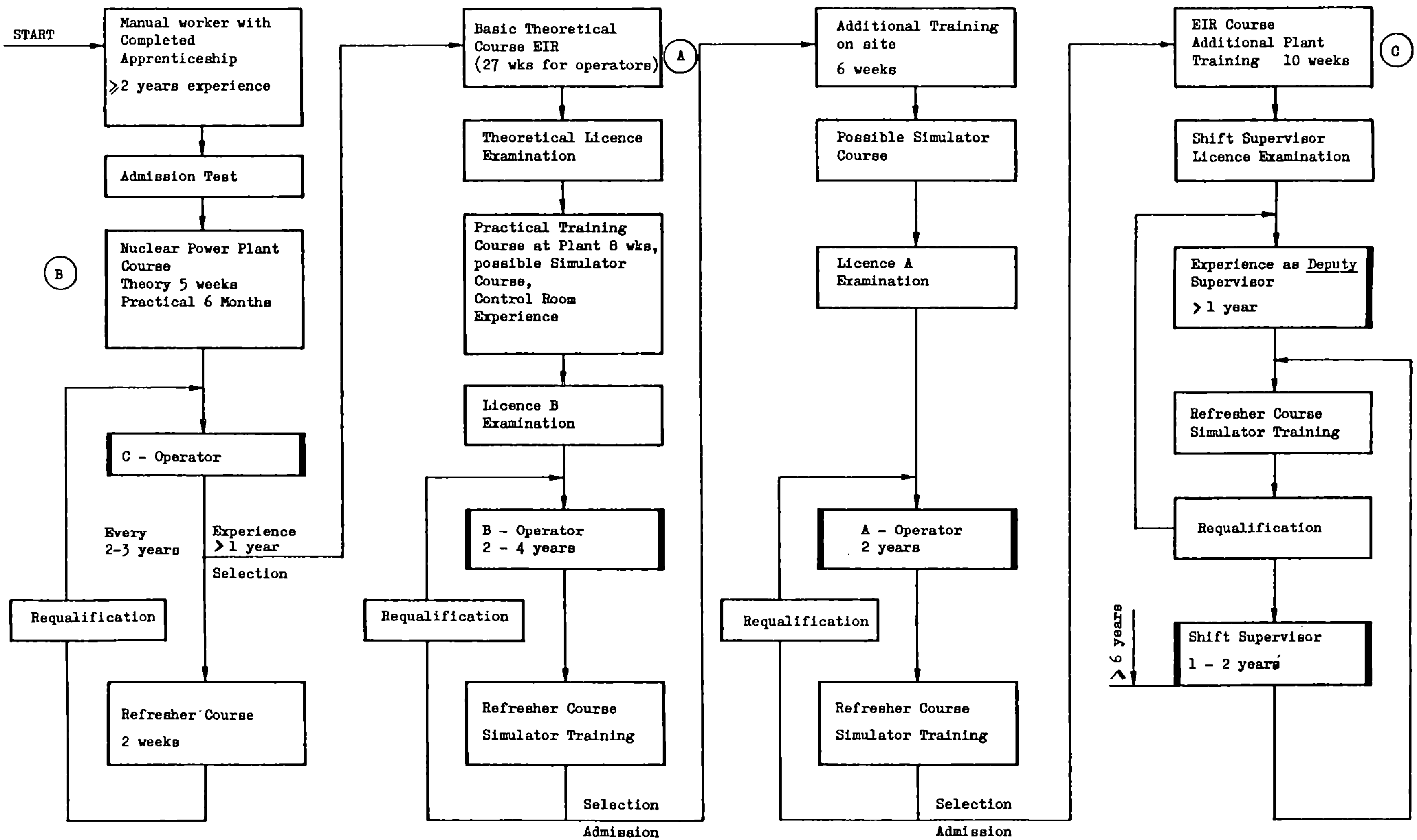


Fig. 2 OPERATOR TRAINING PROGRAMME (valid in operational plants)

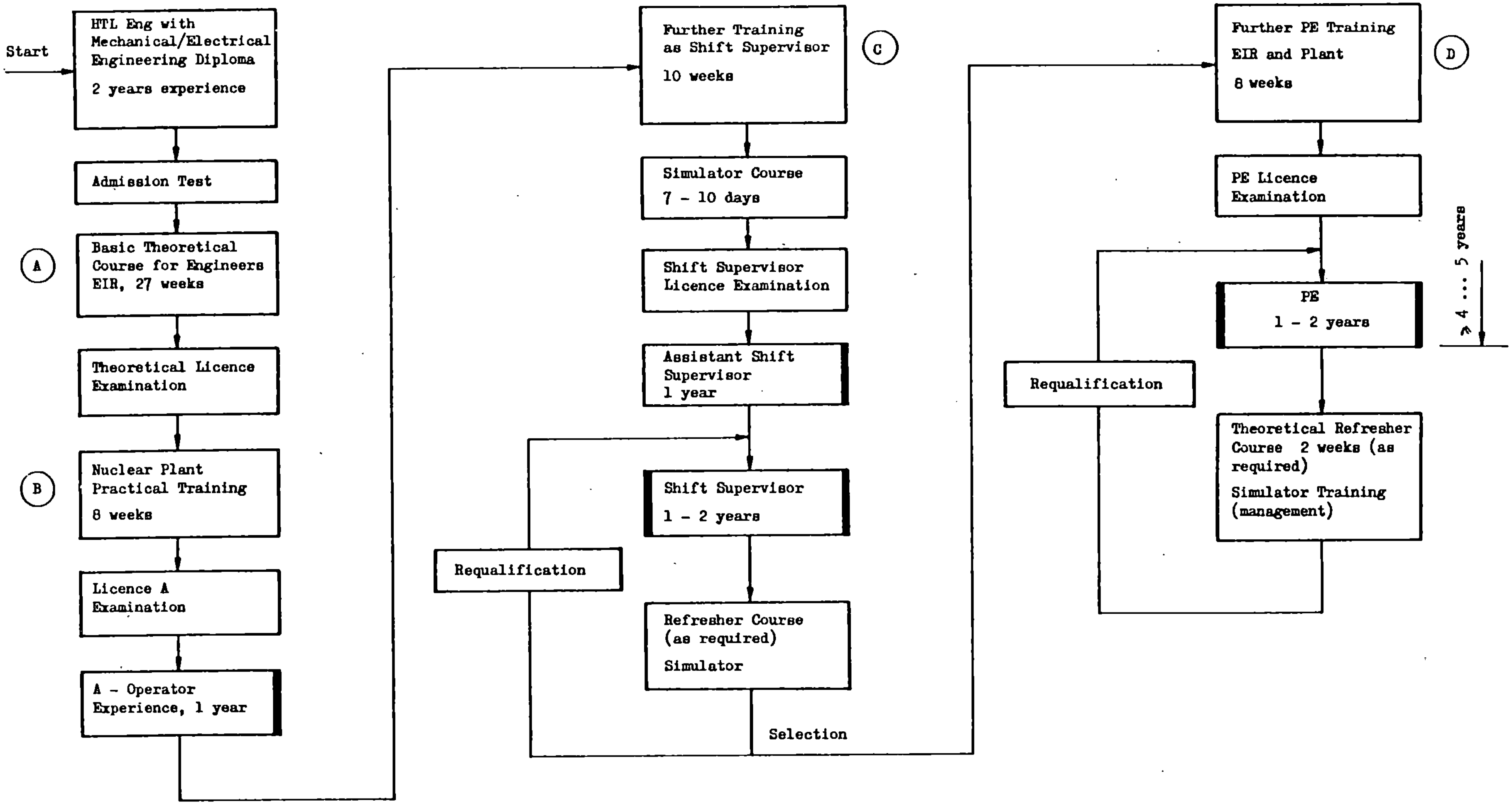


Fig. 3 ENGINEER TRAINING PROGRAMME (valid in operational plants)

Fig. 4 Table of PE Follow-up Training

Subject	PE Activity	Length/Frequency	Remarks
Shift Duty	Shift Supervisor	2...4 weeks per year	
Incident and Emergency measures	Shift Crew Instructor Speaker or Participant	A few hours per week About twice a month	With night and weekend shift crews PE Meeting with Operations Head
Emergency Drill	Planner or Supervisor	1 internal partial exercise every 3-4 months 1 full drill per year	 With external organisations
Simulator Training	At first -participant Later - instructor	7-10 days every 1-2 yrs	
Theoretical refresher course	Participant	As required every 2-5 years	EIR School
Personnel management Crisis management	Participant	About 2 days as required	Special institutes and seminars

QUESTIONS TO W. STEFFEN

S. Gronow

Q: I would like some further information on the psychological tests given to Picket Engineers. What form do they take and how long do they last? How many candidates fail these tests?

A: The psychological test is performed with every individual candidate by an experienced psychologist before the candidate starts his training. The test lasts for about two ... <u>three</u> ... four hours and contains the following disciplines:

- Anamnesis dialogue
- Structure of the intelligence
- Adaptability/memory
- Stress capacity
- Composition (written)
- Graphological test

(Structure of the intelligence, Adaptability/memory, Stress capacity: partly oral with written aids)

The average elimination rate during the last five years was 25 percent.

Van Reijen, Gerardus **Q:** How often is a Picket Engineer taking over operational responsibility from a shift supervisor, e.g., how many times a year?

Joachim B. Fechner **Q:** Could you give us any numbers on turnover rates for Picket Engineers?

A: The appropriate numbers are different in the individual plants. They depend on the operation time/experience, responsibilities of the PE and composition of the shift team.

Numbers from experience are:

Calls on the PE as advisor

0, 5 ...1 ... 2 per week

Takeover of the shift by the PE

0 .... 1* .. 10** per year

* Plants which require takeover only in accidents and emergencies.

** Plants which require takeover in transients, incidents, accidents and emergencies.

K. Stadie

Q: I should like to make an observation concerning the responsibility of the Picket Engineer during an emergency. It is said in the paper, that when we enter the control room--during an incident--he may decide to take over control or advise the shift supervisor. However, he is required to take control over during an emergency.

I submit that it would often be difficult to determine when an incident becomes an emergency. Have you any specific criteria defining this transition? (assuming that the accident progression is understood at the time?)

A: In every emergency, the Picket Engineer must take over the supervision of the shift group and record this in the shift logbook. All events which may be classified as emergencies are defined in the "Emergency-Instructions." There--beside a general definition--specific criteria

of emergencies are also given to seperate emergencies from other accidents or incidents.

In doubtful cases, the PE will also take over the supervision.

In Switzerland, not only technical incidents may be classified as emergencies but also fire, sabotage, earthquake, flooding, unacceptable release of radiation, etc.

INSTITUTE OF RADIATION PROTECTION

PAPER I-4

CSNI Specialist Meeting on Operator Training and Qualifications
Charlotte, N.C. USA, 12 - 15 October, 1981

PHILOSOPHY, PRACTICES AND EXPERIENCE IN OPERATOR TRAINING AND LICENSING IN FINLAND

M. Friberg
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1. ORGANIZATIONS

1.1 Operational organizations of the power companies

At the moment there are four nuclear power plant units in operation in Finland, two PWR-type units in Loviisa and two BWR-type units in Olkiluoto. The Loviisa power plant is owned by Imatran Voima Oy (IVO), which is a state-owned company and the main contractor of the plant was the Soviet export organization V/O Atomenergoexport (AEE). The thermal power of one unit is 1375 MW. The Olkiluoto power plant is owned by Teollisuuden Voima Oy (TVO), which in turn is owned by the companies for which the power plant provides electricity at cost price in proportion to the share each company has. State-owned companies constitute a substantial proportion of the owners. The main contractor of the Olkiluoto power plant was the Swedish company Ab Asea-Atom. The thermal power of one unit is 2000 MW.

The operational organizations of the Loviisa and Olkiluoto power plants resemble each other and they are more or less similar to the operational organizations of nuclear power plants in most other countries. At the top of the organization there is the plant superintendent, who has the technical office, maintenance office and operational office under him. The operational office has a division for the operation of each unit. The division is led by the operations engineer of the plant unit in question. The operating shifts, six for each unit at both plants, work under the leadership of the operations engineer. Each shift has a shift supervisor and two operators, one responsible for the reactor side, the other for the turbine side. At Loviisa these two operators are licensed separately for their respective jobs, but at Olkiluoto, where the division of work is not as clear as at Loviisa, the licensing examinations of these two operators are alike. In addition, the

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operating shifts include a so-called supervisor of local operations and 3 - 4 assistant operators for operational work to be done outside the control room. The operational organization is depicted in Appendix 1.

At each power plant there is one person who is responsible for the preparation, development and implementation of the training programs for operating personnel. The need for training is determined by the heads of the offices, each for his own office. As concerns the operating personnel, the operations engineers play an important part in choosing the items to be taught.

1.2 Organization of the regulatory authority

The regulatory body for nuclear power plants in Finland is the Institute of Radiation Protection (IRP) working under the authority of the Ministry of Social Affairs and Health. The duty of the Institute of Radiation Protection is to supervise the safety of all activities involved with radiation in Finland. The most part of the work connected with the supervision of the safety of nuclear power plants is carried out at the Department of Reactor Safety.

The organization of the Department of Reactor Safety is depicted in Appendix 2. The so-called co-ordination groups for supervision of operation have been set up for both plants to co-ordinate the work relative to the supervision of nuclear power plant operation. The co-ordination groups comprise representatives of each special area in the organization and they are led by a plant-specific chief supervisor of operation, who has participated in the inspection of the plant systems while examining the Safety Analysis Report, has been in charge of the supervision of the start-up testing and thus has a thorough knowledge of the plant. The chief supervisors of operation are personnally responsible for matters related to the licensing

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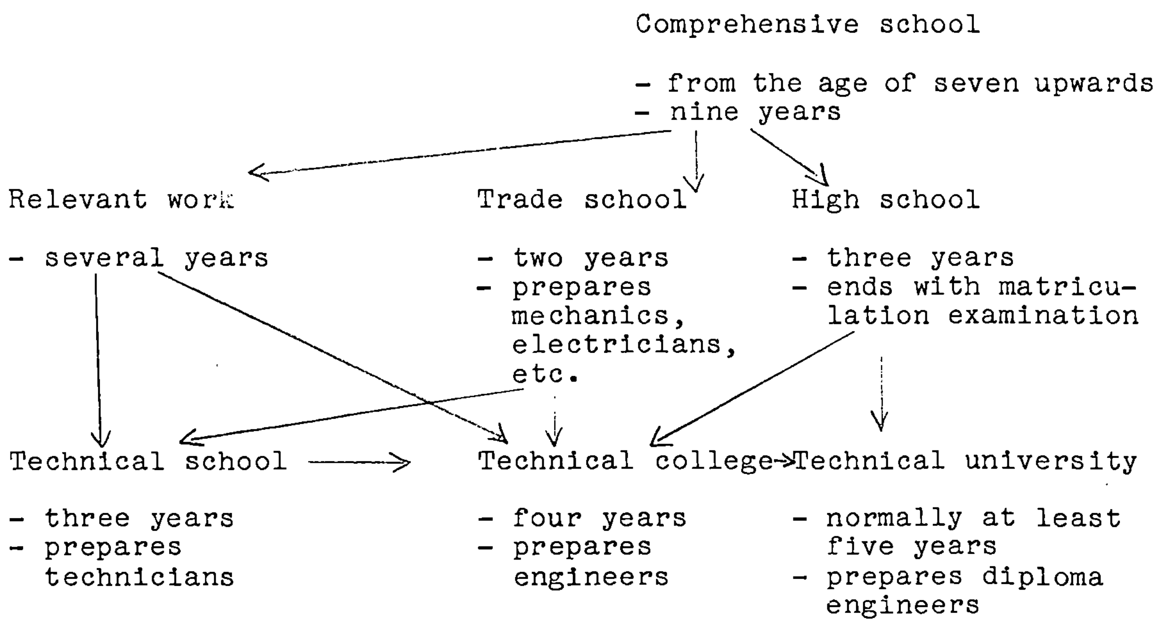
of operators. Oral examinations, which constitute a part of the licensing procedure, are held by the chief supervisor of operation together with a representative of the Systems Engineering Group, usually the chief of the group.

2. TRAINING OF THE OPERATING PERSONNEL

2.1 Requirements concerning the basic training

The requirements issued by the Institute of Radiation Protection for the basic training and working experience of operators are presented in Guide YVL 1.7 ´Qualifications of Nuclear Power Plant Personnel´. Before elaborating these requirements, it may be useful to give a brief description of the Finnish educational system, especially in regard to technical studies.

In Finland one can pursue technical studies at three levels and graduate as a Diploma Engineer, Engineer or Technician. The educational system of the technical studies is roughly as follows:



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The education in a technical school is for the most part practical and it consists mainly of classroom lectures and exerises.

The education at a technical college is comparable to education at a university, even though it is more practically oriented. It is not far from the truth to say that the degree of an Engineer is on a level with a B.Sc. in the USA. A Diploma Engineer´s degree corresponds to a M.Sc. in the USA.

An operator must at least be a technician. He must have two years´ working experience, of which one year shall be in the field of nuclear technology.

A shift supervisor is normally required to have an Engineer´s degree. In exceptional cases, a talented technician who has proved his ability as an operator may also be licensed as a shift supervisor. The required working experience is normally three years, one year in nuclear technology. If a candidate has only a Technician´s degree, the respective figures are seven years and three years.

The operations engineer of a plant unit shall have the education of an engineer and he is required to have seven years´ working expecience, of which two years shall be in the field of nuclear technology.

2.2 Training programs

The requirements and recommendations of the regulatory authority concerning the training of operators are presented in the above-mentioned Guide YVL 1.7. The requirements are mainly meant to apply to replacement personnel, because the operators of new plants have normally had three years´ education before the loading of the reactor and thus their education is thorough enough.

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According to the recommendation of the regulatory authority, the duration of preliminary training is at least one year. In addition, the duration of the on-the-job training that is required is not less than four months for shift supervisors and two months for operators.

There are no regulatory requirements for the use of simulators in training. In practice all TVO operators have been trained at a full-scale simulator duplicating the control room of an older Swedish plant. The initial training period at the simulator has been five weeks for each operator (in groups of four men). Loviisa plant has a full-scale simulator of its own duplicating its control room but the simulator was completed only after the start-up of the plant.

After the operators have been accepted, they are required to participate regularly in retraining. The requirements of the Institute of Radiation Protection concerning retraining are also presented in the above-mentioned Guide YVL 1.7. The retraining program shall be submitted to the Institute of Radiation Protection annually and the implementation of the training program is followed by means of regular inspection tours.

3. LICENSING OF OPERATORS

The licensing procedure for nuclear power plant operators in Finland is presented in Guide YVL 1.6 ´Licensing of the Operators of Nuclear Power Plants´ issued by the Institute of Radiation Protection. The licensing procedure includes medical examination, written examination, oral examination and the so-called verification of skill in work. In addition, the Guide deals with the licensing of foreign operators for the duration of start-up testing, exchange of duties and transfer to a parallel plant unit.

The medical examination of the operators is performed by a doctor who is familiar with the special nature of the operators´ work. A certificate of the medical examination is submitted to the Institute of Radiation Protection together with the application for the acceptance of the operator.

After the medical examination and passed written examination, the operator candidates are accepted as operator apprentices at plants in operation and they can take part in the operation of the plant in the control room when guided by an licensed operator. Part of the questions in the written examination are prepared by the power company, part by the Institute of Radiation Protection.

The oral examination is conducted in the main control room of the plant unit separately for each candidate. Besides the examiners of the Institute of Radiation Protection, an examiner from the power company takes part in the examination. The operators may be asked questions on any administrative or operating procedures as well as other documentation they are supposed to need in their work. The oral examination usually includes questions concerning emergency situations. The oral examination also comprises a tour at the plant, which is made to ascertain that the candidate knows the locations of the most important components and that he is able to operate the control equipment outside the control room, if need be. A report giving a grade for each question and the final result (passed/failed) is prepared immediately after the examination. The report is prepared and signed first by the examiner of the power company. The examiner of the Institute of Radiation Protection signs the report only if he agrees with the grading. Therefore the examiners of the power company

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and the IRP first discuss the result of the examination by themselves. A candidate who fails the examination must wait at least two months before he can take a new examination.

The verification of skill in work takes place while the candidate is an operator apprentice. It means that he is given a possibility to participate in different operational situations. At new plants a preliminary license is granted without the verification of skill in work, so that the reactor could be loaded and taken in service. The verification takes place during power ascension tests.

The license of an operator granted by the IRP is valid for two years. Qualifications for a renewed license are medical examination, regular work in the control room, participation in retraining and passing of an oral examination. If the candidate has not worked regularly in the control room or has not participated in retraining as required, the IRP may also request a new written examination.

Besides shift supervisors and operators, licensing examinations have also been conducted for the operations engineer at each plant unit and for the simulator trainers at Loviisa. These examinations have corresponded to the examinations conducted for shift supervisors.

The basic principles of the licensing procedure for operators have remained the same since they were first adopted about five years ago. Details and formalities have been gradually adjusted in the course of time.

4. EXPERIENCE OF OPERATOR LICENSING

As mentioned before, the retraining programs of operators are regularly submitted to the Institute of Radiation Pro-

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tection and the implementation of the programs is followed by means of inspection tours made in accordance with the IRP program for supervision on operation. Additions to the training programs are suggested by the IRP when needed. Yet the formal licensing procedure of operators described above is considered necessary. The experience gained of the implementation of the operator licensing procedure in Finland has so far been positive. Below we list some observations based on present experience.

- For their part, the licensing examinations ensure that the operators are able to perform their duties. The impression that the operator makes in the examination usually corresponds to the impression he later makes in his work. However, there are some occasional exceptions.

- Operators have a serious attitude towards the examinations, because they are not mere formalities and there are also failures (even in renewed examinations).

- The examinations reveal better than any other method the weaknesses and gaps that exist in the training of operators. The examinations have also revealed that operators have diffuculties in finding existing information by means of control room documentation. Retraining programs will be developed on the basis of the deficiencies detected in examinations.

- In renewed examinations, especially the potential modifications carried out at the plant are emphasized, which makes the effective training of operators necessary. The same applies to modifications made in operations instructions and in other administrative procedures.

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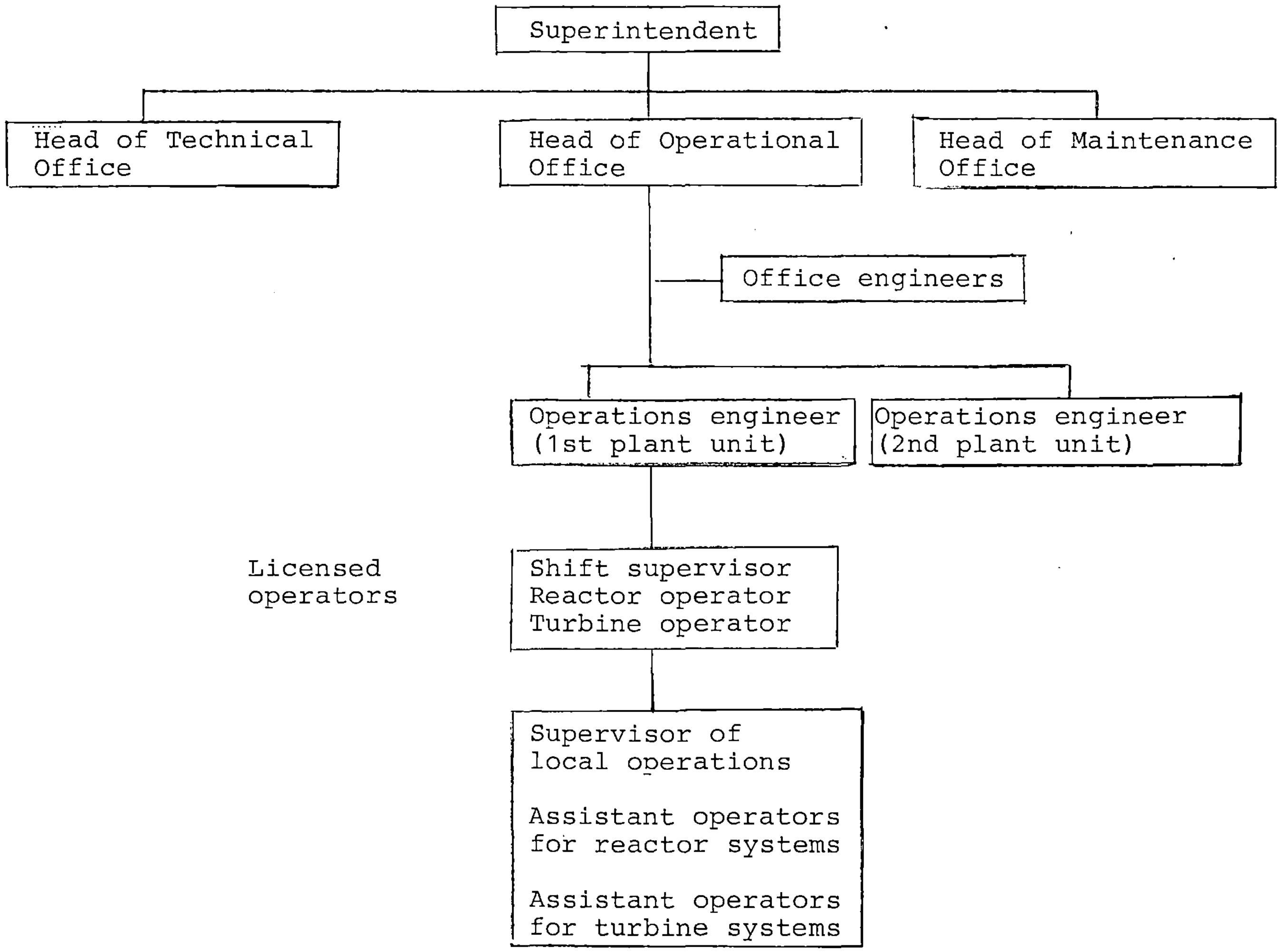
- Renewed examinations force the operators from time to time to review the operation of the plant in those accident and disturbance situations which need not be studied for the normal operation of the plant. In this respect simulator training is of the greatest importance.

- Examiners, both from the power company and from the regulatory authority, get new views from the operators on the function and operation of the plant. Due to this, the supervision and inspections performed by the regulatory authority may have a closer relation to the reality than would otherwise be the case.

STRUCTURE OF THE OPERATIONAL ORGANIZATION



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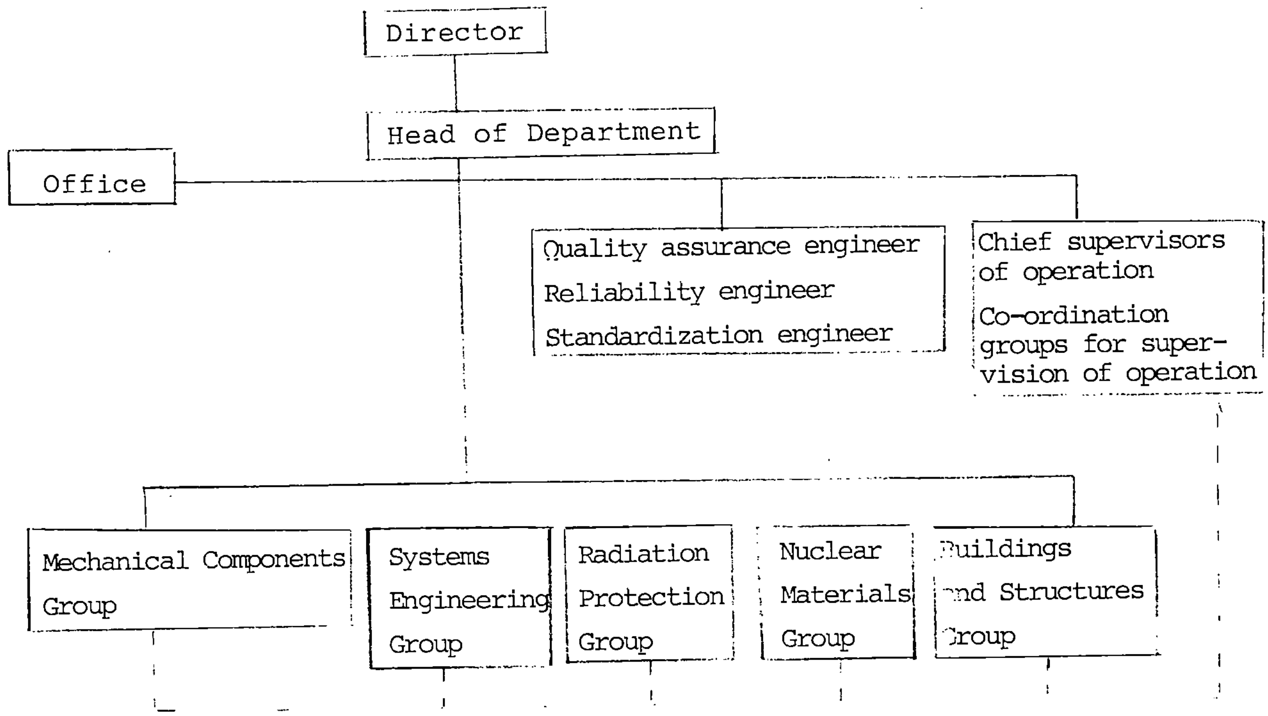
ORGANIZATION OF THE DEPARTMENT OF REACTOR SAFETY



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QUESTIONS TO LAAKSONEN

Robert Mackie

Q: You stated that the license examination results correlate strongly with the quality of later work in the plant. Did you do a formal correlational study and, if so, what measures of performance did you use?

A: We did not perform any formal study, but my statement is based only on the objective opinion of the plant operating management.

John Christenson

Q: In what language were the licensing exams for Russian personnel conducted?

A: The Russian personnel spoke their own language, and we used the professional utility interpreters to translate the questions and the answers.

K. B. Stadie

Q: I am intrigued by the fact that there are 30 Russian operators who are licensed to operate the Lovisse reactor. I presume they are licensed on the basis of the actual Lovisse reactor and not a typical Voronesh type reactor? Are the Russian operators used routinely or are they on standby only?

A: The Russian operators were on stand-by during the start-up testing stage and during the two-week long "demonstration run," which was the final part of the plant commissioning. They never really operated the plant, and they left after the plant had been taken over by the utility.

FUNCTIONS, ROLE AND ORGANIZATION OF CONTROL ROOM PERSONNEL INCLUDING SELECTION, TRAINING AND QUALIFICATIONS IN THE NETHERLANDS

Shift organization and selection

As with other complex, technical systems, the safety of a nuclear installation not only depends on the quality of the hardware but also on that of the organization, including the quality of the operators.

The importance of skills and behaviour of the operators and, more specifically, the man-machine interaction has been more and more recognised.

The plant's general organization is about the same as for other nuclear power stations in Europe and overseas. Our plant organization has three main sections:

- Operations
- Maintenance
- Health physics/Nuclear physics.

The operations group, mainly existing of shift personnel and some staff functions, occupies a central place in this organization.

This group is responsible for an efficient and safe operation of the plant, and has a big say in the activities of the maintenance group, and is involved in modifications and backfitting programmes via representations in project groups. Operators are often acting as project leaders. Operation can push the other groups to deliver their services timely and properly.

A shift exists of:

- a shift supervisor, who is directly responsible for the operation of the plant. From the control room he supervises the status of all the operating activities. He coordinates the work requests, assisted by the operations planning group, and releases the work permits. So he always knows what is going on in the plant. The shift supervisor is also responsible for the control room logbooks; he writes incident reports. The shift supervisor can be assisted by advisers, but he has to take the decisions unless he is explicitly overruled by the plant manager.

- an assistant shift supervisor. Both supervisor and assistant are licensed reactor operators.

- a reactor operator, who operates from the control room all the equipment of the plant, in particular the reactor part. He is responsible for roundmen activities and coordinates and performs periodical tests.

- two <u>operations technical men</u>. They carry out surveys and checks throughout the plant and operate the plant equipment locally.

Our aim in operator selection and training is to form a team of operators having the know-how and know-why both of the process and of the installation in normal and abnormal situations.

Ways to meet these goals are the selection of men with clearly defined education and certificates with, in addition, some experience with steam generating systems.

The educational system in our country is for the greater part controlled by the Government and in general is clearly organized with well defined levels of knowledge, difficulties, and extensiveness. Furthermore, up till now we are in the lucky circumstances that there is a long tradition that many youngsters go to sea. So we can man the shifts, in general, with marine engineers from the merchant fleet. By tradition this profession often descends also nowadays, from father to son.

These engineers are very familiar, not only with shift service and steam generating systems, but also with the great responsibilities of running complex and expensive (high-capital investment) installations. The conventionally fired plants are in principle manned by the same category of people.

Characteristic of the education and training of marine engineers is the succession, after 10/12 years of high school, of theoretical study and practical work for a range of three certificates by the Government authorized at a technical college.

The certificates are only handed out after passing theoretical examinations and acceptance of the required period of practical work on board ship.

From shift members we ask:

- operational technical men A-degree
- reactor operators B-level
- shift and assistant shift supervisors C-level

The C-level in this system is equivalent to a B.A.S. degree

After some years, many of these engineers tend to seek a shore job for family reasons.

By their training and practical, as well as mental, experience and included, their feeling for responsibility, they are very well suitable to run or maintain complex technical installations such as electricity generating systems.

Keeping sea-going jobs and passing their two or three levels of graduations, our candidates are already selected before they apply for a job as a reactor operator or, in general, in the process industry.

On-the-job and licensing

Initial on-the-job training is done to give applicant operators a well-based knowledge, theoretical and practical, of both the process and installation, so that in the end he can manipulate the systems under normal conditions and can diagnose and decide how to handle the systems under abnormal conditions. Assistant and shift supervisors are recruited from the experienced and well-certified operators; they get on supplementary training. The training programme coordinated by the operation manager and given by shift supervisors, experienced reactor operators, physicists, chemists, etc. This first training takes about one year in combination with shift-service to learn the practical part of the work. The applicant operators also spent a part of their time with the health physics and chemistry groups. The theoretical study covers:

- reactor theory
- nuclear physics
- plant systems, included reactor protection system and safety-related systems
- a two-week course on reactor physics is followed at a specialized institute.

The practical part of the on-the-job training is given on shift, the applicant operator joins as an extra man one of the groups. He has to go through the complete task of the operators, guided and watched by operators already licensed, who remain responsible for what is done.

Before an operator is licensed he has at least once:

- to make a reactor start and warming up of reactor and turbine
- to bring the reactor to full power
- to start the auxiliary systems of reactor and turbine
- to shut down the reactor and to close down the reactor and turbine sub systems
- to start the reactor cooldown system
- to cooperate in preparing the reactor for refueling and to do fuel handling himself
- assisting in carrying out periodical tests of the safety and control systems of the primary loop.

There are emergency procedures. The operator has to know them but is not supposed to follow them blindly. The built-in, automatic actions of safety-related systems give the operator some time to decide what way to follow to bring the installation in a safe condition.

The operators are tested on a number of subjects:

- reactor theory
- radio chemics
- health physics
- turbine and generator with sub systems
- safety-related systems and emergency procedures
- electrical systems.

The results of an examination are judged by the examiner together with the operation manager.

It is the utility that qualifies the candidates under full insight and supervision of the authorities.

The government is having the licensing procedure under review, but no more changes have been proposed so far. It is more or less a formalization of what has been common practice up till now.

<u>Retraining</u>

All the reactor operators, assistant shift supervisors and shift supervisors are told to join a two-year retraining programme.

The retraining subjects and the time spent on it are registered individually on personnel retraining overview charts. The theoretical part is the same for everyone involved in this programme and contains:

- Emergency procedures, Technical Specifications, Safety Reports
- System modifications, Working of control systems, Working of Safety-related systems
- Reactor physics, Thermal hydraulic behaviour of the reactor, Dynamic behaviour of the Health physics reactor-turbine control loop
- Discussions of incidents (loss of coolant).

This is given in two days a year.

The practical part is individual and handles with:

- evaluation of plant disturbances
- reactor start, shutdown
- system tests
- fuel handling and refueling

to mention some items.

Then there are real exercises, such as trying out alarm schedules, fire fighting, first aid, the use of compressed air masks, but also fuel handling and waste preparation.

Simulator training

Our plant, and many others, are doing so well that operators have quite seldom the opportunity to start or stop the reactor, and, of course, it is impossible to exercise incidents with a real plant.

For long periods the only real manipulation with the reactor is to lower the power rate to about 25% every three months to do some turbine control valves tests. So we agree that plant simulation can be a useful means of operator training. We see it as additional to our training programme, and we will integrate simulator training into this already existing programme.

We have the impression that simulator training sometimes, pushed by the TMI-incident, is overfocused and is advertised as a remedy for every operator or operations organizational problem. This,

we think, is not true. Neither is it true that each problem can be solved by replacing the operators by on-line computers running the plant for us.

While our main aim in training and retraining is to base operator knowledge and experience on the how and why of process and installation, we have decided to build up a simulator based on a design concept that makes it possible to experiment also with man-machine problems. This simulator will, in its principle lay-out, not be a full scope, a generic, or a basic principle simulator, but we are experimenting with a computer for the system models and the process sequence, with CRT's for display of system diagrams and information.

The operators will manipulate this simulator and communicate with the aid of key boards, trigger-ball, function switches, etc. This concept makes it possible to build up, refine, and extend the simulated parts of the installation and the process step by step. Disturbances can be introduced in the same way. Another feature of this simulator concept is the possibility of feeding it with data from the real process, to which disturbances can be added.

<u>Involving operators in plant occurrences</u>

After this information on selection, training and the use of a simulator, and after I have tried to give you an idea of our training philosophy, it is worthwhile to tell you how we keep the

operators involved in many activities concerning the total installation. We do this again to give them a fair chance to get a solid knowledge of the how and why of the process and the installation and, also, this is a way to prevent them from becoming bored while working long shift periods on a low-activity level. So they are involved, operators and shift-supervisors, in nearly everything that has to do with the installation, both hardware and software. Involving the operators into this field means that they have their say or are even responsible for it, can discuss and give their critiques on those items. We think this to be a useful way to keep the operators alert and openminded for what is going on in the plant.

Another feature of our ideas about training is that the operators in an abnormal situation should take their time to collect and interpret/diagnose parallel information before they react and start to manipulate the installation.

By its nature, a nuclear process in this sort of installations have a large time constant for the process parameters that are not controlled by automatic devices.

In same smaller incidents, system disturbances, the operators had the opportunity to show that it worked out alright. To mention a leakage from a weld in the main feed water line, leaking control rod drive mechanisms, complete loss of feedwater.

Our training programme, in fact, is more than a programme in which we try to teach them the mentality we consider to be required for running a nuclear power station, it is supported as mentioned already by giving the operators also other tasks than just shift service. We try to release the operators from shift service, for say 10% of their time, to work in daytime service on partly routine jobs and partly special jobs. For example, they are working then on:

- holding up-to-date:
  - o system drawings and diagrams
  - o check lists
  - o system descriptions
  - o emergency procedures
  - o system administration
- evaluation of plant disturbances (foreign and own plant)
- modification and backfitting plans in close cooperation with maintenance and engineering departments
- handling fresh fuel and preparing the transport, flask loading of spent fuel
- troubleshooting
- instructing outside workers in fuel handling
- waste preparation for final disposal.

The operators and shift supervisors act also as project leader, when there are opportunities. For example during the refueling outages and system outages one of the shift supervisors is always in charge of the turbine revision, preparing the programme

together, with the manager of the mechanical maintenance group, and, during the outage, he is responsible for the complete job, with the obligation to report to this manager.

<u>Control room lay-out</u>

Already in an early design stage of the control room of the Dodewaard station, attention was given to man-machine interaction problems and to the work environment for the control room personnel. Purposely, no use was made of the so-called miniaturized panel system. So a clear separation was made between the systems on large scale panels in a logical arrangement. The total manipulating possibilities, the alarms and other information on these panels are limited to what is essential to manipulate and control the installation. Apart from the panels, there is a desk with all devices to manipulate and control the reactor. Sitting behind this desk, the operator also has a good view over the other panels to survey the normal plant status, and the situation of safety and emergency systems. Complete information on plant status and alarms are given by the datalogger automatically or on request.

One of the lessons learned is that more attention can be given to the arrangement of switches, measuring instruments, and so on. The same applies to the alarms. Further, it would be helpful for the operators that the information on the alarm panels could be selected and reduced in abnormal situations, as done in the datalogger.

As an example, we rearranged the complete instrumentation of the feed water and reactor level control panel. The already existing plans, made in close cooperation between operators and engineer, were in fact speeded up by the TMI incident.

The TMI incident was not an interference in our plant life. We had already been working on a system modification and backfitting programme. As a result of studying the information that came available after TMI, those programmes have been changed where appropriate, both on our own initiative and at the request of the Government. And again the operators were involved in studying the reports, and reviewing our plant systems, check lists, emergency procedures, etc.

It may be worthwhile to say something about the control room organization. The operational technical men normally do their work in the plant. The operators work in the control room. But we consider it to be very important that operators and shift supervisors make an inspection tour at least once every eight hours of the whole plant, turbine building, reactor building, etc., and we made this tour to a standard routine. So they know what is going on in the plant and they do not forget how a turbine or a pump vibrates and how oil and steam smell.

Senior reactor operator

Now we have seen background and experience of our shift supervisors and operators, how we hold them responsible for

knowing and running the installation both under normal and abnormal conditions.

I outlined the retraining and the continuously on-the-job training programme we have. With the foregoing in mind, I hope that you will understand that we do not see what function a senior reactor operator can have in our organization. We are only afraid that the presence of a senior operator or technical advisor would make the other uncertain, feeling overruled, and easily running into discussions for example about who is responsible for what. We have also our problems with the ideas one can hear leading towards so called completely automated or computerized systems. What to do with electronics advisors? What information has the operator to trust and who is to be held responsible if the electronics advisor gives a wrong advice?

Some conclusions

- Plants need well-educated, well-trained operators who are very familiar with the layout of the plant, the design of the systems, knowledge of the process, and a sound feeling for what they are working with.

- Attention has to be given to control room layout, man-machine interaction and to presentation and selection of plant information.

- A simulator can be a useful device helping the operators to do a better job, but its value should not be overestimated, it is just one of our tools.

- After TMI there is a tendency to over-focus on the role and behaviour of the operators, one could really get nervous being analysed and watched by so many specialists.

- Of course, we agree that it is of great importance to study and experiment on all the special items handled by this conference, but that is not only valid for the nuclear business. And, of course, we hope that those studies will end in results that are transferable to the daily routine of nuclear power stations operated by normal human beings to help them to do their jobs with enthusiasm in an efficient, reliable, and safe way.

QUESTIONS TO LOBBEZOO

P. E. Blomberg

Q: Is the possibility of feeding the simulator you described with data from the real process performed on line? Also, does the simulator thus operate in parallel with the real process?

A: Yes, it is performed on line so

1. this gives the possibility that the simulator operates parallel with the real process, the simulator is then open-ended
2. the situation of the real process can be used as a starting point for one simulator run. It gives also the possibility of feeding/backtrack/playback of what happened with the real process.

K. B. Stadie

Q: I am intrigued by the fact that there are 30 Russian operators who are licensed to operate the Lovisse reactor. I presume they are licensed on the basis of the actual Lovisse reactor and not a typical Voronesh type reactor? Are the Russian operators used routinely or are they on standby only?

A: The Russian operators were on stand-by during the start-up testing stage and during the two-week long "demonstration run," which was the final part of the plant commissioning. They never really operated the plant, and they left after the plant had been taken over by the utility.

QUESTIONS TO LOBBEZOO

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The Nuclear Power Plant Operator - A Safety Barrier - Regulatory Requirements in the FRG -

J. B. Fechner, Federal Ministry of the Interior,
Bonn, Federal Republic of Germany

1. Introduction

The great extent to which the operating personnel can influence the safety of nuclear power plant operation has been demonstrated by the incidents at the Brunsbüttel and at the TMI 2 nuclear power plants in 1978 and 1979, which all of you certainly know. The results of the German Risk Study [1] show that the large contribution (about 72 %) of a small break LOCA to the overall probability of a core melt accident is mainly caused by human error events. These few examples already indicate the operator's potential to contribute to nuclear safety as a risk factor. On the other hand, the safe operation of the German nuclear power plants within their limits and conditions for about 130 reactor years since 1960 clearly shows that operators in the first place act as safety barriers: they monitor plant operation, diagnose and correct malfunctions of systems or components, recognize and analyse dangerous plant states, initiate necessary safety actions or emergency measures, supervise maintenance and repair activities, act as key communications men of the unit, etc. .

Design principles like redundancy and diversity have been applied to the design of all items important to safety, and automation has been carried to such an extent in German plants, that manual actions of the operating personnel during normal operation are only necessary for slow control functions. In case an accident occurs, fully automized safety actions will transfer the plant into a safe state in which it could remain

for about 30 minutes without causing danger to the personnel, the environment or the plant. Thus shift supervisors (SS) and control room operators (CRO) have been put in a position to assess all available information on the plant state and on the course of the respective event thoroughly and to decide on corrective actions without being pressed to react immediately along pre-planned instructions. In cases where the accident sequence deviates from what has been analysed before - and I believe that this will happen in most cases to a different extent - plant safety will depend mainly on the operating personnel, in spite of automation. The operators' ability to respond flexibly to this unknown situation on the basis of their training, experience and in-depth knowledge of the plant, and to assess rapidly large amounts of information will make them indispensible and irreplaceable "components" of the safety system.

For these reasons operating personnel and especially SSs and CROs have to meet safety requirements regarding their qualification as stringent as those specified for other safety related components of nuclear power plants.

2. Regulations and Guidelines

The importance of the qualification of personnel as regards the safety of nuclear power plants had already been clearly recognized in 1959, when the Atomic Energy Act [2] - the legal basis for the licensing of construction and operation of all nuclear installations - was put into force. Article 7 of this act states that a licence to operate a nuclear installation may be granted only if, among other prerequisites such as safe plant design, technical safety features, security measures the following requirement is met:

"No facts shall be known give rise to any doubt as to the reliability of the personnel responsible for the management and control of the operation of the installation (responsible personnel), and these personnel shall have the requisite competence."

Because of the large amount of responsibility they are vested with, and because of their ability to affect directly the safety of plant operation, the following functions belong to the responsible personnel category:

station superintendents, health physicists, operations superintendents, maintenance superintendents, technical superintendents, training officers, shift supervisors, control room operators and their respective alternates. For these personnel the legal qualification requirements cover reliability and requisite competence.

The licensing requirement of article 7 of the Atomic Energy Act concerning the qualification of personnel has been further specified for nuclear power plants in three guidelines on

The proof of the requisite competence of responsible personnel [3]

The contents of the examination of responsible shift personnel [4]

The requirements for retraining programmes for responsible shift personnel [5].

These guidelines were established in 1978 and 1979 by the licensing authorities, and they are administrative agreements forming a common basis for uniform actions by the authorities. They are not legally binding; however, through licensing decisions or directives of the authorities they will become binding for the applicant. The experience of the utilities

regarding selection and training of operating personnel has been evaluated for the drafting of the guidelines.

3. Requisite Competence of Shift Personnel

The requisite competence of SSs and CROs - as well as that of other responsible operating personnel - comprises a successfully completed professional training, knowledge of design and operation of nuclear power plants, practical experience in nuclear power plant operation. This means, that the respective candidate shall have

(1) at least a professional qualification as a graduate engineer in a technical subject for SS, as a technician or master craftsman for deputy SS, as a technician or craftsman for CRO;*)

(2) safety-related knowledge - adjusted to the responsibilities of the respective function - in fields such as nuclear physics, reactor physics and engineering reactor safety, radiation protection, fire protection, work safety, nuclear and radiation protection law, design and operational behaviour during all operational states and accident conditions of the plant, operating manuals and instruction (including operational limits and conditions, emergency procedures), directives of the authorities and relevant safety standards;

(3) the ability to specify, initiate and execute all measures and actions necessary for safe operation of the plant and for the assurance of safety in case of potentially hazardous events;

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*) Craftsman is equivalent to 3 years, technician to 5 years, master craftsman to 6 years of vocational training at a technical school including practical work in industry and an examination controlled by the Chamber of Industry and Commerce or by the government. Graduate engineer is obtained through 3 to 4 years of practice-oriented studies at a technical college including a government controlled exam.

(4) a certain minimum of practical experience:

SS and deputy SS: three years in a nuclear power plant, including two years with the operations department and six months as control room operator in the plant of the applicant;

CRO: one and a half years with the operations department plus six months on shift in the plant of the applicant.

The safety-related knowledge of point (2) and the abilities of point (3) are to be obtained through special basic nuclear training (often at off-site training centres), through plant-related training by vendor courses and at simulators, and through intense in-plant training by the utilities. Participation in commissioning activities is regarded as being of ultimate importance for the knowledge of the plant and it's operational behaviour. A minumum duration for training in fields like nuclear physics, reactor physics and technology, reactor safety, radiation protection, fire protection and work safety hàs not yet been prescribed by the authorities; however, activities are under way to specify a minumum of three (for CRO) or four (for SS and deputy SS) months training for these fields plus additional four (for CRO) or six maybe eight (for SS and deputy SS) weeks of simulatortraining.

In practice, the utilities meet and in same cases even go beyond the above mentioned minimum requirements:

- 40 % of the SSs or deputy SSs are graduate engineers, 45 % master-craftsmen; 40 % of the CROs are master-craftsmen, 40 % craftsmen, 20 % technicians;

- more than 5 months basic nuclear training plus 2 months of simulator training;
- 6 to 8 months of special courses on plant design and operation;
- 2 to 4 years of practical experience in fossil-fired plants, at research reactors or on merchant-ships in addition to the required nuclear experience. However, only for control room operators a maximum of six months' experience gained at fossil-fired plants can be regarded as compensatory for the nuclear experience under point (4).

Unfortunately, the number of SS or CRO candidates with extended practical experience in fossil-fired plants has decreased from about 50 % to about 15 % during the last 2 years.

For nuclear power plants just commencing their operating life additional training at a simulator, participation in design, construction and commissioning of the respective plant may be accepted to a certrain extent as a substitute for the required practical experience by the authorities.

The applicant (utility) has to prove the requisite competence of his candidate-CROs and -SSs prior to the commencement of nuclear commissioning by submitting relevant documentation to the regulatory authority. Furthermore, the candidates for CRO, SS or deputy SS functions have to pass a written and an oral examination successfully, which covers the safety-related knowledge of point (2) and the abilities of point (3) and will be dealt with in part 5 of this paper.

4. Graduate Engineer v. Master Craftsman

Before the incidents at Brunsbüttel and Harrisburg a professional qualification of master craftsman instead of the qualification of a graduate engineer had been acceptable to the authorities for shift supervisors. This requirement was enhanced in 1979 in consequence of these

incidents: shift supervisors now have to be graduate engineers. In cases where SSs do not hold a graduate engineer degree (operating plants and plants going into operation until the end of 1983) a responsible shift engineer (SE) has to be permanently on site in addition to SS and deputy SS by January 1, 1984.*) He is responsible for the safe operation of the plant by his shift crew in all operational states and accident conditions, and he can give orders to SSs and deputy SSs. The SE has to keep himself fully informed of every detail concerning the plant operation to the extent necessary to meet his responsibility for safe operation; he shall be capable of taking full command of control room activities without delay after a malfunction or any significant deviation from normal operation has occurred.

This decision of the regulatory authorities was based on the conviction, that only the knowledge, abilities and practical experience listed under points (2) to (4) in part 3 of my paper in combination with the expertise and the personal qualification of a well trained graduate engineer can ensure best that the operating personnel will act as a reliable safety barrier under all circumstances; the authorities further believe, that the engineer's expertise is indispensable in the control room after an anomalous event has started to develop.

There have been a lot of critical comments by labor unions and by utilities on this modification, saying that engineers will feel underemployed and bored by routine operation and demotivated by shift work, and will soon try to leave the shift supervisor or the SE function. Such a situation would lead to increased fluctuation of qualified personnel and - as a very serious consequence - to a permanent loss of practical in-depth knowledge of the plant and of its operational behaviour. Several utilities even have argued that for normal operation a master craftman-SS practically would be

*) Infact, since 1980 new nuclear power plants will be licensed only if all SSs will be graduate engineers.

as qualified as a graduate engineer; a complete and analytical understanding of operational deviations leading beyond the normal operating range would be not needed for the SS, who should just follow the instructions of his operating manual. For malfunctions or accident situations a graduate engineer, who is on call and responsible for other functions elsewhere in the plant, would suffice as a better trained partner for the analysis of the respective anomalous event.

The authorities keep an eye on the possibility of demotivation and increased turn-over rates for graduate engineer-SS's, and they will try their best to avoid such a development which could be counterproductive to safety. However, up to now there is no clear indication of an increase in turn-over rates. Furthermore, the authorities believe that by job enlargement and diversification (for instance safety analyses, planning of major repair activities, training of operating personnel) by relieving SSs from non safety-related routine tasks (documentation, record keeping), by further increasing the autonomy and independence of the SS's position, by increasing public recognition of his importance as a safety barrier (social standing), and by better payment the SS function can be made sufficiently attractive for engineers.

5. Examination of SS and CRO

Shift supervisors, their deputies, shift engineers and control room operators have to pass a written and an oral examination successfully, before they can be authorized for their respective functions in the respective plant. The examination is held by a board of examiners, which consists of three members of the responsible personnel category of the respective plant, two outside experts under contract to the competent authority, and one representative of the competent authority.

The contents of the written and oral examination has been outlined in detail in guidelines already mentioned. In these guidelines all subjects to be covered by the examination, especially those concerning the safety-related knowledge and the abilities as addressed under points (2) and (3) in part 3 are specified for SE, SS and CRO. The depth of the examination is characterized by a set of exemplary questions and corresponding answers. The subjects and problems to be dealt with in a specific examination are submitted by the utility and have to be approved by the competent authority.

Each candidate has to pass the written exam prior to being admitted to take the oral one. The written examination is rated by a point system; the passing grade has been raised from 50 to at least 70 out of a possible 100 points overall. In order to pass the oral examination successfully, there has to be a unanimous positive vote by the board of examiners. Because of stringent selection criteria applied by the utilities during the training phase only about 2 % of the candidates failed to pass the exam in the past.

The oral examination consists of an optional plant walk-through to demonstrate the candidate's knowledge of locations and functions of important systems or components, and of an experts' discussion between the candidate and the board of examiners in the control room. The main emphasis lies on the analysis of assumed plant states by interpretation of instrument indications, signals, alarms and announcements in the control room, on a description of the intended manual actions and the expected response of the system. As far as possible, manual actions will actually be carried out. Candidates are primarily expected to demonstrate their ability to handle occurrences in the respective plant and their

knowledge of procedures and manuals rather than to demonstrate their knowledge of plant design.

Predominantly, system malfunctions and accident sequences will be dealt with in this part of the oral exam. The candidate is encouraged to use all the working aids which he is going to use during his day-to-day work, such as operating manuals, operational limits and conditions, drawings or wiring diagrams, during the exam. In fact, it is one of the objectives of the exam that the candidate should demonstrate his ability to make meaningful use of these documents.

At present, no examination at a simulator is taken. This will, however, be required in the near future, once the scope of simulator training for responsible shift personnel and design requirements for simulators have been specified by the authorities. The authorities are convinced, that the importance of full scope simulators for training and examination has increased considerably; once the simulator resembles the operational and accident states and the dynamic behaviour of the respective plant correctly and completely it is the best training instrument available besides the control room equipment itself.

The written and oral examination has to be taken only once, i.e. when the candidate is licensed for the respective plant and the respective function for the first time. No regular repetition is required. However, the examination has to be taken again when a shift supervisor or control room operator has not been actively working in his respective function for more than 15 months or when he is moving to another plant. The latter time limit will probably be reduced to 9 months within the near future.

6. Retraining

The licensing requirement concerning the competence of responsible personnel implies the obligation of the applicant to keep the competence of his employees throughout their working life at the level required by the current state of science and technology.

This has to be accomplished by immediate information on those important changes of the plant design, of its operational or accident behaviour or of operating instructions and manuals which are important for the respective function. Furthermore, the applicant has to provide for regular retraining activities, for instance in-plant lectures, training courses, simulator training, emergency or fire fighting-drills, to be attended by each member of the responsible personnel category.

For SE, SS and CRO the scope and the extent of retraining have been specified in a guideline [5] already mentioned in part 2. The retraining programmes have to be established by the training officer, who will be responsible for its execution as well. The programme shall cover theoretical and practical retraining subjects. Examples for theoretical subjects are:

fundamentals and characteristics of the operational and accident behaviour of the plant, plant technology, design changes, changes of instructions, new regulatory requirements, operating manuals, radiation protection and work safety, analysis of malfunctions in their own and in other plants.

Practical subjects are, for instance:
execution of regular tests and inspections; reactivity-controlling actions and other control activities

which have not been carried out in the plant, at a simulator; correcture actions for malfunctions or accident sequences at a simulator, fire fighting-, emergency-, first aid-, radiation protection-, and respiratory equipment drills.

The retraining activities serve the following purposes:

- o to maintain the licensed operators' specific knowledge of the plant and of relevant technology;
- o to ensure, that the licensed operators are cognisant of changes in plant design, plant procedures and regulatory requirements, of incidents in their own plant or similar plants and their significance for operation;
- o to maintain and extend the operators' practical operating abilities.

The retraining programme has to be submitted to the competent authority, up-dated every three years and consequently has to be started again. Every SE, SS and CRO shall participate in regular retraining activities for at least 100 hours per year. In practice, many utilities provide for about twice as much regular retraining, including one week at the simulator per year.

7. Reliability

The Atomic Energy Act requires that no known facts shall give rise to any doubt as to the reliability of the responsible operating personnel. On the basis of information concerning the places of residence and other personal data of these personnel, the competent licensing authority will investigate on its own whether such facts are evident or can be obtained from sources accessible to the authorities.

For instance, criminal records kept at the Office for Protection of the Constitution and at the Bureaus of Criminal Investigation will be checked.

Furthermore, it is of great importance for ensuring reliable operator performance under all conditions that only personnel are selected and kept for the SE, SS or CRO functions who are physically and psychologically fit. There shall be no physical deficiencies that could impede or adversely affect these personnel in their job performance. Their personal characteristics shall be such, that they will act cautiously without losing their heads in case of an emergency, in spite of extended phases of boredom from normal operation.

With regard to physical fitness, a medical examination of the candidates at the beginning of their nuclear training, and annually repeated medical examinations are performed by authorized physicians on behalf of the respective utility.

In addition to a check-up on those physical characteristics which are also examined for radiation protection purposes [6] as required by the Radiation Protection Ordinance [7], a careful examination of the sense organs is performed to determine whether the following characteristics meet the relevant acceptance criteria which have been specified by a medical subcommittee of the Advisory Commission on Radiation Protection:
visual acuity (proximity, distance), space perception, colour vision, field of vision, power of hearing, capability of clear and accurate linguistic communication. The physician will also give his opinion on the mental alertness and emotional stability of the trainee; in case of dubious diagnostic results a spe-

cialized physician will be consulted. The physician will look for symptoms of abuse of alcohol or drugs as well; on the basis of the results of all his examinations he will certify whether the trainee is physically fit to be a shift supervisor or a control room operator or not. This certificate is submitted to the regulatory authority.

With regard to psychological fitness of SSs and CROs it would certainly be desirable to perform objective and validated psychological tests [8]. However, such test batteries have not yet been developed for shift personnel of nuclear power plants; therefore, the assessment of personality characteristics such as stress resistance, capability to concentrate, tenacity, calmness and stability, sense of responsibility, reliability, decision-making capability, willingness to cooperate is left to the long-term surveillance (3 to 4 years prior to authorization and continuously thereafter) by other responsible operating personnel like trainers and supervisors.

No documentation regarding the results of this long-term surveillance by the operating organization is submitted to the regulatory authority. Attempts of the authorities to specify the afore-mentioned personality characteristics and to harmonize the respective acceptance criteria for all utilities have been critisized and rejected by the labor unions; they claim that the results of this kind of surveillance are very much dependent on the qualification and the personality of the respective supervisors, and that this procedure is in conflict with fundamental personal rights. These problems have to be examined further by legal experts.

About 2 to 3 % of all SSs, deputy SS and CROs had either to be rejected as candidates or to be removed from their functions because of doubts pertaining to their reliability in the past, mainly on the basis of

the results of long-term surveillance by supervisory personnel.

8. Schedule of Shift Work

The guidelines already mentioned in part 2 of this paper require, that each operational shift crew has to be staffed at least with a SS (plus additional SE if necessary), a deputy SS, a CRO plus alternate, a turbine operator and a radiation protection commissioner. Additional subordinate operating personnel (inspection, maintenance and repair) is added by the utilities to each shift crew. The nuclear power plants are operated with 5 to 6 shift crews.

Shift work of the operating crews in most of the plants is scheduled as follows:

- o the 8 hours morning, evening and night shifts, respectively, are grouped together in weekly blocks; this is also true for an additional training or workshop shift during normal working hours and for seven days of free time off-duty;
- o there are only about 15 hours of recreation between two night shifts;
- o shift duration on week-ends and official holiday in about 50 % of the nuclear power plants is 12 hours.

Some of the criteria suggested in the ergonomic literature [9 - 11] for the planning of shift schedules are not met by the above mentioned schedules:

- o the number of night shifts in sequence should be as small as possible;
- o every night shift should be followed by at least 24 hours of recreation time off-duty;

o shift duration should be rather 8 hours than 12.

In other areas like civil air-control and operation and control of railway traffic schedules for shift work have already been implemented which are in accordance with these ergonomic criteria, and which do provide for as many free week-ends (for social contacts) as control room personnel in nuclear power plants get at present.

It cannot be excluded from safety considerations concerning the operators' performance in nuclear power plants, that the potential for human errors during 12 hours shifts or during weekly blocks of night shifts could be enhanced because of the desyncronization of the internal circadian rythmicity of the operators from external timing systems. The Federal Ministry of the Interior therefore has started discussions with utilities and labor unions on possible modifications of the shift schedules for control room personnel in order to increase safety. Final results have not yet been obtained, as utilities and labor unions do not support our attempt for the following reasons:

o training and retraining would be made much more difficult when shift schedules would be switched from weekly blocks to daily changes;

o the adaptation to the performance minimum occurring between 2 and 4 o'clock during night shifts is facilitated for weekly blocks, whereas single night shifts would tend to enhance perturbations of the sleeping rythm;

o a week-end-oriented planning of shift schedules and therefore social contacts would be aggravated by introducing single night shifts followed by 24 hours off-duty.

Before requiring any change of the shift schedules presently valid we therefore are going to investigate to which extent the potential for human errors of control room personnel could be influenced by different shift schedules.

9. Concluding Remarks

The fact that detailed requirements regarding the qualification of control room personnel have been specified by the licensing authorities does not yet guarantee this qualification. It is the applicant's obligation and his sole responsibility to train his personnel, to keep it optimally qualified, and to adjust this qualification to any change in the state of science and technology. He is the only one capable of transforming the regulatory requirements into operation-oriented training objectives which take into account the constraints and needs of the actual tasks.

Therefore, before implementing any significant change of qualification requirements these are fully discussed with representatives of the labor unions and of the utilities, in order to make use of their practical experience and to enhance the applicant's motivation to apply these requirements meaningfully.

It has to be kept in mind, that besides the qualification there are other important factors which have substantial influence on job performance and reliability of operators. Whether a well qualified employee will be able to influence the course of any accident sequence in a positive way or not will also be determined by the ergonomic design of the control room and the working environment, by the quality of his working aids (operating manuals and procedures), by the managerial and organizational structures in

force, and - last but not least - by his motivation. The objective of all efforts to optimize the contribution of the "human factor" to the safe operation of nuclear power plants should therefore represent a simultaneous optimization of all these influences.

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QUESTIONS TO J. B. FECHNER

Homer McCririck

Q:

1. Did the task analysis indicate that a graduate engineer is required in the control room?
2. Have the results of the task analysis been published?

A:

1. As the task analysis has not yet been completed, I cannot state whether this is the case or not. This subject will certainly be addressed once the results are available. However, I do expect to get much information on the personal character statistics (like leadership, responsibility, self-consciousness, etc.) which we are looking for in the graduate engineer, from the task analysis.
2. No. This could only happen by the end of 1982, at the earliest.

CSNI SPECIALIST MEETING ON OPERATOR TRAINING AND QUALIFICATIONS

EXPERIENCE GAINED IN SPAIN IN LICENSING REACTOR OPERATORS

A. ALONSO, REACTOR OPERATORS EXAMINING BOARD. JEN
R. GUTIERREZ " " " " "
P. VILLAJOS " " " " "
F. BILBAO IBERDUERO, S.A.
E. UGEDO TECNATOM, S.A.
R. VARGAS TECNATOM, S.A.

(APENDIX BY M. MATAIX, HIFRENSA)

CHARLOTTE, N.C. U.S.A. 12-15 OCTOBER 1981

I. INTRODUCTION

The analysis of the Spanish experience in the training and performance of reactor operators has to be viewed against the characteristics of her nuclear power program and the position of the country within the context of the nations.

The nuclear power program in Spain is characterized, among others, by the following aspects:

First. An early start. The first generation of nuclear power plants -three units- was put into service between 1968 and 1972. The operating experience in Spain amounts therefore to over thirty reactor-years. On top of that, the three units were of different types -PWR, BWR and GCR-and came from different countries, i.e. U.S.A. and France.

The first operating crews for those plants were trained by the main suppliers, following the methods of the times. Subsequent applicants were trained in situ within the operator's organization. The performance of these personnel has been highly satisfactory.

Second. A stepwise introduction of nuclear power plants. Three generations or groups of plants can be easily defined. The second generation comprises seven units, all of them LWR's, which could become into operation between 1981 (Almaraz I) and not later than 1984. The third generation, now starting construction, or in the verge of receiving the construction permit, includes six units with LWR's from different exporters.

The training of operators for the second generation of nuclear power plants is in the process of being completed within a large and increasing participation of domestic organizations, following the pattern established in the countries with more advanced nuclear power programs. The crews for the third generation are in the prerecruiting phase.

Third. Program based on diversity of types and suppliers. All units are imported, come from different suppliers within a given country and from different countries. Nevertheless, all of them belong to the LWR family, with the exception of Vandellós, a GCR supplied by France. This diversity of types and suppliers is also found in other countries.

Under such condition, together with the desire of increasing the domestic participation to all phases of reactor operation, the country has gained, not without effort, a wide experience in training and qualification. The TECNATOM training center for reactor operators represents the results of such an important effort.

To place the country within the context of the nations, it is of some interest to divide them into three major groups, attending to their status on the development and application of nuclear tecnology. To the first group belong those countries who have been able to develop nuclear power up to the commertial status. Those are the exporters. A large second group of countries are importing their NSSS's from the first, but at the same time contribute, in a very significant manner, to the design and construction or their nuclear power plants and assume responsibility for the entire operation, including commissioning. Those are the Qualified importers. Spain is clearly in this second group. A third group of countries are just starting their first nuclear power plants. They are the importers.

The picture above has a very significant influence on the training and qualification of reactor operators, as these actions are just but a part of the development of nuclear technology and constitute an important element in the transfer of nuclear technology from exporters to importers. The exporters, together with their physical products, do also develop ways and means to train and qualify reactor operators, which are transfered to importers. On their way, Qualified importers have already received the basic transfer of knowledge and tecnology; upon this base they elaborate to suit the particular needs and desires of the country.

Within the framework above -peculiarities of the Spanish nuclear power program and position of the country within the concert of nations- the paper presents the experience gained in Spain in the training and qualification of reactor operators.

II. THE BASIC PRINCIPLES AND LAWS

The regulatory process is governed in Spain by the Nuclear Energy Act, a basic document approved in 1964. In 1972, Ministerial Decrre 2669/72 developed the implementation of the licensing aspects contained in the Act. Very

recently, in 1980, a Nuclear Safety Council has been created by law 15/80.

The Act recognizes that any nuclear installation carries a risk and therefore makes it necessary to protect public health and safety, as well as property. The Act goes on to say that responsible personnel working in nuclear and radioactive installations must be well qualified for the job to be performed. The new law reaffirms such idea.

That basic principle is further developed in Decree 2669/72. First of all, personnel "manipulating the controls of any nuclear or radioactive installation" must possess a specific licence granted by the Nuclear Safety Council, as amended by the new law. Two kinds of licenses are defined, i.e. operators and supervisors, as in the legal requirements of other more nuclearly advanced countries. Supervisors must have an intermediate degree in education.

Qualification of applicants are verified by an Examining Board acting on behalf of the Nuclear Safety Council. The five member Board includes a representative of the person or entity holding, or ready to obtain, an operating licence for the installation at hand. The Board is chaired by a President and assisted by a Secretary, who must be competent in nuclear safety or radiological protection matters. All members are appointed by the Nuclear Safety Board except the one representing the operator.

The Examing Board does not act when the training of the applicant has been completed in agreement between the operator and the Nuclear Energy Board. This is the Spanish governmental organization responsible for nuclear research and development with defined activities for education on nuclear matters. For the purpose above, this organization relies on the Institute for Nuclear Studies, also a governmental organization within the first. The Institute can not provide at present a complete education for nuclear power plant operators, therefore this type of applications have been handled in all cases by the Examining Board. Following her importance, it has been established that a member of the Institute should seat in the Board.

The licences are nominal, specific and with limited validity. A transfer of a license to another installation, even a similar one, has to be requested and obtained following a similar process. Nevertheless, it the case of

twin stations grating licenses for both units is being considered. The validity of the licenses is limited to two years and it can be extended, without farther examinations, when the applicant has been active for at least fifty per cent of the time.

The physical and psychical conditions of applicants do not pass without attention. To care for that, the Nuclear Safety Council will also nominate a Medical Examining Board. As in the previous case, a designee of the applicant is also a member of the Medical Board. The Board examines the applicant to certify that physical and psychical conditions are suitable for the activities to be performed and the responsibilities to be adquired.

To coordinate the activities of both examining boards a Licensing Office has been established. The Office, after checking that all conditions have been met, and through the President of the Examining Board, proposes to the Authority the granting of the licenses. The administrative procedures described above are shematized in Fig. 1.

III. TRAINING AND QUALIFICATIONS REQUIRED

The basic regulations do not specify the training to be accomplished and the qualifications to be obtained by reactor operators. To that aim, the Nuclear Energy Board has published two safety guides, one on technical and scientific knowledge(*) and the other on medical requirements(**). This guides set the pattern for the training program as described below.

The construction permit for nuclear power plants reminds the owner that the future operating crew has to be properly trained. The permit also establishes mechanisms for the licensing authority to be periodically informed about the recruiting and training of future operating personnel. Typically, the recruiting is complete more than three years before fuel loading and formal training starts at about that time.

(*) Safety Guide nº 2. Qualifications and requisites for applicants of licences for nuclear power plant operators. JEN (in Spanish)

(**) Safety Guide nº 5. Physico-psychical requisites for applicants of licences for nuclear and radioactive installations. JEN (in Spanish)

At present, the training required is formally distributed among the following phases:

Phase I.- Basic Nuclear Training (Three to four months)
Phase II.- Nuclear Power Plant Technology (PWR or BWR), (six months)
Phase III.- Simulator training (Three months)
Phase IV.- Familiarization with the plant to be operated including drafting preoperational testing and operating procedures (Twelve months)
Phase V.- Training on site, including participation in preoperational testing (Eighteen months).

Phase I is generally acomplished within the Institute of Nuclear Studies -recently the Institute for Energy Technology, attached to the Polytechnical University of Barcelona has also been participating- the subjects to be taken are very basic as they correspond to persons without knowledge, or with a limited one, in nuclear and reactor physics and nuclear technology in general. Practical aspects are given a great deal of importance and include radiation measuments and reactor operation. A typical time allocation and table of contents are given in Table I.

Phase II is imparted in different private enterprises specializing in PWR or BWR technology. In occasions the training is obtained at the main supplier's facilities. In many instances, this phase is complemented with a period of attachement to an operating plant of the same family, but this is not a formal requisite. A typical allocation and table of contents are given in Table II.

Phase III is presented to candidates at the TECNATOM training center and includes the use of full scope simulators -PWR and BWR. Reactor operators for the second generation of nuclear power plants have being trained in the center. Operators for the first generation of plants very seldom receive simulator training. For units of different origins, belonging to the third generation of plants, the training in the existing simulators is being considered. Time allocation and table of contents is given in Table III.

Phases IV and V try to familiarize candidates with the design and operating peculiarities and details of the home-plant. To acomplish the training aims, utilities may follow different methods, suited to the possibilities and characteristics of each organization. Some utilities have established very well organized training schools run by the

organization or training is partly left to specialized organizations.

IV. EVALUACION OF CANDIDATES

Once candidates have applied for a license, the Operators Licensing Office analyses the acompaning documents to verify compliance with the pre-requisites contained in the basic legal documents and in Safety Guide nº 2. The Examining Board meets formally to accept or refuse candidates for farther evaluation. Phases I and II are evaluated by looking at the individualized reports produced by the training organizations. Phase III is actually evaluated by watching the performance of candidates in actual simulation sessions at Technatom training center. Phases IV and V are audited by selected members of the Examing Board. The reports produced are then evaluated to decide whether or not candidates have adquired the required training. The designee of the operator has then a chance to deffend applicants if in his opinion justice is not properly applied.

The Examing Board decides the dates for the written and oral formal final exams. The written exam is a six hours exercise, well standardized, which will include the subjects given in Table IV for operators and in Table V for supervisors. The evaluation is done independently by each member of the Board with the exception of the operator's designee. Each main subject has to be passed above the sixty per cent mark and the average has to be over seventy per cent. The final results are presented to the operator's designee for discussions.

The oral exam takes place in the plant itself. The examiners may or not be members of the Examining Board. Sometimes a member may be assisted by an expert on that particular plant. The exam is also performed using a well established format and typically lasts from one to two hours per person. The examiner and the candidate may walk through the plant while the last will explain the location, characteristics and functions of given components and systems. It also may include simple control room on other type of operations.

Candidates failling to pass the written or oral exam are given a second opportunity not sooner than three months. In this case the owner of the plant has to produce the foreseen training program for the failled candidate during that period.

Table VI summarizes the types and power plants for which licenses have been issued.

V. THE TRAINING CENTER

Along the first half of the seventies licensing procedures and training requirements for operators had been established by the Spanish regulatory body. To that aim a systematic approach to training programs and methods was been undertaken by seven Spanish utilities which in 1972 appointed the engineering company, TECNATOM, S.A. to develop all necessary means so that operator qualification training programs could be made available within the country.

With such a goal, Tecnatom initiated the planning of a training center; the first step was to develop training material covering lective sessions for phase II, phase IV and phase V (phase I was already covered by the Institute of Nuclear Studies and some Universities).

The lack of a simulator forced the utilities with plants under construction (seven units) to send the trainees to U.S.A. training centers, while Tecnatom provided structured plant observation training at the already operating Spanish stations.

In 1975 Tecnatom released funcional specs. for the design and construction of two full scope training simulators, modelled after the Lemóniz (930 MWe, PWR) and Cofrentes (970 MWe, BWR) NPP's. Design work started on February 1976 for PWR and August 1976 for BWR being both under regular service since October 1978 and February 1979 respectively.

The simulators and complementary training facilities have been installed in a 5.000 square meters building.

In parallel with the construction of the simulators, careful attention has been paid to the selection and training of instructors as well as to the development of training material, such as lecture series, quizzes and examination questionaires, slides and transparencies, evaluation criteria and standards.

V.1. Training Center Organization

The Training Center technical staff (instructors, program analysis and technicians) is made up of 41 people

distributed in six Sections:

- Fossil-fuelled PP's instruction	(5)
- PWR NPP's instruction	(15)
- BWR NPP's instruction	(7)
- Maintenance	(10)
- Q.A.	(2)
- Technical secretary	(2)

The three first instructing sections are assigned with the following responsibilities:

Courses programming and scheduling
Training lectures preparation and updating
Training aids preparation and updating
Lecture administration
Simulator drills administration
Quizzes/exams questionaires preparation
Students performance reports
Simulator models updating (in collaboration with analyst engineers)
Operating Manuals coordination
On-the job site training coordination

The Maintenance section main tasks are:

Preventive maintenance of electronic equipments
Replacement on defective equipment and/or repairiing of troubleshooting
Spare parts procurement
Simulator software and hardware updating
Implementation of advanced simulator features
Availability reports

The Q.A. section mainly ascertains of the excellences, according to prestablished benchmarks, of all didactic means being used for training purposes. The engineers in charge are assigned with the jobs of periodic auditing of lectures and partial examinations evaluations as well as the administration of final exam to each student and the issuance of successful certificate, if pertinent.

The Technical Secretary mainly perform R & D duties in the area of NPP staff training and qualification. Systematic contacts with parallel training organization and regulatory bodies are the principal information sources. The NPO operating experience, as stated in the Licensing Event Report (LER's) and other similar reports, training material.

The occupancy of TECNATOM simulators is given in Tables VII an VIII

V.2. TECNATOM simulators main features

a) Plant normal operation

Capability of reproducing with a high degree of accuracy all the processes that are taking place during plant operation:

- Cold startup at refueling conditions of temperature and pressure
- Nuclear startup from hot standby to rated power
- Turbine startup and generator syncronization
- Reactor trip followed by recovery to rated power
- Operation at hot standby
- Load changes (manual and automatic)
- Startup, shutdo n and power operations with less than full reactor coolant flow.
- Plant shutdown from rated power to hot standby to cooldown to cold conditions
- Core physics testing after initial load
- Operator conducted surveillance test on safety-related equipment or systems.

Tight tolerances as dictated by ANSI 3.5.

b) Plant abnormal operation

Capability of reproducing with a high degree of accuracy up to 187 abonormal situations (failure and emergencies) that may potentially take place at the modelled NPP. Accuracy ranges are fixed by ANSI 3.5.

c) Speed-up and slow-down capability

Capability of performing processes affected by a time scale factor of 10 is a relevant feature in benefit of training effectiveness.

d) Selection of initial conditions

Initialization possibility is of prime importance to assign a set of coherent values determining a well defined funcional situation (e.g. cold shutdown, hot shutdown, full nominal load, variable degrees of fuel burn-up, etc), up to 60 initial conditions are available at Tecnatom simulators. Time saving is the main

advantage.

e) "Freeze"

The instructor's faculty of stopping a process dynamics while maintaining variables values constant at the time of freezing allows instructor-student review of operational errors and advisable corrective actions.

f) Automatic data recording and setback

A systematic disc recording of relevant parameters values for a 2-hours, at one minute intervals, allows to set the process back and replay it.

g) Optional data recording

A permanent recording of data allows to use them for a future operation as an initial situation.

h) Instructor's Aids Programs

In association with the Instructor's Consele provide the necessary functions for conducting and monitoring the training sessions.

i) Software Tools

Necessary for the development and maintenance of the simulator programs (e.g. Database Management Systems, Precompilers, Debuggers, etc.)

V.3. Malfunctions reproduction

Abnormal situations are characterized by a number of malfunctions that can be instructor inserted. Roughly, both simulators have the capability of inserting 187, variable severity, malfunctions. Malfunctions are grouped as follows:

Reactor control	22
Nuclear instrumentation	18
NSSS	33
Auxiliary systems	16
Main steam and turbine system	64
Heater drain and vents	3
ECCS	5
Electrical system	14
Miscellaneous systems	22

V.4. Additional features

The above referenced normal and abnormal evolutions define the operating scope covered by the simulators before TMI accident.

Following post TMI recommendations of NUREG-0660 the simulators capabilities have been enlarged to allow realistic training under degraded core cooling conditions and/or considering active as well as pasive ECCS equipment failures.

Assisted by the simulator manufacturer,Tecnatom has placed a big amount of effort in systems remodelling aiming at providing the PWR simulator with accurate performance capabilities under conditions desired from small LOCA's. Special attention has been paid to physical phenomena such as reactor coolant two-phases flow (forced and natural) under saturation conditions; natural circulation under water solid conditions; pressurizer level behaviour depending upon rupture location.

Daily attention is being granted to significant operating reports issued by different institutions (NRC, INPO, etc.). Careful evaluation of applicability to Spanish NPP's is carried out and potentials for additional phenomena to be inserted in the simulator are analyzed. A good example is the local saturation areas in the upper vessel head during plant cooling down through RCS natural circulation (St. Lucie; June 11, 1980). Simulation of this effect implies further subdivision of reactor vessel model in interactive nodes thus allowing temperature gradients between adjacent nodes which may result in local boiling areas and associated effects in pressurizer level.

New and more reliable operating data is being collected from actual NPP's operating experience and best estimate computer codes in order to have a reference data base to validate simulator performance; in addition, simulator models are being expanded to accomodate previously undetected physical phenomena emerging from reportable events in NPP's operating throughout the world, with high training value.

VI. OVERVIEW AND MAIN CONCLUSIONS

The Spanish nuclear power program is mainly characterized by its important magnitude, early start, stepwise in-

troduction, diversity of types and suppliers, a high domestic partipation in the design and construction of plants and, most important, a complete responsibility on all phases of operation.

The situation above has been backed by an early development of basic regulations and detailed procedures, the later being based on internationally recognized practices, but including some peculiarities such as the creation of Examining Boards including designees representing the operator. The total number of licenses granted up to last june 30 amounts to 148.

Education of candidates is acomplished locally. The basic nuclear education of recruits takes place mainly at the Institute of Nuclear Studies with some participation from high Education Institutions. The detailed education is adquired at TECNATOM Training Centre which includes a PWR and a BWR simulator.

The higher emphasis on reactor operators training derived mainly from TMI-2 is being incorporated into the educational system. This emphasis is also reflected into the operating permits recently granted.

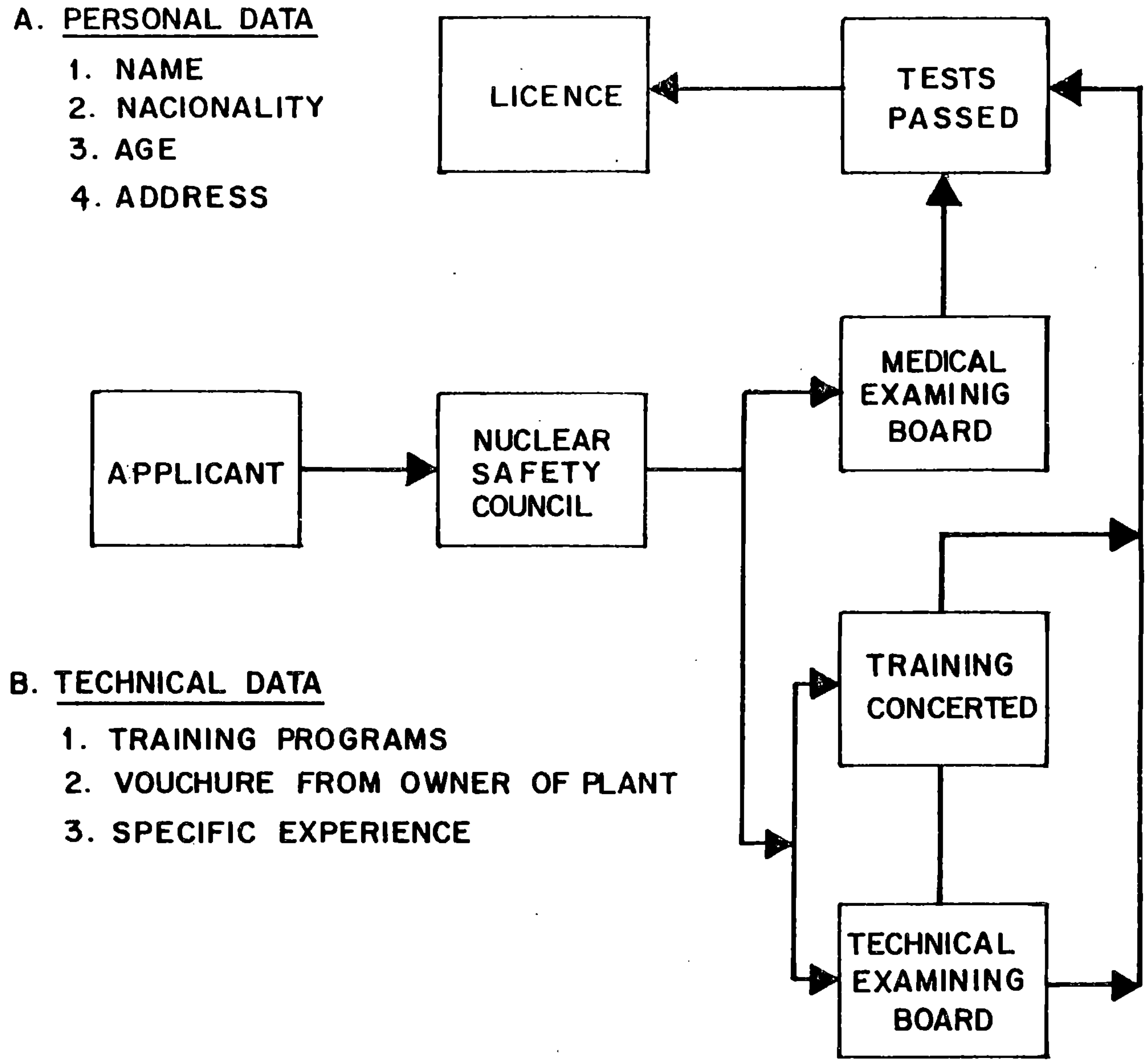

FIG. 1.- OPERATORS LICENCES

LIST OF TABLES

TABLE I. TYPICAL TIME ALLOCATION AND TABLE OF CONTENTS FOR

PHASE I - NUCLEAR FUNDAMENTALS

A. TIME ALLOCATION

Total course length	-	69 days (net)
Lecture series	-	256 hours
Quizzes/exams	-	26 hours
Laboratory	-	42 hours
Reactor operation	-	34 hours

B. COURSE OUTLINE

Atomic and Nuclear Physics

Reactor Physics

Nuclear instrumentation

Reactor kinetics

Techonology of different reactor types

Thermolhydraulics of nuclear reactors

Health Physics

Nuclear Safety

Computer and computer languages

Applicable codes and regulations

Zero power reactor and lab practices

TABLE II. TYPICAL TIME ALLOCATION AND TABLE OF CONTENTS FOR PHASE II - NPP TECHONOLOGY

A. TIME ALLOCATION

Total course length	-	75 days (net)
Lecture series	-	286 hours
Quizzes/exams	-	44 hours
NPP observation period	-	4 weeks

B. COURSE OUTLINE

Design philosophy

Reactor coolant system

Physics, thermohydraulics and mechanics of the core

Reactor auxiliary systems

Chemistry and readiochemistry

Control and instrumentation systems

Heat transfer and steam generation

Reactor auxiliary systems

Engineered safeguards

Turbine generator plant

Modes of operation

Observation at a commercial NPP

TABLE III. TYPICAL TIME ALLOCATION AND TABLE OF CONTENTS FOR PHASE III - SIMULATOR OPERATION

A. TIME ALLOCATION

Total course lenght	-	50 days (net)
Simulator operation	-	120 hours
Quizzes/exams	-	24 hours (written)

B. COURSE OUTLINE

Panels and consoles lay-out

Instrumentation functional description

Administrative procedures

Reactivity and efficiency calculations

Plant safety and emergency procedures

Normal operating instructions

Abnormal operating instructions

TABLE IV

SUBJECTS TO BE COVERED IN WRITTEN EXAMINATIONS APPLICABLE TO OPERATORS

A. GENERAL

1. PRINCIPES OF REACTOR OPERATION
2. SPANISH NUCLEAR LEGISLATION

B. PLANT SPECIFICS

3. DESIGN FEATURES
4. OPERATION CHARACTERISTICS
5. CONTROL AND INSTRUMENTATION
6. SAFETY SYSTEMS
7. NORMAL AND EMERGENCY OPERATION PROCEDURES
8. RADIATION PROTECTION

TABLE V

SUBJECTS TO BE COVERED IN WRITTEN EXAMINATIONS APPLICABLE TO SUPERVISORS

A. GENERAL

1. REACTOR THEORY
2. SPANISH NUCLEAR LEGISLATION

B. PLANT SPECIFICS

3. DESIGN PARAMETERS
4. OPERATION CHARACTERISTICS
5. RADIOLOGICAL PROTECTION AND FUEL HANDLING
6. MANDATORY PLANT SAFETY DOCUMENTS (OPERATION PERMIT, TECHNICAL SPECIFICATIONS, OPERATING MANUAL, EMERGENCY PLAN).

T A B L E VI

LICENSES ISSUED BY REGULATORY AUTHORYTY FOR NUCLEAR POWER PLANTS

YEAR	LICENSE TYPE	JOSE CABRERA	STA.Mª.DE GAROÑA	VANDELLOS	ALMARAZ	LEMONIZ	ASCO	COFRENTES	TOTAL
1968	SENIOR OPERATOR	7							7
	OPERATOR	5							5
1969	SENIOR OPERATOR	2							2
	OPERATOR	-							-
1970	SENIOR OPERATOR	3	12						15
	OPERATOR	2	4						6
1971	SENIOR OPERATOR	-	2						2
	OPERATOR	-	-						-
1972	SENIOR OPERATOR	-	1	9					10
	OPERATOR	-	-	12					12
1973	SENIOR OPERATOR	2	-	2					4
	OPERATOR	-	1	2					3
1974	SENIOR OPERATOR	2	-	-					2
	OPERATOR	-	-	1					1
1975	SENIOR OPERATOR	-	3	2					5
	OPERATOR	1	1	-					2
1976	SENIOR OPERATOR	-	1	1					2
	OPERATOR	4	3	-					7
1977	SENIOR OPERATOR	-	-	1					1
	OPERATOR	-	-	-					-
1978	SENIOR OPERATOR	2	-	-	7 ★★				2 (7★★)
	OPERATOR	-	3	-	-				3
1979	SENIOR OPERATOR	-	-	-	1 ★★				(1 ★★)
	OPERATOR	-	-	-	-				
1980	SENIOR OPERATOR	-	-	-	8	7 ★★	5 ★★	9 ★★	8 (21★★)
	OPERATOR	4	-	-	12	-	-	-	16
1981 ★	SENIOR OPERATOR	-	3	-	-	-	-	-	3
	OPERATOR	2	6	-	-	-	-	-	8
1981 ★ LICENSES UNDER EVALUATION	SENIOR OPERATOR	1	-	-	-	7	12	-	20
	OPERATOR	6	-	3	-	12	6	-	27

★ UNTIL JUNE, 30 th

★★ NEW FUEL POOL HANDLING

ISSUED: 148

UNDER EVALUATION: 47

TABLE VII

Courses	Students			
	1979	1980	1981	Total
Initial training	60	32	7	99
Simulator refreshing	-	-	38	38
Turbine operator	-	-	8	8
Retraining	-	-	-	-
Heat transfer, fluid flow and thermodynamics	-	6	26	32
Short courses (Engineering, managers, load dispatcher, etc.)	-	-	18	18
	60	38	97	195

TECNATOM, S.A. TRAINING CENTER OCCUPATION - BWR SIMULATOR

TABLE VIII

Courses	Students			
	1979	1980	1981	Total
Initial training	40	26	72	138
Simulator refreshing	-	40	30	70
Turbine operator	7	-	12	19
Retraining	3	6	-	9
Heat transfer, fluid flow and thermodynamics	-	24	5	29
Short courses (Engineering, managers, load dispatcher, etc.)	-	13	50	63
	50	109	109	328

TECNATOM, S.A. TRAINING CENTER OCCUPATION - PWR SIMULATOR

APENDIX

THE PARTICULAR EXPERIENCE OF VANDELLOS

BY

M. MATAIX, HIFRENSA

The particular experience of Vandellos power plant

by Mariano Mataix

The Vandellos nuclear power plant was one of the first three installed in Spain and constituted, in that way, what we denominate the first generation of nuclear power plants of our country. These three plants were each one of a different type : PWR, BWR and graphite-gas-natural uranium. Vandellos is of the last type, which corresponded with the family of reactors adopted in France and abandoned later on, due to its worse economic conditions compared with those of the water reactors.

Vandellos was contracted in 1967 and started operation in 1972. In order to fix the ideas I will give some significant dates :

First criticality : 11 - February - 1972
Coupling of 1st group : 6 - May - 1972
Coupling of 2nd group : 12 - May - 1972
Commercial operation : 3 - Juin - 1972

With this review we have the scenario in which we developped our activity towards the organization of a team capable to carry on the operation of the nuclear station with due garanties. In talking about this experience it is opportune to consider a special characteristic of Vandellos : its high degree of automatism. You should take into account that it is a nuclear reactor with two computers working on line -one always in stand-by, ready to take on from the one in operation, and consequently receiving the same information- which admit around 4.000 on-off data and 1.800 analogic, permitting the control of the installation in a very precise way.

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This is a very interesting point, in my opinion, because experience has shown very favorable results out of the use of the automatism and however it seems that the same criterion has not been followed in the application to other stations. It is true, and convenient to remark it, that in a reactor of natural uranium, the high number of channels which is necessary to survey permanently, watching out for a possible increase in their activity, made it mandatory the use of a computer working on-line, and that was an incitation -increasing its capacity- to employ it for other tasks, specially for the control of the plant. But, anyhow, the results have been good and -this is what interest us most on this ocasion- has an incidence on the type of personnel needed for the handling of the power plant.

In a meeting such like this, dedicated to the operation training, it is sure there will be many papers dealing with the necessary planning and giving all short of detailed information on the different phases of the program. I want to restrict myself to expose only some points, which could be specific of the power plant I am talking about.

When we started thinking about the organization of the crew that would be in charge of the operation, we had at our disposal the deep experience of Electricité de France which had started up two power plants similar to Vandellos, plus several others of the same type, although of different technical characteristics. Therefore, as it was not question of inventing new schemes of organization, it is clear that ours followed in general the one adopted by Electricité de France for theirs, and we profitted from their installations and experience for the training of our personnel.

However, we did introduce an important variation, and I think it has been a determinant factor in the good behaviour of the plant. It consisted in having engineers with university degrees working on shift, so that during a sufficiently extended period, which lasted approximately one year, there was always in the control room an engineer responsible of the operation. This, in those years, could seem to some a very expensive luxury, as it implied the contracting of five more engineers. On the other hand, having to work on shifts is always a bother and -in as far as my knowledge goes- as there were no other plant with this arrangement, we supposed could have difficulties with the people involved. In this, I can say that everything went smoothly and the engineers saw clearly the logic of having to work on shifts for a long period and accepted it. It must be considered that the development of the actions in a nuclear power plant is quite different from those in a classic thermal power plant. In this late case, when something goes wrong the first thing is to cut out the flame to the boilers, putting in that way the installation in conditions of safety. Afterwards it will be required the aid of as many experts as necessary, without having to worry about problems of safety.

Things go very differently in a nuclear plant, as it is well known of everybody who has been involved with this type of operation. The first instruction I would write in the operation handbooks, for the happening of an important perturbation which -it is convenient to emphasize this- has not been controlled by the automatism, is : "Think before acting". To think, to reason, to evaluate the possible consequences of the action that it is going to be carried on is fundamental. You must take into consideration that there are situations in which to make a scram would be the worst thing to do. In the example of the Vandellos power plant

it is not necessary to search for a quite hard-to-imagine situation. If, for any reason whatsoever the whole auxiliary station failed, leaving us without the four boilers, the worst thing to do would be to provoke a scram.

But returning to our simple instruction, "Think", we must consider that, in the circumstances it should be used, would require deep theoretical knowledge, joint to a very good practical experience. It is obvious that the practical experience it is something that people acquire with the passage of time, while exercising the responsibility of decision. The engineers of Vandellos, before taking on this responsibility passed a long period of training in the similar French power plants, which was very profitable to them. However, it should be recognized, that while there is another person by your side, who is to account for anything that could happen, the exaction from the engineer in training is quite different from what it would be if he were in full charge of the operation of the plant. And this is equally applicable to the handling of a nuclear reactor than of a plane, a ship or a simple car. But the theoretical knowledge should have been acquired previously, in the university or the engineering schools. And I would dare to say here, that in this aspect the difference between a person with the instruction corresponding to a university level, compared with who has it not, is fundamental. When one reads about the accident of Three Mile Island, more firmly believes in the necessity of a good theoretical background for the compromised situations. Anyway, I do not want to be misinterpreted as trying to propound that having engineers working on shift is the medicament for all our illness. I only try to signify that the higher cost which it implies is well repaid -in my opinion- by the greater safety and -this is also important- by an increase in

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the load factor, because the better the theoretical background of the responsible man, the better he will be able to judge the way to come out of trouble without the easy recourse to an immediate scram. To finish this point I shall repeat that after one year, the engineers stopped working on shifts, but one is always in close contact with the control room. In this way, the operators, already with a big experience, have the back up of an engineer with whom they can establish telephonic communication very quickly and, if necessary, in a matter of 10 minutes, can be in the control room to take care of a difficult situation. It is opportune to remark, that this increase of operating staff is no problem for the normal Power Utility due to the fact that the construction of the plants is a continuous process, so that if the management considers that their necessity is ended, after a certain period, they can be transferred to other plants where their experience will be most valuable. Even in the case of HIFRENSA, which is a corporation very particular, for having just a single plant, without prospects -as long as that is humanly foreseable- of having a second one, there was no problem because as time goes by there is a normal displacement of people to other jobs, and the problem is to keep them.

About the other subjects I wanted to talk, one has already been mentioned. I am refering to the automation of the plant. Similarly to the problem of the engineers -but much more in this case- is something that costs money, and that for two reasons : because of the cost of the equipment and that of the required training for the operating staff. The experts who have visited Vandellos frequently remark the high cost that must have meaned this advanced degree of automation. But today, when it is demanded from the containement building of a PWR to resist the effect of forces which are almost in the domain of the science fiction, I think it would be much more logic to invest that money in the first

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consideration than in the second. In anycase, it will be adequate to mention a story told by Sir Winston Churchill during one of his famous speeches of the Second World War. It seems -and I use his own words- there was a custom in ancient China that anyone who wished to criticize the Government had the right to memorialize the Emperor, and, provided he followed that up by committing suicide, very great respect was paid to his words, and no ulterior motive was assigned.

Well, I have no intention to comply with the Chinese custom, after the heresy of propounding spending more in automatism than in one of the consecrated principles of safety, which signals the possibility of some stupid pilot succeeding to collision his Boeing 707 against the reactor building. And the same explanation is valid for the last theme of my intervention, in which I will say a few words against other inamovible principle in which, unfortunately, I do not believe, or let us say better, that I have doubts about its truth. I am refering to the gigantism of the installations, based on economic reasons.

The first question that maybe some will ask me is : "What relationship has the gigantism with the operation of the plant?". In my opinion, quite a lot. And this for two reasons : one is of psychologic type, the other purely technical. The first, which affects directly the behaviour of the operating staff, is the fact that the stress put on a person is very different according to the importance of the equipment he is in charge of. One more reason, therefore, for increasing the automatic control of the plant if we increase its size, in order to compensate in this way, for the psychological tension of the exposed situation. The second is due to the fact that the bigger the equipment the more difficult is its maintenance, so that the time that is lost in this work can, maybe -I do not know, but would be convenient to find a way of valuing it- compensate the saving per kilowatt installed, taking into account that in the end, which determines fundamentally the economics

of a plant is its load factor. And with this, I finish my memorial to the Emperor.

QUESTIONS TO A. ALONSO

G. Schlegel

Q: Could you tell us how you perform examinations on simulators? Where are you putting your weight on? Is it knowledge (ability to understand the process) or correct reactions? What criteria do you use for measuring the performance?

A: Examiners representing the Technical Examining Board watch the performance of candidates during a special session at the end of the instruction period. Examiners decide upon the problems to be presented to the operating crew. Attention is also given to the individual reports produced by simulator instructors.

Following the Spanish regulations, reactor operators are expected to react correctly to face the situation at hand; shift supervisors, on the other hand, are expected to understand the physical process

which will be taking place in a real situation.

To measure the performance of candidates, standard procedures are used with the intention of making the evaluation as objective as possible.

Q: In Tables VII and VIII, you give data for simulator refresher training. Is this a requirement and, if so, how much time is spent at the simulator?

A: It isn't required. The training is predicated on the following standards, guidelines, and recommendations:

JEN-Ministry of Industry, Spain. It is mandatory nationwide. This code is further developed by Nuclear Safety Guides 2 and 5.

- Document U.S. - 10 CFR 50-55 (NRC, USA), "Operators Licenses"
- Regulatory Guides (NRC, USA) 1.8, 1.114, 1.134, 1.146, 1.149

- "Selection and Training of NPP Personnel" (ANSI N-18.1)
- INPO applicable guides and recommendations

The time spend for retraining purposes at the simulator is one week.

THE U. S. NRC DIVISION OF HUMAN FACTORS SAFETY PERSPECTIVE ON OPERATOR TRAINING AND QUALIFICATIONS

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The most definitive statement regarding the NRC position on operator training and qualifications is presented in NUREG-0737, Clarification of TMI Action Plan Requirements and is often referred to as the "March 28th letter." This letter was sent to all power reactor applicants and licensees by Harold R. Denton, the director of the NRC's Office of Nuclear Reactor Regulation. The letter details (1) the experience and training requirements for licensing of reactor operators; (2) requirements for courses in specific topics, including mitigation of core damage; and (3) certain control manipulations required of operators to assure capability to control plant parameters.

Since that letter was released, several efforts were undertaken to study and establish supportable criteria for operator qualifications and guidance regarding training. These include: (1) A staff proposal to the Commissioners, SECY 81-84, and its predecessors, a proposed rulemaking on "Qualification of Reactor Operators" to be included in the Code of Federal Regulations, 10 CFR Parts 50 and 55; (2) Regulatory Guide 1.8 - "Personnel Qualification and Training"; (3) NRC participation in ANS 3.1 - "Standard for Selection, Qualification and Training of Personnel for Nuclear Power Plants"; and (4) Staff response to NUREG/CR-1280 - "Power Plant Staffing", NUREG/CR-1656 - "Utility Management and Technical Resources"; and NUREG/CR-1750 - "Analyses, Conclusions and Recommendations Concerning Operator Licensing." Each of these documents has suggested or specified training and qualification requirements. To date the NRC has not reached a consensus on a rule that could be issued for public comment. The purpose of this paper is to describe some of the present and planned work which is designed to provide a technical basis for guidelines and regulations on training and qualifications of licensed operators and other nuclear power operations personnel.

Operator Qualifications

The most relevant effort currently underway is a result of the Commissioners' response to SECY 81-84. The Commission directed the staff to:

1) Establish a peer review panel to review the various proposals and comments thereon regarding operator qualifications, to conduct workshops as necessary, and to develop a recommended course of action.

2) Seek additional comments from American Nuclear Society (ANS) and Institute for Nuclear Power Operations (INPO) and to elicit a counter-proposal from industry.

3) Hold workshops to bring together various groups including the peer panel, those affected, academicians and training professionals.

On September 16, 1981, the industry proposal was presented to the Commissioners by representatives of the Atomic Industrial Forum (AIF) and INPO. Basically, the proposal suggested that the NRC not make any rulings until the U. S. Department of Energy supported INPO task analysis project, which is described elsewhere in these proceedings, is completed.

The peer panel and workshops are being coordinated for the NRC by Battelle-Pacific Northwest Laboratories (PNL). The peer panel will be composed of employees from other Federal agencies who have had experience in training and qualifications of personnel, e.g., defense agencies, Office of Personnel Management, and Federal Aviation Administration. The first meeting of the panel is scheduled for the week of November 16, 1981, and initial recommendations will be made early in 1982. The first workshop is scheduled for mid-December (after the peer panel meets and has an opportunity to develop ideas for workshop consideration). That workshop will be designed to elicit comment from those most directly affected by such rules, i.e., operators, and utility management, in a forum with training professionals.

Until recommendations are received from the peer group, the NRC staff will not proceed with the development of any new or modified rules. However, a number of projects have been initiated which relate to the problems of selection and training of NPP personnel.

Licensing Examination

Primary among these is a review of the NRC operator license examination. Recently, some new topics (e.g., thermodynamics, heat transfer and fluid flow) were added to the examination, a higher passing grade was required, and simulator examinations were required as of October 1, 1981. However, concern has been expressed regarding the validity of the examination, and NRC is

experiencing some logistics problems regarding the examination process.

Oak Ridge National Laboratory (ORNL) has been contracted to assist the NRC staff in addressing both the exam validity and logistics problems. The most significant logistic problem is the staffing burden that preparation, conducting and grading of exams places on NRC examiners. Means such as: development of objective questions, objective rating schemes for oral responses, and possible machine preparation and scoring of parts of the exam, are being considered to reduce this burden and improve reliability in the short term. For the longer term, the question of validity, that is, does the examination predict actual performance, will be addressed. The intent of this portion of the project is to develop analytical methods to be applied to the job/task analysis data being collected by INPO and the NRC contractor. The job/task analysis data will identify the task elements necessary to perform satisfactorily in the control room. It will then be necessary to determine the skills and knowledge needed to accomplish the tasks. This information can then be used to design tests which measure the potential operators' level of achievement on those skills and knowledge, as well as actual knowledge of the plant. The same data should be applied to the design of training programs.

New Programs

The job/task analysis materials collected by INPO and the NRC contractor will be used not only for the examination program, but also for other training related efforts. These include: determination of reactor operator qualifications, guidelines for training curricula, guidelines for shift staffing, evaluation of the Shift Technical Advisor requirement and feasibility of licensing personnel in addition to reactor operators.

Other programs which address the question of operator training and qualifications are included in NUREG-0660, "NRC Action Plan Developed as a Result of the TMI-2 Accident," often referred to as the Task Action Plan (TAP). The Licensee Qualifications Branch has developed a program to address the issues raised in NUREG-0660 as well as others which have been identified since that NUREG was issued. The remainder of this paper summarizes some of the technical programs identified in the draft program plan. These include: the training organization, curriculum and facilities, and personnel selection and assessment.

The objective of the various projects is to provide the technical basis for regulations and guidelines related to required education, training, experience, and examination of all operations personnel in nuclear power plants. This includes: management of training programs; qualification of trainers; course content and structure, i.e., curriculum; materials (both printed and audio/visual); training facilities and equipment (including simulators); personnel evaluation, assessment, and testing; training facility accreditation; qualification based selection;and licensing of personnel other than operators.

Training Organization

The training organization task is designed to develop acceptance criteria and procedures for auditing training programs and procedures and requirements for NRC accreditation of training institutions. This includes assurance that training is formalized and structured, lesson plans are developed and implemented, instructors are qualified (both in their area of technical expertise and with regard to their ability to teach), supervisors are qualified, and tests are conducted properly. Accreditation will provide a means of certifying training programs that meet the acceptance criteria established.

NRC activities to date have been limited to conducting Senior Reactor Operators (SRO) examinations for instructors of certain courses at utilities, and the development of a plan, to be audited by the Operator Licensing Branch, for training centers to qualify their instructors as SROs. Also a draft accreditation plan was prepared but lacked requirements and acceptance criteria. So, in effect, there has been no definitive accreditation program which includes defensible requirements and acceptance criteria developed for Commission action.

To accomplish this task, NRC and INPO documentation will be reviewed to determine if sufficient information exists to prepare acceptance criteria for an accreditation program. If sufficient information does not exist, the effort to collect necessary information will be initiated. This will include development of criteria for evaluating training programs based on review of current training programs, task analyses, and feedback of operator experience. Criteria will address both technical knowledge and teaching qualifications of instructors (including any future licensing or examining of instructors) and acceptance criteria for materials, methods and equipment (including simulators) as well as the training facility. Programs for licensed and non-licensed personnel will be included in the long term program.

After acceptance criteria have been developed, a regulatory guide will be issued providing guidance on accreditable training programs, including the organizational structure of the training function, qualifications of instructors, and the content and conduct of training. The guide will also describe the process to be used for accreditation, including the qualifications and structure of the accrediting body.

Curriculum

The objective of the curriculum task is to develop criteria for training and retraining programs and guidelines for a coordinated program of training courses for all plant personnel to detect, recognize, and properly respond to actual plant conditions. This includes determining training objectives that are based on the trainees' job requirements and recognizing the trainees' qualifications, skills and abilities. Classroom instruction, practical (on-the-job) training and retraining, off-site instruction, and training media will be considered.

NRC activities have been limited to the work dictated by the TAP items on core damage mitigation, nuclear power fundamentals and plant drills. Briefly, NRC has reviewed licensee developed plans for training of core damage mitigation and has included guidance on plant walk-throughs of emergency operating procedures in NUREG-0799, "Draft Criteria for Development of Emergency Operating Procedures." No work has yet been done at NRC on establishing definitive requirements for a basic course in nuclear power fundamentals.

The technical activities within the curriculum task will emphasize the development of criteria for material to be included and media to be used in training and retraining courses at utility training facilities, training centers, and for on-the-job programs. Course content will not be limited to technical knowledge, but should also include decision-making and skills development. Acceptance criteria will be established for accreditation and auditing of training and retraining programs.

To accomplish this task, all existing documentation related to training for core damage mitigation, nuclear power fundamentals and plant drills will be reviewed to determine adequacy for the short term. Current training programs will be addressed through INPO and surveys of the industry. Feedback from operators will be collected via a survey or through workshops. Long term curriculum guidelines will be based on the results of the task analysis work of INPO and RES and the results of training and licensing workshops. The task analysis data must be analyzed to determine the critical task elements associated with

performance of assigned tasks. Such analysis should include technical knowledge, psycho-motor skills, decision making requirements, and the level of each needed to perform the job. General learning principles, e.g., motivation, participation, part vs whole learning and transfer of training will be reviewed to assure inclusion in the guidelines.

After the critical task elements have been extracted they will be analyzed to develop criteria for training courses. Appropriate techniques, such as factor analysis, will be applied to the data to identify skill areas of primary importance to different jobs and learning stages. Course content will then be integrated with training methods and training facilities to establish general training guidelines.

Implementation of guidelines will be accomplished through appropriate ANS Standards and Regulatory Guides or NUREGs.

Training Facilities

The objective of the training facilities task is the development of criteria for training facilities and associated equipment. The purpose is to assure that adequate facilities and training equipment, including simulators, are available to nuclear organization personnel so that these personnel can easily transfer the knowledge and skills learned to the operational setting. Included will be guidelines for simulators (both full-scale and part-task), and interactive-computerized instructional systems. Consideration will include the relationship of this equipment to the programs for initial training and retraining, to prepare personnel for operating in the modified control room resulting from the control room design review, and to familiarize personnel for new Emergency Operation Procedures and use of the Safety Parameter Display System (SPDS).

Staff activities have been limited to addressing issues raised in the TAP for full-scope plant simulators and have not addressed part-task simulators or other instructional equipment. The past work has been limited to the selection of sequences for modeling, improving codes, data collection on operator actions, and upgrading simulator standards and associated regulatory guides.

Projects designed to address those portions of the TAP objectives not already being studied will be developed. Possibilities include: review of training programs to assure that operator response times and capability to recognize and cope with accident situations are addressed so that training improvements consistent with this information can be recommended, study of the issue of automatic vs manual control and recommend guidelines for relative

degrees of automation necessary, determination of operator error rates as related to information access and display, improvement of diagnostics and corrective action aides.

Future directions for human factors involvement with training simulators will be dictated by improvements in simulator hardware and software, control room modifications and changes in operating procedures. Though the NRC Office of Research is responsible for the bulk of the basic simulator research, the Division of Human Factors Safety (DHFS) will consider specific tasks related to training, examinations, human engineering modifications and procedures evaluation. The DHFS is planning a workshop of simulator specialists to review existing programs and develop a long term program in simulator technology.

The workshop will specifically consider the short term work necessary to address training on enhanced control room designs resulting from the control room design review, implementation of the SPDS, and integration of this training with training required to implement revised Emergency Operating Procedures.

Personnel Selection and Assessment

The objective of the personnel selection and assessment technical area is to provide the technical basis for requirements regarding the qualification, including education, training, experience, and fitness, of nuclear operations personnel and how those qualifications should be determined. In order to determine qualifications, criterion based critical job elements and means to measure the elements must be established.

The most technically accurate methods of determining critical job elements is task analysis. The task analysis data will be factor analyzed to determine critical elements and their combinations and measurement techniques will be developed to determine the individual's level of ability or achievement. The scope of this technical area is to review all positions in the nuclear organization, not just those positions that currently require licensing. Also, the basis for qualification will consider not only technical matters, but should also address psychological fitness. Further measurement should be based on statistically reliable and valid tests developed according to professionally acceptable standards.

The current programs in this area were discussed earlier in the paper with regard to SECY 81-84 and the improvements to the license examination. Other projects will address psychological fitness and licensing of other personnel.

Summary

In summary, the DHFS perspective on operator training and qualifications is still in the developmental stage. Future guidelines will be based on the programs described above, will be comprehensive and apply assessment technologies available today. Until the results of these efforts are available and have been reviewed by the staff, the DHFS will adhere to the guidance in NUREG-0737 and other Commission directives.

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QUESTIONS TO J. J. PERSENSKY

Joachim Fechner

Q: What are the industry's reactions to the ambitious program of NRC in the area of personnel qualification and licensing?

A: The actual program plan has not been published for industry review. However, INPO has been made aware of some of the projects and will be briefed on the projects once final statements of work have been approved by the national labs involved and the NRC. We intend to work with INPO and those projects which overlap with their ongoing activities.

CSNI Specialist Meeting (CHARLOTTE)

10/12 - 10/15/81

Panel Discussion

(This record was transcribed from a tape recording and has been edited slightly for clarity.)

Chairman: E. L. Zebroski

October 12, 1981

PANEL DISCUSSION

The Swiss paper in this session described the interesting "picket engineer" concept for ensuring that shift crews are directed by a technical expert during plant disturbances. I think it is especially important for other countries, including the U.S., to know that Switzerland has 120 man-years' experience with this concept. So, we have much to learn by looking at that experience and how it has related to the other operators.

Mr. Laaksonen covered the training in organization programs for the two PWRs and BWRs in Finland. He defined rather clearly the relationship of training to the prior educational experience of each individual. Particularly interesting was this bi-national program, which exists in both the PWRs and BWRs.

The presentation from Holland was interesting in that it represented a maturation of a conventional approach to training. I did not detect any emphasis on novelty or doing things differently. I noticed an interesting result, however, that training must be executed with great skill because of the excellent operating performance of these reactors. So sometimes, doing things without too much novelty has an advantage, if you are interested in safety. That is a small sermon for the NRC.

The presentation from Germany centered around the transition now underway to the graduate engineer. This parallels to some

extent the discussions in this country. I think, also, there are a fair number of SROs in this country who have college degrees in some subject or another--perhaps not as much as the 40 percent that was listed in Germany. However, the transition has some difficulties. I think it might be interesting to compare thoughts on these difficulties--which is the career obstacle for those people who do not have a degree--and how that might be handled. A good addition, I think, was the Nuclear Catastrophe Training, which I will choose to refer to as Training for Severe Accidents. I think the sharp drop in experience level, which was described for Germany, is also characteristic in most other countries that have relatively large programs. This suggests that the assumption of the craftsman or journeyman level of knowledge of pumps and valves in control systems--which comes from many years of operating experience of some kind of heavy equipment--is not automatically present. So that obviously needs to be part of the education. He (Dr. Fechner) also remarked on the difficulty of a graduate engineer in demotivating some people who are already operating. The other highlight was the use of the task analysis as a tool to indicate what kind of training was needed.

The Spanish program, I think, was really remarkable in the tremendous diversity of plant types. I think I counted five or six, if you count increasing use of domestic supply. So, you have six different suppliers, each with their own ideas initially about training programs and requirements. I think another

interesting highlight was the topic of 187 different types of malfunctions as a regular part of the training program, which was a well-defined 43-month training sequence. The question I was tempted to ask was how this degree of uniformity was arrived at. Clearly, there was a long transition period in which this level of standardization of approach in this training program was not available.

Mr. Persensky's paper focused on the preoccupation we have in this country with SECY-81-84--the issue of better defining the qualifications of operators and the use of peer panels and consultants to arrive at the answer to this question. I think many people recognize that the key problem is how to accomplish the transition in a way that is not damaging to those plants that are operating well already. The development of guidelines for curriculum and training requirements are something that we have a great mutual interest in with the NRC and with INPO. Here again, I think the very hopeful comment is the increasing use of simulators for education as distinct for skills training.

If I may ask the panel to comment, tell us what you felt was the highlight in the presentations or a maximum of two highlights if you feel strongly about two issues. Then, we will ask the same of the audience.

Mr. Fechner, if you will start.

I would like to cite two highlights with somewhat negative undertone: (1) the lack of activities related to stress, which has to be put into training, is a deficiency that struck me when I looked at all the papers that were presented. These activities are only being begun right now, and it will take some time until this will show up. Until then, we will have to live with what is at hand. (2) The other point that struck me--especially as we have been going in this direction in Germany, too--is the increasing degree to which the authorities are interfering with what the utilities at least are responsible for. By looking back at the analysis on TMI-2, it was said that there already had been too many guidelines, criteria and documents to really comply with all of them. These more or less blurred the picture for those responsible for safety. I am envisioning the potential for going too far in this direction for specifying every detail and guideline in official documents. That, in an indirect way, is taking responsibility off from those who are responsible for the safety of operation. On the other hand, we are, as well, making it more difficult for them by issuing so many documents.

Mr. Alonso

It was brought to my attention the important question of who qualifies the examiners. Who are the people responsible for the examiners--to be sure the examiners do the right thing? In the

Spanish system, I believe that is one of the priorities of the system--that the examining board is made up of a certain percentage of utility people. The question still remains, who is responsible for nominating the examiners and what are the real qualifications of the examiners?

Mr. Miga

After this first day, I learned that we have a great chance in France to have only one utility and a high degree of standardization. So, the relationship between safety authorities and EDF are very different compared to other countries. One of the principal differences is the licensing requirements. I would like the opportunity to answer a question concerning the accreditation of our training program. At the present time, the safety authorities have knowledge of the training program implemented in Spain. There was no approval of this program required until now, but it might be the case in the near future. In our opinion, the plant superintendent has a sufficient commitment to deliver because of his high degree of experience in maintaining a plant. He generally has experience of more than 15 years. He has the same data as an official organization: first, the results of the examination, but in addition, the judgement of the plant superintendent regarding parallel shift work. Furthermore, the only person responsible for the plant in respect to programs in nuclear safety and, in general, the equipment, is the plant superintendent and only him. So, you must consider the man has

the risk of going to prison, and he has the responsibility for choosing training and licensing the man to whom he delegates a part of his own responsibilities. Another point concerned the shift supervisor, and there are several points of view. The safety and physics advisor has no direct responsibility in the shift duties. He is supposed to be the technical advisor of the shift supervisor in such circumstances where there is a need. In all circumstances, the shift supervisor has full responsibility for the shift. The safety and health physics advisor is in charge of coordinating programs of health physics, especially during the first moments after an accident. He also is involved with the training of the team personnel, and, finally, he is in charge of analyzing the significant events.

Mr. Laaksonen

The only thing I would like to mention is the close relationships in the approach of the small countries like the Netherlands, Switzerland, and Finland. We have, from the start of our nuclear programs, established high requirements for the operating staff. So, we have required engineering degrees from the very beginning. The program has met the needs of the utilities and the regulatory bodies little by little. We also have tried to work the best we can with the small resources we have in the small countries. I think the main point is that this necessity of the basic education has been stressed.

Mr. Lobbezoo

I am most impressed by the performance in France to find and train the large number of men they need each year and the training system and organization they have got to meet their goals.

Mr. Myerscough

One thing that has impressed me compared with the UK situation is the problem people seem to have about employing graduate engineers on shift. We have done this for many years and, in fact, we have not found any difficulties with boredom, and so on. It may be that we have got, perhaps with the gas-cooled system, more to do on-shift. We have unloading fueling going on almost continuously. But we certainly have not had major difficulties with people being bored because they are overqualified. That is the first point I would make. The second point I would make is that in many of the papers, it seems to me that we are overemphasizing the need for the operator to operate the plant. In most modern plants, the role of the operator is diagnostic, rather than operational. There is very little, in fact, that the operator can do immediately after a fault to save the plant, particularly a PWR plant. The main role of the operator is to diagnose a situation. In order to diagnose the situation then, he needs to have a thorough understanding of the design purpose of the plant. I sympathize and agree with our friends from France in that having a single utility has great advantages.

Although we have a single utility in the UK, we do not have a great deal of standardization. Again, we put the emphasis back firmly with the person who is responsible for the safety of the plant, namely the station manager. Again, that may help because we do have a single utility.

Mr. Steffen

It is astonishing that the overall approach of licensing procedures is more or less the same in all countries. I think the problems lay in the details. Second, for me to question the worth of psychological tests is important because there were different or opposite statements in the reports. And the third comment, nothing has been said about stress training.

Mr. Persensky

I think it would probably be easier to deal with one utility, but I am sure they have their problems also. I think the thing that stands out in my mind is that the degree requirement is in fact a political decision. I am glad to hear somebody admit to that. I think that could also be the case here in the United States. I hope that once we do have some data, we can base it on a technically sound decision and not only a political decision. The other thing that I am fascinated with, because of the problems we have with the shift technical advisor requirement, is the Picket Engineer concept. To me it sounds like it

might be a feasible alternative to the way some of the utilities are using a shift technical advisor right now as a position in which someone can grow into the operations of the plant.

Mr. Zebroski

Okay. I have one provocative question that occurs to me as I hear these presentations. It seems to me there is a polarization of viewpoint or attitude between countries and even within countries on the lesson of severe accidents like Three Mile Island. The question is whether the system is 90 percent wrong and must be basically restructured, or whether the system is 90 percent right and must have some refinements in the 5 or 10 percent connected with response to severe accidents. I see a variety of attitudes on this question. Perhaps we should give the floor a chance now.

Dr. Warren Witzig

Warren Witzig, Penn State University. Ed, to illustrate my point, I want to tell a very, very brief story. It pertains to task analysis. There once was a very wealthy hunter of wild game, and he decided to establish two peer groups to determine how best to go hunting. The one group he dispatched to an African safari, and he found that it required very fine, high-priced British rifles and very fine German telescopes and range finders and electronic means for calling animals. The second

peer group went to Australia to the outback, and they discovered they needed a snare and a bent sapling and a shovel to dig a pit and cover it with appropriate concealment. Each case was very effective. I wonder if there is not a dilemma in this task analysis in that we are asking a certain group of people to define what it takes to do the job. Aren't we therefore subject to some biases? Anyone.

Dr. Zebroski

I would comment on your anecdote, it was a very good one, but another perhaps academic way of expressing this is that you can determine requirements by a synthetic process drawing upon many man-years of experience or you can assume you are starting from the beginning and you must analyze everything before you can make any moves. Obviously, one culture has thousands of years' experience in making traps work, and they do not do any analyses; they do it synthetically. I think the answer is, of course, that you must blend the two. Is the past generally wrong, or is the past generally right and in need of refinement? Are there any other questions or comments along this line?

Okay, we can allow the panel to expound further, then. Does anyone on the panel wish to address this or another topic?

Speaker?

Well, I would like to comment a little on this question. The answer would certainly, from my point of view, be it is right 90 percent and it just needs minor refinements. However, even accepting this position, one could nevertheless start all over again by doing a systematic analysis of what we need. Because in doing this in a systematic way, we are much better off in precisely defining these minor refinements needed. I guess it is much better to go this systematic way because then you are sure that you will not miss any important point.

Charles Ehret

I remember hearing repeatedly words like "demotivation," "boredom," and I heard that operator error is the major contribution to serious accidents. We heard from Dr. Steffen just now that there is a problem in the psychological testing area, in the stress testing area, and he indicates there are, in fact, authorities in the area of shift work analysis psychologists who have already made recommendations and yet the authorities in this country have not yet heeded them. I wonder if our industries were working on a nine-to-five schedule if we would have the same problems as those that convened this particular conference. We surely would still have problems but not the ones that this particular conference addresses. Early on, Dr. Lobbezoo indicated one way of approaching the problem, and that is to

select a group that was already experienced in shift work, namely people who had experience at sea. I think our own people have done that. Later on, we heard that good, objective measures of performance are needed in the operating arena by Persensky. Joel Kramer said a lot more in the way that science is needed first. I think the central issue is that shift work is a problem. Does anyone in this room know anything about rotas? What are industrial shift schedules? What is their history? What is their proper design? What is the theory? What is the agreement? There is universal agreement that some rotas are absolutely unacceptable. The bulk of the power industry is on those rotas. What about the biological clock itself that causes shift work boredom? The kind of boredom that you are talking about is strictly related to a condition that is called depression, and depression is generated by phase-shifting and retrograde amnesia. So those of you from Europe that may have suffered from slight jet lag on the trip to the West will recognize that you are going through the kind of transient that our shift workers go through every week. I think this is the central issue that has to be addressed. What is the nature of rotas? What is the proper study of the design of rotas? How do we arrive at an acceptable rota? On the other hand, what about our own biological clock that causes us to be inoperative during the inactive phase of the day, or very poorly operative, and how, in fact, can we mitigate? So, from the point of view of measurements in the arena that we heard awhile ago, we already have a large number of mitigation measures that are being used in

some industries. There are already industries in this country and in Canada that are starting to look into this on their own initiative. The mitigation methods are there. So are the measurement methods. We can, in fact, measure the performance of a man as we can the performance of experimental animals. Both of these are ready to go on line. I think we have no good experience in saying what happens in the arena. Witness the FAA problems, not only with the airline pilots association, but also with the air traffic controllers. That is a problem that has been going on for at least 15 years now--the attempt to write new FAA regulations that will make air traffic safe even from a point of view of the pilots' competence to fly the aircraft. Just now a new board has been established out of NASA, and I am glad to say that Major Kirt Graber from Walter Reed is on that board. So, what I am trying to say is that I think the central thrust of this particular conference seems to be on this problem of human factors that contribute to boredom, to demotivation, to depression, and that we have to face these in terms of their analytical components. The structure of rotas on the one hand and the structure of what we like to call the chronohygiene component on the other. I will talk more about that on Wednesday, but I think I heard a great deal about it from every one of the papers this morning.

Dr. Zebroski

If I may gently supplement your comment, though, it seems to me that everything you say still depends on whether you have an adequate selection and training process in the first place. I still think we might know enough about these fields to suggest some intelligent approaches without having to go through a long peer group analysis to rediscover that particular wheel.

Mr. Myerscough

I hesitate to step in here coming from a system that does not operate PWRs, but there is apparently no evidence at all, certainly in the UK, that operator errors are due to the factors that this speaker has just mentioned. We have no evidence that people on shift are bored, and we have no evidence that any of the operator errors are due to bad shift rotas. And that has been our experience in operating gas-cooled reactors the past 25 years.

We do have a little evidence of some fairly serious events happening on night shift, however. There is one other broad comment, which is that the response of the people in the subjective factors is very much a function of the operational and managerial environment. If you motivate people in the appropriate way managerially, they will function at a higher level than if they are demotivated because they are unhappy with the

organization or the structure. I think INPO is, as you know, struggling with something called Management Criterion Technical Support, and one of the obvious correlates which can sometimes contribute to a minor event escalating to a more serious one is that the technical support is usually weaker and less experienced on off-shifts. These people are often less well-qualified than in the premium day shift where more senior people tend to get the privilege to serve. I am not sure that they are entirely rhythm questions. I think they are partly managerial structure and how people make the procedures and flow of authority between the shifts.

Bob Long

Ed, just one comment. Certainly at GPU Nuclear we have looked at the shift rotational problem. One of the things we concluded was that contrary to the man from Argonne, there is very little study of the kind of rotational shifts that we are on. Most of the speakers mentioned six-shift rotations, where one week in six is on third shift, and four out of the six are on day shift. We had trouble concluding much of anything from any studies where people were rotating every third week. But that is really a new pattern in most of the industry. Some utilities had four, some had five shifts, and only this last year-and-a-half have the majority, I believe, gone to the six-shift pattern. So, in that sense it is new, but physiologically it would seem much less demanding than the old rotation where people jumped every week to a different rhythm.

Dr. Zebroski

Okay. If we go on the the question of the degree, I will offer a couple of provocative observations and then get discussion. It is clear that there are two aspects of a degree. One aspect is that if you have the degree, you have established a certain minimum intellectual capability, at least if it is from a respectable university. Even if the particular training is not very relevant, it implies a level of teachability and self-discipline, so that is a positive. The negative on the degree question is that we all know people with more than one degree who we would not trust to run a dog pound. So, you can have extensive academic training that may be a very weak correlation with the ability to operate anything in a satisfactory and coherent fashion. So I think these are the two polarized elements. I can only express a personal opinion, that in my preoccupation with the role of training and the need to show a demonstrable improvement and, hopefully, a measureable improvement in the ability to respond to severe sequences that are outside of the procedure book, you do conclude that a cognitive ability is important, and there are a number of different ways of developing that. What you would really like to have in the senior reactor operator and the superintendent is an understanding of the physical functioning of the system, which I can describe as about the equivalent to the first two years of a first-class mechanical engineering course in this country. That means some courses on basic material property, strength of materials, thermo-hydraulics, and

so on. You can then define a curriculum that is being used in many places, which given that the person has the capability to assimilate this level of information, then would make the degree per se somewhat irrelevant. So I come out just exactly halfway between the non-degree and the degree people on this subject. I hope that is provocative enough to get some comments.

Unidentified Speaker

First of all, I think I agree with you that a degree in itself is no guarantee at all, but we have found in the reports we heard today that some countries seem to like the idea and others do not. Perhaps, may I suggest, that one of the reasons where an academic has some success is that the operators are seen as a transitory job in advancement within the utility over a period of time, while in the other cases, it looked to me like the operator is an end in a career. Maybe there's something to be learned from these two aspects--as a transitory career or a career in itself--the operator.

Dr. Zebroski

This brings to mind Mr. Lobbezzo's comment that to rise to command rank in the Navy you must have a good deal of sea duty and that may have the same characteristics as operating a reactor. You may have long periods of boredom where not much happens --but that is part of the career growth that you have to have

before you proceed. Certainly the kind of culture that permits that kind of progression will have fewer problems with boredom and demotivation than one that does not. Any other comments on the degree question? We have not heard from the NRC folks on this question. Bravely, I hope.

Joel Kramer:

I guess there are four proposals that have been put forth on the issue of the college degree plus the questions related to grandfathering and the pipeline issue, given that there are a number of plants that will not be operating for 3 or 4 or 5 years, I would say, yet operators are being trained. There are two staff proposals, and there are at least two commissioner proposals at this point, and, obviously, there is no consensus. My own personal feeling is that it is not necessary from a technical standpoint, but it may have certain other advantages in the political social sphere of things and the public image concept. We are just going to look at it further and hope that we can come through some better consensus than we currently have.

Dr. Fechner:

My comment is to some extent a deviation to what is the published official attitude of the Federal Republic of Germany. So, in contrast to what I have presented in my paper, I would like to present my personal view. I think the master craftsman

or another degree that you want to select below the graduate engineer would be much better in the shift supervisor position, plus some kind of better-qualified assistance along the lines of the Picket Engineer concept. I believe it is ridiculous to have somebody academically trained for 1 percent or even .1 percent of the situations that he will probably never experience. He will most certainly lose most of this knowledge gained at the university. Given four or five years' time, he will be as good as any master craftsman who has been working on shift for a long time and who really knows his plant and who stays with the plant. This will really offer the feature of an in-depth knowledge and understanding of what is going on, what is behind the story. He will also be in a position, this master craftsman, to smell a rat, to really smell what is going on from the very beginning. In the situation where you have an engineer on shift who leaves after five years, you lose all of the experience you have. The same thing will happen when he stays there; however, he just degrades in terms of knowledge.

Dr. Zebroski:

The experience we have had over a great many years, Mr. Myerscough, is that a percentage of graduate-level people on shift will graduate up the system and will become station managers. This is a very good training ground for those positions. But even if a person stops on shift, a shift manager in a large nuclear station has very considerable responsibility. If we

start to regard the role of shift manager as an operator that has to diagnose faults as they are, then we still firmly believe that in order to diagnose what is going on in a major fault situation, a man must have a technical qualification equivalent roughly to a degree.

I might comment that one industry which has many similarities to nuclear power is the chemical industry. Even the most routine end of it, which you might say is the refinery operations, almost always have a degreed chemical engineer or chemist on the shift. But that is an old cultural tradition in the industry because they never started out with the assumption that you could write procedures for everything. There are always symptom-oriented responses in the operation of a chemical plant, and, in fact, the attempts to go otherwise have sometimes been disastrous. The question still is whether the degree is critical or the level of training.

I would like to throw another provocative point out, though. All right, Bob. You're next.

Bob Long:

To close the issue on the college degree, I might indicate to those of you who may or may not be aware, that at TMI-2, we had college degree people in the control room--4 of them.

Dr. Zebroski:

Well, that leads directly to my provocative next question. Why are we talking about improved training at all? I would like to offer two hypotheses that are partly mutually contradictory. One is that we are concerned or dissatisfied with the ability of people with conventional training to respond to extremely rare events where relying on either personal or organizational past experience is deadly wrong or dangerous, or where you must rely upon hundreds of years of experience and preferably a great deal of analysis beyond that experience. In other words, the severe accident that has never happened but that clearly you must defend against. If that is the main objective, then the points that were made here are very clear that it is very hard to motivate operators to take this seriously. They say, "I am never going to see this in my lifetime. My plant has never seen it; why are you bothering me with these hypothetical questions." So, on that scale, something like the picket or shift technical advisor comes in very strong. The other side of that question, the other reason for improving training, is somewhat at odds with this. You can have perfectly safe responses to a severe event, which are perfectly safe on the NRC scale in that no one is hurt and there is no release to the environment, and yet, the response from a plant standpoint is a disaster. That gets you into the reliability, capacity factor, and productivity side of the scale, which in some respects on a day-to-day basis, requires a great deal more elegance and understanding and discipline in both

operation and maintenance than simply being safe. So I think from the industry side, I tend to agree with the comment from Germany that the highly dedicated career person who will stay with it for a long time is almost the only way you can conceive this highly elegant, disciplined operation over long periods of time. And then, of course, the meeting point between the two may be that you supplement them with the Picket Engineer for the very rare event. I happen to believe the difficulty with most of the accidents we have studied, where the operator did not respond correctly very quickly--they always respond correctly sooner or later, but not very quickly--is in the control room. The aspect of the control room human factor is design, which is to present the most important information without the confusion of the less important information. This development is taking place now in many countries. We call it the safety console or the safety panel in this country. I think if you have better information presented under those conditions, where you have symptom-oriented guidelines which tell you to respond to the symptom rather than try to find 1 of 3,000 specific procedures, and when you tie these together with the appropriate training program. To me, you can then measure a reduction in error rate on severe sequences directly. You will try the naive operator without the aids and the guidelines to measure his performance, and you try the trained operator with the guidelines and the display aids and measure his performance again. And in the very crude attempts we have already made, we ran 12 sets of operators through such a very primitive display system without really any training. The

instructors felt that very substantial reductions in error rate would result from this combination. And so, at the moment, it seems to me that is the most urgent element of the training. Then the luxury addition would be the training that gives you the optimal response instead of merely the safe one. Do I provoke any comments on that viewpoint?

Mr. Alonso:

Thank you very much. You mentioned that sometimes it is very hard to convince operators that they should be trained for the real events. My experience, and I am sure it is also the experience in other countries, is that sometimes it is even more difficult to convince utility managers that this training is necessary. I go on to say that sometimes even the license authorities are not convinced that this is necessary. I believe this is a very important point and is one key to the problem. You mentioned that perhaps you cannot convince the utility managers and licensing authorities that this type of training for real events is necessary by telling them that. Well, in that case you do that, then your plant is more reliable and even more economical.

Dr. Zebroski:

Yes. I think I have heard another observation related to that point, that it is important to be safe, but it is equally

important to look safe. If you have a flow of objectively minor events, but which have the appearance to the public of being near catastrophes, which so often the press tends to have fun with, then you are almost as bad off as if you had this more severe situation. So, a secondary objective is the question of finding the optimal response instead of the merely adequate one. The optimal response will greatly reduce the frequency or consequences of even these non-serious events, non-serious in the sense of public risk, but which nevertheless look as though some serious safety margin was lost. Of course, every time you have a major outage, that implication is left in the minds of many people. So reducing major outages is certainly a secondary but very important by-product of improving the training and selection of people.

Mr. Adams:

I would like to mention that we have heard quite a lot about motivation. If you have a degree, you can be motivated to maintain the knowledge given to you by your degree. Perhaps I can draw an analogy that may have some interest. This century there have been basically only two industries that have started from scratch that in some way affect or are hazardous to the public. One is the aircraft industry, where larger and larger numbers of people are at the hands of an operator, usually called a pilot, and the other is the nuclear industry. All other industries have grown up and have the benefit of accidents, when, in fact, in the

aircraft industry, they also have the benefit of accidents. You will find that pilots do not need a degree to fly an airplane. A jumbo jet carrying 350 people can crash on a town and kill another 350 people. The pilots do not need a degree, but they need to be highly trained in just that one aspect, how to fly the airplane and how to take the correct action if something goes wrong. Now, for this, they are retrained and they are reauthorized on a very, very regular basis. They have a relatively short lifetime at work, but they are also very, very well paid. If you take an operator and operate a nuclear power plant, and he does something wrong because he is not trained correctly, you can kill an awful lot of people--far more than the jumbo jet pilot--very, very easily. Yet we pay them peanuts. We leave him alone until 4:00 in the morning on his last shift, and he is extremely tired, and the biorhythm mentioned before is extremely important. We say to him, get on with it and we will pay you peanuts. Perhaps the object we should really be thinking about is creating the operator as an elite nuclear engineer. Perhaps the associate degree that is being put up by one of the universities in America is a thing we should all be aiming for, not just in America but internationally, and we should pay the people with the responsibility who are at the sharp end more money, and that is quite a lot of motivation.

Dr. Zebroski

I think the laws of supply and demand are making that escalation in money occur at a much greater rate than most people are aware, and I think we will have people flocking for the training when they become widely aware.

I think since we are really making such good progress, I would like to propose that we finish in about ten minutes. I would like to throw out one more topic now for general discussion, which is the role of what people call the cockpit simulator with all the dials and gauges, which is as close as possible to the actual plant, versus the concept simulator or the function simulator or the training tool of the kind that Mr. Myerscough mentioned. The concept simulator is a diagnostic indication of what is happening in the plant, not necessarily typical of the plant instrumentation. I believe there is only one of these that is widely available on the market now. There are several of these in this country and several of these in other countries, at Studsvik, for example. But there are very active steps underway to develop additional concept simulators, and one can still go further. I do not know how many of you have access to an Apple computer, but if you have an Apple, then for $30 you can buy a program called the TMI-2 Meltdown program. With this, you match your wits against a gradually deteriorating reactor and everything that happens, happens a little bit faster with time, and, of course, sooner or later you lose, and the name of the

game is to last as long as possible. Now I think it is an intriguing thought to me that you could turn this into a teaching tool. You could have one, even on this relatively small computer with its relatively small memory. You could take a variety of different actions with pumps and valves and control rods in order to keep up with the game. And with even a medium size mini now, you could do something that simulates a great many functions of the reactor. One semi-serious thought is that one of the roles could be a semi-continuous retraining in that you could have this kind of a game available on those quiet shifts when not much is happening. It could be one way to keep your shift technical advisor or Picket Engineer from going to sleep. He would be testing himself against this game and you could have many different levels of this, as in chess. You could have four levels of difficulty in coping with these severe events. Actually, we are in the process of talking with a number of potential contractors who might be interested in developing such systems, but it is clearly a very intriguing and powerful teaching tool. However, the other consideration is that most operators over 40 do not like this sort of thing, and most operators under 40 are used to TV games, and they are happy with it. Joel, do you have a comment?

Joel Kramer:

Concept simulators is the subject. To follow up on what Ed just said, I suggested to Harold Denton that we might want to use the Atari Scram Game, which goes with the 801, rather than the

Apple, as a replacement for our operator licensing process. It is a little bit too primitive, but the idea is a good one.

Does anyone here have extended experience with the Studsvik concept simulator? Yes.

Gary Grant:

Gary Grant, INPO. I would just like to inform the session, for those who do not have experience with the concept-type simulators, that INPO did host a seminar earlier this year in which we gathered training people throughout the industry to come down and evaluate both a part-task type concept, i.e., the Studsvik simulator and an engineering simulator. Of course, all of the attendees were familiar with the full-scope simulators. The results of that session were quite encouraging in terms of the impressions training people had with respect to the usefulness of part-task simulation as a useful tool, not only for engineer training, but also for operator training, and that is more or less an in-place evaluation by people involved on a daily basis with training as to the effectiveness of that training tool.

If we could have some more comments from the British who have used this, or Mr. Persensky is next.

Mr. Persensky:

I will make a quick comment. I attended a Society for Applied Learning Technology Seminar (SALT) about a month ago, where they discussed the use of simulators in nuclear training. There were a number of papers discussing some incidental kinds of use of the concept simulator. I did not hear enough with regard to any specific data that has been collected to support the use of it in general at this point. I think there is some encouraging work being done right now, both as far as the Studsvik type and some of the smaller systems.

I think one attribute that is very evident on the concept simulator is that it is relatively easy to program it to carry out a variety of very severe accidents, and the similar programming on a full-scale simulator is extremely difficult, if not impossible. There is very basic division of that kind if you wish to train for the more severe events.

Mr. Myerscough:

UK. Can I correct what perhaps may be a misunderstanding? We were not suggesting that what we call the generic-type simulator take the place of a full-scale. We use and certainly have a need for each different type simulator. At the end of the training, we have a full-scope simulator that is an exact replica of our RGA stations. What I am suggesting is that there is a

need and a place in the training for the generic-type simulator, probably at an early stage of the training. The other point I would make is that I am always a little concerned when people talk about simulator courses and simulator training. We would not regard the simulator as a thing apart. It is designed as part of the training package. We would certainly not consider putting operators on simulators by themselves. A simulator has no use unless it is being used with a trained tutor, someone who really understands the system and can work with the operator. There probably is a case for smaller scale things like computer-assisted learning, for instance, which might assist the shift staff at working on their own. Although again, a word of warning that people usually tend to think that 2:00 in the morning is the least busy time on the shift and they can just go around the corner and do some training. People who have been on shift will understand that the night shift, and particularly at 2:00 in the morning, is quite often one of the busiest times.

Unidentified Speaker:

I would like to comment on just possibly another application of this approach, and perhaps it has already been considered, but the thing that occurs to me is that there is a possibility here for dealing with people who seem to generally assume that all operators have is a mental model as to how the plant operates. That, of course, is a very personal thing. I do not know of anybody who denies that every operator has a mental model. I do

not know of anybody who would state that those mental models have a high degree of congruence. I do not think that anyone really knows. But, in any case, if it is important that the operator's mental model is important in diagnosing plant state and trends, a technique of this kind is a way that we might be able to control through training how that mental model takes its shape. And possibly, if we can agree on what a good mental model is, we can try to move in the direction of that for all operators through the training process.

Dr. Zebroski:

I think we have time for one more burning issue if we can tackle it. Otherwise, we can think of adjourning. Is there anyone who wishes to suggest still one more topic? I guess we have not talked about stress. Are there some comments on stress? There is one question that I have no feeling for at all. It is the ability of psychological testing as distinct from just man-to-man observation in judging the stability of the individual under stress. Is that a discipline that has some creditability or are we still floundering on that kind of a question? We have enough psychologists here. I hope to hear an answer to that.

Charles Ehret:

I think the biggest problem, very simply put, is that there have been very few successful attempts that have led to, shall we

say, operationalizing what people think of as stress. Therefore, the measurement of it becomes very difficult.

Dr. Zebroski:

I think we have run an efficient session. I thank the speakers, for one thing, for all being precisely on time. I have never had the good fortune to run such a session before where everyone really observed the time limits as beautifully as we did today, and I think also the audience is to be congratulated. The comments and questions were all very relevant to the subject. We did not have any great wanderings into philosophy. So I thank both the panel and the audience, and we will continue tomorrow with another provocative session.

Thank you.

SUMMARY

SESSION II - TRAINING

CHAIRMAN: A. ALONSO

Eight papers were presented. Two papers explained how two large institutions are instrumenting the needs of the industry. The Grenoble Nuclear Research Center is using a training reactor and a concept simulator to satisfy the needs of the industry and the academy on its side; INPO is addressing, in an effective and systematic way, the training needs of its members.

Two U.S.A universities, Memphis and Cincinnati, presented examples of how these institutions for higher education have implemented programs to serve specific training needs to given utilities.

Representatives of the German utility, RWE, and the American GPU Nuclear explained, in detail, the training given to their own reactor personnel, using mainly their own training organizations.

In all six cases above, emphasis was put, among others, on the teaching tools used. Two presentations, by American authors followed, addressing very specific educational aspects. One was on accountability in training to optimize the revenue of the money spent, and the second was on stress decision.

Even though the presentations covered a wide field, the training activities of other European institutions and universities, together with those by reactor vendors, are missed.

RÉPUBLIQUE FRANÇAISE

COMMISSARIAT A L'ÉNERGIE ATOMIQUE

CENTRE D'ÉTUDES NUCLÉAIRES DE GRENOBLE

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PAPER II-1

SILOETTE, A TRAINING CENTRE FOR REACTOR PHYSICS AT THE NUCLEAR RESEARCH CENTRE OF GRENOBLE

CHARLOTTE, N.C., USA - October 12-15, 1981

by Dr. Michel DESTOT

1. INTRODUCTION

Located at the Nuclear Research Centre of Grenoble, SILOETTE is a pool type reactor with a power of 100 KW.

Designed as a nuclear model for the testing reactors SILOE and MELUSINE, both installed at the same site, SILOETTE has also been used for other applications, involving :

- either its use as a neutron source (in the core as well as on beam tubes) ;

- or its utilization as a training reactor, associated with an electro-nuclear power station simulator. In any case, the latter application constitutes nowadays the main activity linked to the reactor SILOETTE. It is exercised in connection with the French National Electricity Authority (ELECTRICITE DE FRANCE - EDF).

2. SILOETTE, AS A NUCLEAR MODEL FOR SILOE AND MELUSINE AND A NEUTRON SOURCE

SILOETTE has been used since its origin for achieving studies and measurements of reactor core physics (measurements of reactivity, of fluxes, of spectra, screening, etc...).

The equipment of SILOETTE with neutron beam tubes allows other applications that do not require large amounts of flux. The neutron radiography inspections are one of the best known examples of this, as well as certain studies linked to safety (for instance determining the void ratio of a two-phase flow).

Moreover, experiments in the reactor core itself can be carried out under almost ideal conditions : little background noise, no disturbance by the environment - unlike what can occur in an experimental reactor fitted with numerous devices, very accurate operating steps, with very quick power rise and fall.

3. SILOETTE, AS A TRAINING REACTOR

3.1. Objectives pursued

The Reactor Department of the Nuclear Research Centre of Grenoble, starting from SILOETTE, has created an activity of training for reactor physics, which has operated permanently since 1975, in order to comply with the important needs originated by the development of the electronuclear power plants.

Its main aim is the initiation to the fundamental physical phenomena which determine the operation of the reactors.

For this purpose, besides the courses and lectures (general education and specialized training revolving around the principle of operation, reactor kinetics, dynamics and thermics, as well as the main features of the various reactor systems, the problems linked to the structural materials, the damage, radiobiology,...), a rather complete series of practical work sessions is proposed on a training reactor (SILOETTE) and on an electronuclear power station simulator (PWR, GCR).

The education concerns predominantly the engineers and technicians assigned to take on responsibilities in power plant operation :

- engineers of the National Electricity Authority (EDF)
- technicians, supervisors and section foremen of EDF
- engineers of the electronuclear industry (Framatome, Westinghouse, A.C.B., Creusot-Loire, Merlin-Gerin,...)
- students of the National Polytechnical Institute of Grenoble (Atomic and Electronuclear Engineering sections), and of the University.

Substantial efforts are also made in the realization of probations of the same type for the benefit of engineers, technicians and students from foreign countries.

3.2. Training on SILOETTE

The pool Reactor SILOETTE is particularly suitable for training. In fact, the fissile core remains visible during its operation ; handling therein is very simple and can be directly checked by the trainees.

As the control board is located inside the containment which contains the pool, one can at the same time watch a manoeuvre being carried out and see its effect being written on the recorders of the neutronic channels.

Each practical work session is arranged for a team of 5 or 6 trainees (a voluntary limitation for pedagogical reasons and safety conditions inside the reactor).

Several series of practical work are proposed :

- Approach to criticality :
  . research of the critical mass by loading fuel elements ;
  . research of the critical position of the control rods ;
- Flux and power measurement :
  . vertical distribution (with and without disturbance) ;
  . transverse distribution (with various media) ;
- Reactivity measurements :
  . measurements by period meter ;
  . measurements by reactivity meter ;
  . reactivity balance.

4. ASSOCIATED TRAINING SIMULATOR

4.1. Objective

It is an electronuclear power station simulator, intended for the initiation of the trainee to the comprehension of the main physical functions that determine the behaviour of a nuclear boiler. Thus, only the main control instruments of the simulated power plant that are necessary for comprehension, appear on the control desk.

From this viewpoint, the objective pursued is different, but complementary to that of a control room simulator (like that of Bugey - EDF), whose purpose is to try to impart reflexes for the operation of the reactor.

4.2. Composition of the simulator

The simulator comprises :

a) a digital computer SEMS, type SOLAR 16.65 of 256 KØ (taking over a computer MITRA 15 of 64 KØ). It solves permanently in real time (and if necessary in accelerated time) the various equations involved by the simulation of the power plant, with programs oriented in Formula Translation).

Two types of operational procedure have been accepted :

- zero-power operation : kinetic model simulating only the reactor ;
- powered operation : dynamic model simulating the whole plant.

Otherwise, test programs allow to check the proper operation of the computer - interface - console chain.

b) a control and display console

It includes the main control organs (selection and movement of the rods, charge take-up or drop, concentration, dilution of the boron in the case of PWR).

The main parameters which allow to follow the evolution of the reactor operation are displayed from voltmeters, one-way and two-way recorders, plotting table and graphic recorder BENSON (with time-lag).

c) a console/computer interface

It achieves the acquisition of the digital data coming from the computer. The handling of these data by microprocessors allows one to determine the part of the console towards which the information travels along. In the opposite direction, this interface transfers to the computer the data coming from the control organs of the console.

4.3. The simulation programs

The reactors PWR and UNGG are presently simulated from specific programs, perfectly adapted for their use on the simulator. Thanks to the versatility of its design (in particular, micromodule interface), the simulator can be completed from its basic outline in order to simulate other types of reactors (HTR, CANDU, Fast Neutrons...). It is still advisable to note that, outside the training periods, the computer remains available for achieving classical scientific calculations.

a) Main features of the PWR program

The simulation program allows the study of the operation of a power plant, either in real or accelerated time. The model used describes the main organs of the plant that are necessary to the calculation of the principal physical parameters :

- the reactor (core neutronics and thermohydraulics) ;
- the primary piping assimilated to a time-lag ;
- the steam generator ;
- the control channels :
  - . control of the average primary temperature by means of the control rods ;
  - . control of the steam bypass of the turbine.

A reduced amount of safety measures and operational boundaries has been accepted so as not to complicate the console.

b) Typical exercices

From the simulation program of PWR, several sessions of practical works or exercices turning on the study of the reactor operation can be achieved.

As an example, six sessions which involve the main parameters can be proposed :

⁑ Kinetics of the cold reactor

- Approach to criticality ;
- Stabilization at various power levels ;
- Emergency shut-down by means of insertion of safety rods or of by possible injection of a poison ;
- Successive steps of reactivity : evolution of the corresponding power.

⁑ Distortion of the fluxes according to the rod positions

- Axial distortion of the flux by the control rods.

⁑ Temperature effects, powered reactor

- Modification of the reactor power by displacement of the rods, bringing to the fore the DOPPLER effect in the fuel ;

- Influence of the value of the temperature coefficient of the moderator on the behaviour of the reactor (positive, negative or nil) ;

- Influence of the value of the DOPPLER coefficient.

⁑ Effets of small charge variations around a normal operating condition

- Simulation of small charge variations with various temperature effects :

  . without control of the average temperature (natural evolution of the reactor) ;

  . with control of the average temperature :

    - hand steering of the control rods ;

- automatic control of the reactor ;
- compensation of the rods motion by alteration of the poison concentration.

⁑ Simulation of the charge take-up and drop

- charge take-up and drop ;
- simulation of the steam bypass.

⁑ Effects in the long run

- Xenon poisoning ;
- Samarium poisoning ;
- accumulated above effects.

5. APPRAISAL OF THE EDUCATION

5.1. Importance of the probations

The constant increase of the number of trainees since 1973 reveals the impact of this training

Year	Number of trainees
1973	70
1974	112
1975	162
1976	210
1977	270
1978	350
1979	375
1980	400

The training sessions are organized in accordance with the profile of the trainees. Thus in 1980, about thirty sessions representing 8 types of probations adapted to various profiles of people, have received about 400 persons, coming predominantly from EDF but also from the electronuclear industry and the University.

5.2. Personnel assigned to the training

A staff of about twelve persons is necessary for operating and leading this training centre.
The operation itself of the reactor and simulator mobilizes 4 persons who are assisted by specialized teams of SILOE and MELUSINE (mecanical, electrical and electronical maintenance).

Teaching and leading of the sessions are provided by 7 permanent persons : redaction of the courses and conception of the practical works, teaching and supervision of the various sessions, administration and canvassing.

Finally, this basic team is complemented by a secretariat ensuring the reception, the proper administrative and logistic functioning, as well as making available the written documents relevant to the training.

According to the programs of the sessions, lecturers from outside (from the University, the C.E.A., E.D.F., the relevant Ministries..) are occasionally called on.

5.3. Pertinence of the training

The main conclusion from the experience acquired in this field, is that a complete education of reactor agents cannot cut down any stage : first of all basic theoretical teaching, then comprehension of the principal physical phenomena involved, with application of the training personnel to the assigned reactor, and finally the retention of the knowledge and maintenance of the know-how.

The complementary nature of the means (training reactor, simulators with various functions : comprehension, acquisition of reflexes, specific circuit, theory, assistance to the diagnosis, etc...), as well as the systematic repetition of the lessons, seem to be the most suitable means.

The harmony existing between the educational cycles organized by EDF and the training practised at SILOETTE, constitutes a proof of the pertinence of the means used, and a guarantee of the quality and efficiency of this education.

6. STUDIES, DEVELOPMENTS, PROSPECTS

a) development of the simulation programs

Great efforts are made in this way. Thus, modifications linked to the use of the grey rod control, and the starting-up of the 1300 MWe units, are integrated for the PWR.

Certain particular points concerning the operation of the power plant, either in incidental or accidental phase, are also studied.

b) realization of sessions for the benefit of trainees from foreign countries

The first experiences in the matter (Belgium, Spain, Algeria) have proved fruitful, and now they can be organized more systematically.

c) Study of the operators' behaviour

Projects of substantial development in this field of application of simulation are presently under way. It is a matter of achieving incidental and accidental sequences, for testing the operators' reactions in case of abnormal functioning of the plant.

Besides the training of the future operatives, the aim pursued is to study the errors noticed, to return to the cause of these errors, and thus to propose improvements in the methods of presentation of the information presently valid in the control rooms of the power plants.

7. CONCLUSION

The teaching activities of the Reactor Department of Grenoble draw their original feature and efficiency from the equipment (reactor and simulator) on which they are based.

7.1. The reactor

With the passing years, the interest of a reactor of the SILOETTE type is more and more appraised. It is a powerful tool for disabusing of the idea of the nuclear, with a low operating cost, a flexible use (and subject to none of the disturbances provoked by the multiplication of irradiation experiments like in a testing reactor), which allows profitable activities to be developed.

The possibility of harmonizing teaching and research activities, as well as physical studies, based both on calculation and measurement, is also a precious asset.

7.2. The simulator

The fruit of experience of several years' training in close collaboration with EDF, the simulator represents an irreplaceable instrument in the electronuclear field.

A compact unit, where the digital computer and all the electronic connections are incorporated around the console, it represents nowadays a relatively cheap instrument,easily reproduceable, of easy servicing and rather simple.

The functions of reactor operatives, physicians and teachers, of the personnel of SILOETTE, constitutes a very large and varied capital of competence and experience, which allows the education dispensed to get the double dimension, theoretical and practical, sought and appreciated by all the trainees.

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QUESTIONS TO DR. MICHEL DESTOT

Warren F. Witzig

Q: Please describe the relationship of your institute to French universities. Do you grant any academic credit in conjunction with the universities?

A: In our Siloette training centre, we organize special sessions intended for students of the Grenoble University. These students are future engineers, and the degree of their studies corresponds to the third cycle of the French university; it's to say about five or six years after the "Baccalaureat." In fact, we propose mainly the organization of practical works on our teaching reactor "Siloette" and also on our PWR simulator, during about two or three weeks. These tutorials can complete the courses and theoretical lectures they have during all the year. They are part of courses which carry academic credit. We give a great importance,

both us and the Grenoble University, to these activities. For the Siloette personnel, it is a means to keep a high level of the teaching quality, and for the students it is in fact the first and maybe the only opportunity to have a practical experience on reactor operation.

THE ROLE OF INPO IN IMPROVING TRAINING IN THE U.S. NUCLEAR POWER INDUSTRY

Albert M. Mangin
Institute of Nuclear Power Operations

Prior to the accident at Three Mile Island, few U. S. nuclear utilities recognized the extent to which they can be affected by each others' operations. Most now realize that a significant incident at any nuclear power plant in the world can affect all of them. The accident also demonstrated what was already known by many in the industry: the importance of the human element in nuclear power plant safety.

In response to their newly recognized degree of interdependence, the U. S. nuclear utilities formed the Institute of Nuclear Power Operations (INPO) in late 1979 to enhance nuclear plant safety and reliability nationwide. Because this interdependence extends across national boundaries, in 1981 INPO began accepting participants from outside the United States.

Because of the importance of personnel performance in plant safety and reliability, one of INPO's major functions is to promote excellence in the training, education, and qualification of nuclear plant personnel. The Institute's activities do not relieve individual utilities of their responsibilities to develop properly trained and qualified personnel or to operate their plants safely. Instead, INPO assists member utilities in accomplishing these objectives. INPO helps in two different ways: (1) undertaking projects where an industrywide, collective effort is more appropriate or more cost-effective than individual efforts by member utilities; and (2) performing functions where an informed but independent evaluation of performance is needed. In general, INPO assumes these roles not only in the area of personnel training, but in all areas associated with nuclear power plant operational safety and reliability.

To promote excellence in nuclear power plant training, INPO's Training and Education Division has established three objectives:

1. to establish standards of excellence for industry training
2. to evaluate the quality and effectiveness of industry training programs
3. to assist member utilities in providing high quality performance-based training

A variety of activities and projects have been undertaken to accomplish these objectives.

Establishing Standards of Excellence

INPO is developing training program standards and recommendations that reflect a program of excellence; they are not intended to be a set of minimum standards. Adoption and use of these standards of excellence by our member utilities is voluntary, and they must be adapted to each utility's situation. The establishment of these quality standards has been approached in two phases.

In the first phase, INPO has developed interim guidelines and evaluation criteria based on the best programs and practices that currently exist in the nuclear industry. Through their application, INPO hopes that all utility training will move toward the best industry practices. In the second phase, more detailed model training programs, accreditation criteria, and instructor certification standards are being developed based on systematic analysis of training and education needs.

The first phase of training standard development is almost completed. To develop training guidelines and evaluation criteria based on best industry practices, the INPO staff reviewed written program descriptions, visited and evaluated plant training organizations, conducted workshops, and had selected industry representatives review draft documents.

INPO training and qualification guidelines have been and are being developed for nuclear power plant operation, maintenance, and technical support positions. A guideline is also being developed on the overall organization, administration, and management of training activities. Table 1 lists the guidelines that have been identified and indicates their status (as of October 1, 1981). These guidelines are published and distributed to our members and participants as they are developed. Utilities and training organizations have begun to use these guidelines to develop or modify their training programs.

INPO also has developed and published "Performance Objectives and Criteria for Plant Evaluations." Included in this document are nine training-related performance objectives and the associated evaluation criteria. Three additional performance objectives will be added in the near future. Table 2 lists areas covered by these objectives and criteria.

The second phase of INPO's training standards development process involved systematic analysis of the training and education needs of nuclear power plant personnel. Job and task analysis techniques are being employed to develop detailed, performance-based model training programs that will replace the interim training program guidelines. These model programs will also be the basis for the criteria to be used for accrediting industry training programs. Similar analysis techniques are being used to develop instructor certification standards.

Job/task analysis for instructional development is a logical, systematic approach to gathering and analyzing data about job content and performance to make training program design decisions. For training program development, one needs to determine the knowledge and skills required to perform correctly the tasks involved in the job. Training programs that are properly designed, based on the results of job/task analysis, are performance-based; the training programs' learning objectives and

standards are based directly on the task performance requirements of the job.

Using job analysis, INPO contractors are identifying the responsibilities, duties, and specific tasks performed by individuals in various positions at nuclear power plants. Each task that is performed is then analyzed to identify the task's elements (or action steps), the conditions under which it is performed, the standards of performance, and the required tools and equipment. Analysis of this information will be used to determine the knowledge and skills required to perform each job. With the results of the job and task analysis, INPO will construct learning objectives and performance standards appropriate for the training and qualification of individuals for the analyzed job positions. Based on the types of learning involved and the prerequisite knowledge and skills, these learning objectives will be placed in proper sequence, and the most effective instructional and evaluation methods will be identified. INPO's model training programs will include all of these items: learning objectives; standards; and recommended sequence, method of instruction, and method of evaluation. These model programs will be sufficiently detailed to assist utilities in designing, developing, improving, and validating their instructional programs.

Proper job/task analysis and instructional development ensure that necessary topics are included, and unnecessary topics are not included in training. Although job/task analysis has only recently been applied in the nuclear power industry, it is a time-tested, accepted method for developing valid instructional programs. Using this approach will ensure that INPO model training programs will be valid and that their validity will be documented. It is expected that INPO model programs will be the basis for improving and expanding some existing programs, streamlining others, and validating still others. Hopefully, they will also promote a degree of uniformity and standardization, where appropriate.

INPO's model training program development project began in mid-1980 with the development of detailed plans and initial data gathering. In conjunction with the U. S. Department of Energy, which provided contractor funding through Sandia Laboratories, a contract was awarded in January 1981 to Analysis and Technology, Inc., to perform the bulk of the initial job and task analysis. Analysis is in progress for all operations job positions at light water reactors: non-licensed operators, control room operators, control room supervisors, shift supervisors, and shift technical advisors. This phase of the project should be completed in 1982. A future project will analyze the technician and maintenance positions.

In addition to model training programs, INPO is developing recommended technical and instructional qualifications for nuclear industry instructors. These recommendations are based on an analysis of the data resulting from an industrywide instructor survey conducted early in 1981. These recommended qualifications will be provided to member utilities to aid them in evaluating their instructional staffs' capabilities.

Evaluating Industry Training

INPO's evaluation of the quality and effectiveness of industry training programs involves two separate processes. As part of the plant evaluation program, INPO is currently evaluating utility training programs. In the future INPO will begin more detailed evaluation of industry training programs in the accreditation process.

The plant evaluation process involves visits to utility plant sites and corporate offices by teams of INPO evaluators. Each team consists of approximately eight individuals who evaluate the plant's operations, maintenance, radiation protection, chemistry, organization and administration, technical support and training functions. They spend approximately four to five weeks preparing

for, performing, and reporting the results of the evaluation that is based on the "Performance Objectives and Criteria" that have been published and distributed to our members. (Table 2 lists the training-related performance objectives and criteria.)

One evaluation team member examines the training activities and evaluates the quality and effectiveness of the training provided. Upon completion of an evaluation, INPO provides the utility with a report containing the findings (both negative and positive) and recommendations for improvement. The utility provides INPO with responses to the findings, indicating what corrective actions will be taken. During subsequent evaluations, INPO will examine the implementation and effectiveness of these corrective actions. To date training programs at 40 operating plant sites have been evaluated, and the remaining sites will be evaluated by the end of this year. Current plans call for visiting all operating plants and several plants in the start-up phase during 1982.

In the future, industry training will also be examined as part of the INPO accreditation process. This process is similar to that used to accredit educational programs. The basic concepts have been retained, but the procedures and content have been adapted to the industrial training environment. INPO's long-term objective is to accredit technical training programs conducted for nuclear power plant operations, maintenance, and technical support personnel. Initially, training programs for nuclear power plant operators and shift technical advisors will be accredited. INPO is now in the process of establishing the procedures and criteria to be used in accreditation. Pilot testing of the process is now underway.

The INPO accreditation process consists of five major steps shown in Figure 1. In the first step, the organization seeking accreditation submits an application and general description of the programs to be accredited. In the next step, the applicant

performs a detailed self-study of its training activities and programs using procedures, criteria, and forms provided by INPO. During the self-study, the applicant identifies and begins correcting any weaknesses in the organization's training programs. A report of the self-study findings is submitted to INPO for evaluation. After any deficiencies are corrected, the third step - the site visit - takes place. A team of four or five individuals, most of them INPO staff members, visits the training site for several days, observing training activities, interviewing training personnel and others, examining facilities and materials, and reviewing records and procedures. The fourth step is the preparation of an accreditation report including findings and recommendations. In the last step the Accreditation Committee, composed of utility representatives, education experts, and INPO personnel, decides whether to award or defer accreditation.

The most important aspect of the accreditation process is the self-study. This evaluation is conducted by the individuals who are the most knowledgeable of the programs and activities that are being evaluated; they are also the ones who are most directly affected by the quality of the programs, and they have the responsibility, authority, and ability to make necessary improvements. INPO's role is to provide valid, recognized standards and procedures for the self-study and to verify independently the applicant's findings during the site visit.

Accreditation implies that a program, its materials, and the organization that conducts it (including the management control systems, the training facilities, and the instructors) are capable of producing individuals who are qualified to perform their assigned job functions. This process, when combined with plant training evaluations that will focus more on program implementation and effectiveness, will help to ensure that nuclear power plant personnel are well trained and properly qualified for their jobs.

Assisting Member Utilities

INPO assists member utilities in providing high quality training in a number of ways. Some of this assistance is provided to the industry as a whole, while the remainder is directed to the utilities individually.

INPO's training guidelines, recommendations, performance objectives, and evaluation and accreditation criteria are published and distributed to the industry to assist utilities in developing and evaluating their training programs. These criteria are based on the most common training organizational structures and typical job positions in the industry. The evaluation and accreditation processes result in individualized recommendations for improvement of training programs. INPO provides further individual assistance by referring the training personnel to other utilities with programs that more effectively meet INPO standards.

The detailed model training programs based on industrywide job/task analysis will aid utilities in developing and improving their training programs more than current guidelines and recommendations. However, the model programs will be designed to meet the training needs common to many plants and cannot be plant-specific. They will be designed for typical job descriptions, duties, and tasks and will assume certain trainee entry-level knowledge and skills. Each utility will have to compare its job positions to the typical positions and determine the entry-level knowledge and skills of its trainees. The utility must then adapt the model programs to its situation and develop plant-specific instructional programs and materials. To assist individual utilities in this process, INPO will make available the job/task analysis data base and will provide assistance in using this data base to analyze their unique or plant-specific needs and to design their programs.

Another INPO function intended to assist member utilities is the monitoring and evaluation of industry operating experiences and trends for training-related information. As you may be aware, one of INPO's major functions is to analyze industry events that might have safety significance, notify the industry of these significant events, and recommend appropriate actions that utilities should take to prevent the recurrence of this type of event or to mitigate its consequences. In the near future, these efforts will include more detailed, specific analysis of the training significance of events and the development of explicit training recommendations.

Two types of training recommendations are expected to be included: (1) recommendations that certain industry personnel be informed of the circumstances and potential consequences of a particular event, and (2) recommendations that particular topics be added to the training programs of selected plant workers. INPO's screening of events for training-related information will allow all utilities to benefit from the lessons that can be learned from operating experiences, without requiring them to analyze thoroughly every such industry event.

Recognizing the crucial importance of qualified instructors to the effectiveness of training programs, INPO is currently planning to make available services to assist utilities in developing their instructors. When preparations are completed, INPO will assist utilities in assessing the instructional skills development needs of their instructors and will conduct periodic workshops and training sessions covering the most needed instructional skills.

Conclusion

In conclusion, INPO's role in improving U. S. nuclear industry training is to assist member utilities in developing and effectively presenting performance-based training programs. All of INPO's efforts to develop guidelines, recommendations, model

programs, and evaluation criteria and to evaluate and recommend improvements are aimed at providing this assistance. INPO's existence makes possible industrywide, collective efforts and inter-company communication of information that were not possible before INPO was formed. These benefits, combined with the independent evaluations performed by individuals knowledgeable of the industry, make INPO vital to the U. S. nuclear utilities' efforts to improve and maintain the reliability and safety of their nuclear power plants.

TABLE 1

INPO TRAINING GUIDELINES

PUBLISHED (as of October 1, 1981)

- o Non-Licensed Operator Qualification Programs
- o Licensed Operator Qualification Programs (at Operational Units)
- o Shift Technical Advisor Qualifications, Education and Training
- o Licensed Operator Requalification Training Programs
- o Instrument and Control Technician Qualification Programs
- o Electrical Maintenance Personnel Qualification Programs
- o Heat Transfer, Fluid Flow, and Thermodynamics Instruction
- o Training to Recognize and Mitigate the Consequences of Core Damage

UNDER DEVELOPMENT

- o Nuclear Utility Training Management
- o Licensed Operator Qualification Programs (Prior to Initial Criticality)
- o Radiation Protection Technician Training
- o Chemistry Technician Training
- o Technical Development Programs for Plant Engineers and Technical Managers
- o General Employee Training
- o Simulator Training Management

TABLE 2

TRAINING-RELATED PERFORMANCE OBJECTIVES AND CRITERIA

PUBLISHED

TQ.1	Training Organization
TQ.2	Training Administration
TQ.3	Training Facilities and Equipment
TQ.4	Non-Licensed Operator Training
TQ.5	Licensed Operator Training
TQ.6	Licensed Operator Requalification Training
TQ.7	Shift Technical Advisor Training
TQ.8	Maintenance Personnel Training
TQ.9	Radiological Protection Training

TO BE ADDED

Chemistry Technician Training
Technical Training for Engineers and Managers
General Employee Training

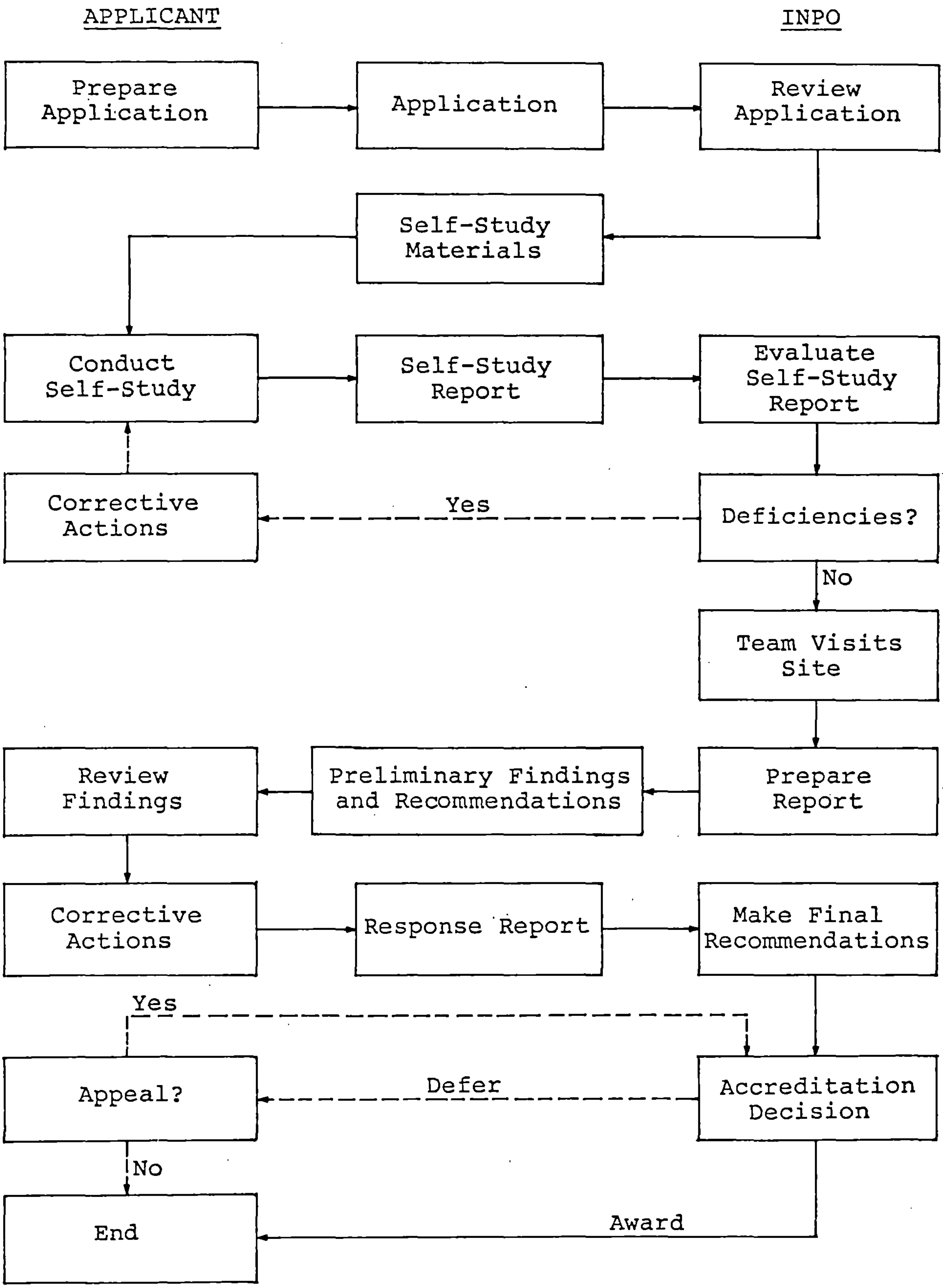

Figure 1
INPO ACCREDITATION PROCESS

QUESTIONS TO ALBERT M. MANGIN

Joel Kramer **Q:** What are the technical, acceptance and evaluation criteria being considered or developed by INPO for the accreditation program?

A: Initially, accreditation criteria will be based on INPO Training and Qualification Guidelines. Later, they will be based on the model training programs resulting from job/task analysis.

Warren F. Witzig **Q:** Is INPO considering the more conventional accrediting mechanisms in the U.S.A., i.e., the professional engineering societies?

A: At the present time, INPO does not intend to seek formal recognition as an accrediting agency by professional societies or educational accreditation organizations.

R. L. Long **Q:** Dr. Persensky's paper indicated that NRC was developing an accreditation

process for utility training programs. You have stated that INPO is doing this. Are you working together, or will the utilities have to deal with two different accreditation processes?

A: INPO and NRC are coordinating their efforts with regard to training program accreditation. It is expected that only one industry accreditation process will result.

ACADEMIC TRAINING FOR NUCLEAR POWER PLANT OPERATORS

D. W. Jones, Ph.D.
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In view of the increasing emphasis being placed upon academic training of nuclear power plant operators, it is important that institutions of higher education develop and implement programs which will meet the educational needs of operational personnel in the nuclear industry. Two primary objectives must be satisfied by these programs if they are to be effective in meeting the needs of the industry. One objective is for academic quality. The other primary objective is for programs to address the specialized needs of the nuclear plant operator and to be relevant to the operator's job. The Center for Nuclear Studies at Memphis State University, therefore, has developed a total program for these objectives, which delivers the programs, and/or appropriate parts thereto, at ten nuclear plant sites and with other plants in the planning stage. The Center for Nuclear Studies program leads to a Bachelor of Professional Studies degree in nuclear industrial operations, which is offered through the university college of Memphis State University.

Experiences of the center during the past eighteen months in successful deliverance of this program indicates that operators are most receptive to academic educational requirements tha will place the operator's job on a professional level. However, since standard catalog courses in the colleges of engineering and science do not always satisfy the requirements of job relevance, special courses had to be developed and special textbooks written to meet the objectives of the program. Furthermore, the experiences thus far gained at nuclear plants where CNS programs have already been delivered has led to the conclusions that (1) an academic degree for nuclear plant operators is necessary for the recognition of the operator's job as a professional, and (2) a relevant degree program can be instrumental in improving the safety and reliability of nuclear power plants.

QUESTIONS TO PROFESSOR D. W. JONES

Joachim Fechner **Q:** You stated that on the basis of your task analysis for the shift supervisor position, a degree would not be required for this function. Did you limit this task analysis to skills and knowledge needed, or did you include personality-related items as well?

A: Yes. A degree is not required on the basis of required technical knowledge alone. Inclusion of overall considerations indicate tha a degree is desirable in much the same way it is in any profession. A degree would also strengthen the professionalism of operational staff.

Joachim Fechner **Q:** Please elaborate on your approach toward ensuring "job relevance," the first basic principle of your program!

A: 1) the text was developed by a team of ROs and academic professors

2) a pilot class was used to identify problems in book and increase application of job

3) reviews were made by industry

4) applications were sought at each plant where course is taught

A. Alonso **Q:** Could Professor Jones give details on the staff number and qualifications of the Center for Nuclear Studies at Memphis State University?

A: 1) Total training staff consists of about 35 full-time personnel and 40 part-time MSU faculty. Total manpower resource available is 100 persons from which CNS draws.

2) CNS develops its own qualification standards for its teaching staff to meet academic, NRC, INPO, and industrial requirements.

a) teach one course on campus for development and evaluation of teaching skill

b) M.S. or Ph.D. in relevant field

c) academic review/approval

d) engaged in relevant professional development

PAPER II-4

A PROGRAM TO IMPROVE EDUCATIONAL QUALIFICATIONS OF REACTOR SITE TECHNICAL PERSONNEL

by

J. M. Christenson & L. E. Eckart
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Cincinnati, Ohio U.S.A.

Contents

Text of a paper to be presented at the OECD Nuclear Energy Agency CNSI Specialist Meeting on Operator Training & Qualifications, Charlotte, North Carolina, U.S.A., October 12-15, 1981.

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A PROGRAM TO IMPROVE EDUCATIONAL QUALIFICATIONS OF REACTOR SITE TECHNICAL PERSONNEL

by
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1. Introduction

Following the TMI accident a widespread consensus in the United States developed about the need to improve the training and educational levels of the on-site staff concerned with the day-to-day operation and maintenance of a nuclear power reactor. Implementation of this idea has taken various forms, including the issuance of NRC regulatory requirements and INPO recommendations. This paper describes the planning and execution of a program that meets all of the Institute for Nuclear Power Operations (INPO) recommendations and NRC requirements for Shift Technical Advisor (STA) education. The program was developed for technical staff of the Zimmer Nuclear Power Station by the University of Cincinnati under contract to the Cincinnati Gas & Electric Co. (CG&E), the primary owner of the Zimmer Station. Initially the program was conceived for the specific purpose of meeting impending regulatory requirement for STA's. However, as the program has evolved, it is now seen as also having the broader purpose of producing a highly qualified site engineering staff with a common technical background.[1]

The function of the Shift Technical Advisor is to provide advanced technical assistance to the power plant operating shift staff during normal and abnormal operating conditions. The general qualifications for this position include a combination of education, training and nuclear plant experience. The qualifications include an in depth understanding of the nuclear plant equipment, systems, operating practices and procedures. The Shift Technical Advisor is also expected to possess well developed analytical skills and the ability to make sound judgements under stressful conditions. These general qualifications lead to extensive education and training requirements for each STA candidate.

The STA Educational Program Plan[2] was developed on a priority schedule during the summer of 1980 to satisfy impending regulatory requirements[3,4] regarding the technical education of STA's. Preliminary consultations with CG&E provided the following premises which furnished the framework for developing the Program Plan and the subsequent proposals for its implementation:

1. The program should satisfy without question the "best estimate" of the impending STA educational requirements.
2. Participants in program (STA candidates) would be drawn from the on-site technical staff and would all have a bachelor's degree in engineering, mathematics or the physical sciences.

3. A minimum of 14 candidates should satisfy substantially all of the STA educational requirements prior to the then scheduled date for fuel loading, October, 1981.
4. The candidates would be required to also participate in extensive training courses beyond those in the STA Educational Program. These courses would cover such topics as plant systems, administrative controls, normal and emergency operating procedures, and simulator exercises. In addition, to the extent feasible, the candidates were to continue their normal on-site technical activities during the duration of the program.

On the basis of the first two premises, the courses in the program were designed so that they would satisfy all of the Institute for Nuclear Power Operations (INPO) recommendations[5] for college level education for STA's, assuming that the program participants had a mathematical background through a first course in differential equations and basic courses in chemistry, physics, and thermal-hydraulic sciences. Premise 3 dictated that course work begin promptly, even before all of the details of the STA Educational Plan were completed. This condition, in combination with the preceding one, placed several further constraints on the sequencing of the courses in the program. Premise 4 required that the program also be coordinated with the other STA training activities and dictated that most classes be offered on-site.

The product of the considerations just described was the STA Educational Program Plan, which specified a total of 485 formal classroom contact hours, divided into 14 courses that would be taught by University faculty at the Zimmer site. The subsequent sections of this paper describe the details of the STA Educational Program Plan, the manner in which it has been implemented, and the experiences during the 14 months that the program has been underway.

2. The INPO Recommendations for STA Education

Table 1 shows the total number of contact hours recommended for STA education and training by INPO and accepted by the NRC as adequately fulfilling current regulatory requirements. These hours fall into four general categories:

1. General Education beyond the high school diploma in the areas of science and mathematics.
2. College level fundamental education in areas of engineering science, engineering mathematics and nuclear engineering.
3. College level plant specific education applying the principles learned in 1 and 2.
4. Additional STA education and training.

Tables 2 through 5 present the detailed breakdown by subject areas of the material in each category. Table 2 shows the breakdown under the general education category. This material, falls into three areas: mathematics, Chemistry and physics. The mathematics includes such subject areas as

trigonometry, analytical geometry, and college algebra. The chemistry requirements are in the area of inorganic chemistry. The physics includes the traditional mechanics, heat, light, sound, electricity and magnetism. In the Zimmer Station STA program, all candidates possessed a B.S. degree in engineering or science and these subject areas were satisfied by all candidates. Therefore the Program does not include any course work in these areas.

Table 3 shows the subject areas included in the college level fundamental education. In the original INPO recommendations each area is further defined in some detail. For example, Reactor Theory must include atomic and nuclear physics, reactor statics, two group diffusion theory, dynamics, through point kinetics including reactivity feedback.

Although all of the STA candidates had a degree in either engineering or science, there was a wide divergence in backgrounds. The backgrounds of the candidates ranged from an M.S. in Nuclear Engineering with Senior Reactor Operating License training to a B.S. in chemistry with no prior nuclear experience. The subject areas shown in Table 3 quite naturally favor those candidates with a degree or related experience in nuclear engineering.

The college level plant specific subject areas are shown in Table 4. Unlike the previous categories, there are no additional details available to delineate these areas. The INPO recommendations further state that these subject areas may be integrated into the college level fundamental education areas.

Relatively few STA candidates had any formal work in these subject areas. The only background that appeared to satisfy these subject areas was Senior Reactor Operator License training, which had been taken by three candidates.

The remainder of the STA education and training is shown in Table 5. Included under this category is training in the areas of management skills, specific knowledge of plant design, operating procedures and simulator training. Training of this type is customarily handled by the utility for the operating staff of each plant. Therefore CG&E assumed the responsibility for all of the training in this category. However, even though none of this type of training falls within the scope of the Zimmer Station STA Educational Program, it was necessary to integrate all of the STA courses into a common time line so the STA candidates could complete all aspects of the program.

3. The STA Educational Program Plan

Starting in August 1980 interviews were conducted with 19 potential STA candidates to ascertain how their educational backgrounds compared to the INPO STA educational recommendations. Based on these interviews, together with a detailed review of each candidate's academic transcripts and experience, the prospective candidates were classified into three categories:

Category I - Candidates with basic undergraduate nuclear engineering background (11 candidates).

Category II - Candidates with a degree in some area of engineering other than nuclear, but one which included courses in thermal-hydraulic sciences (5 candidates).

Category III - Candidates with an educational background different from that required for classification in either category I or II (3 candidates).

After analyzing the needs of CG&E, the capability of the University of Cincinnati faculty and the characteristics of prospective candidates, the STA Educational Program Plan was devised. The Program Plan was completed in December of 1980 and was designed so that it had the following features: (1) Candidates in all three categories could participate in all the courses that they needed for STA qualification. (2) Candidates in Categories I and II would meet all of the INPO educational recommendations upon completion of the program. (3) Existing courses in the University of Cincinnati Nuclear Engineering Program could be utilized to the maximum extent feasible. (4) Courses successfully completed could be applied toward a graduate degree in nuclear engineering at the University of Cincinnati.

CG&E initially requested that all courses be completed prior to December 1981. However, a subsequent clarification of the regulatory requirements,[6] has placed the INPO STA recommendations in the "long-term" implementation category. As a result, the completion date requirement for the course work was delayed. Presently, all courses in the program are scheduled for completion by December, 1982.

The fourteen STA Educational Program courses are listed in Table 6. Some courses are almost identical to existing graduate level courses, at the University of Cincinnati, while other courses are completely new and several courses have been modified to include plant specific material. The general approach has been to integrate the 120 hours of plant specific material throughout the appropriate courses. For example, EC 1, Nuclear Radiation Protection and Health Physics, is very similar to a regular graduate level course, Radiation Protection. For the STA educational program, the course was revised to include examples and homework problems that would better reflect the situations that would be encountered by STA's in plant situations. The course material includes all the topics normally covered in the regular thirty class hours plus ten hours of additional work related to health physics and STA problem situations. The final course, EC 14 represents the culmination of the program. This is a new course made up entirely of plant specific reactor technology material drawn from the Zimmer Station FSAR and other reactor safety reports. The topical material will include radionuclide transport, core and system behavior during LOCA and ATWOS events, startup accidents, power cooling mismatch, core meltdown consequences and risk assessment.

Several of the other courses shown in Table 6 were also developed especially for this program. Typical examples of new courses are:

- Reactor Water Chemistry, EC 7
- Principles of Instrumentation and Control Theory, EC 8
- Nuclear Reactor Instrumentation, EC 10
- Reactor Thermal Sciences, EC 11

The subject areas covered in each course were carefully selected so that all of the INPO recommended topics were included. A keyword description of the topics covered in each course and their relationship to the INPO recommendations is given in Table 7.

4. Implementation of the STA Program Plan

All course work, both lectures and labs, has been conducted at the Zimmer Station. Classes usually meet two days a week either in the early morning or late afternoon hours. Class meeting times are formalized by mutual agreement between the instructor, the program directors and the CG&E Company.

All courses are being taught by highly qualified university instructors and are conducted in much the same manner as on-campus courses. The candidates are expected to spend between one and two hours outside preparation per lecture hour. The courses include regular homework assignments, quizes and a comprehensive final exam. Grades are assigned at the conclusion of the course, and most courses carry graduate credit at the University of Cincinnati. Most of the instructors are from the University of Cincinnati, but three courses are being taught by visiting Adjunct Professors from Ohio State University and Otterbein College.

Because of the intense rate of delivery of the courses in the STA program and the diverse backgrounds of the STA candidates, special educational support has been provided for each course.

The instructor is assigned a dedicated graduate student for each course. In addition to what would be considered regular graduate level course support, the assistant conducts special problem sessions and one-on-one tutoring sessions with the candidates. These extra sessions are <u>not</u> included in the course contact hours. They are above and beyond the class lecture hours. The philosophy has been to provide as much help as is required to give each STA candidate every opportunity to learn and master the subject material, while at the same time maintaining the academic standards of a graduate level course.

In addition a course notebook is provided on site that contains <u>all</u> the lecture notes for the course, solved problems and data. The program directors counsel the STA candidates who are experiencing difficulty in the course or program. Also an STA "library" has been established at the plant site which contains the best reference material for each course.

The University of Cincinnati Nuclear Engineering Faculty has reviewed each of the STA Program courses and has agreed that specific courses may be

used to satisfy some of the M.S. degree course requirements. The result is that an STA candidate, who satisfactorily completes the program, is well along toward an M.S. in Nuclear Engineering. A typical candidate would still be required to take six (6) hours of advanced mathematics, six (6) hours of Nuclear Physics, plus complete either an M.S. project or M.S. Thesis. Many of the STA candidates have expressed an interest in completing M.S. degree requirements after the STA program is finished.

By the end of August 1981, seven of the fourteen courses in the program had been completed. The courses are being taken by a number of CG&E personnel as well as STA candidates, and 26 CG&E employees have completed at least one course in the program. Eleven STA candidates have either completed or received credit for all courses in the program. Of the 19 original enrollees, 4 are no longer enrolled, 8 new candidates have enrolled in the program, so that currently there are 23 active STA candidates.

The results of the STA Educational Program will not be fully known until the program is completed. However, after a year's experience some preliminary results and observations can be made are shown below:

1. In view of the many demands on the candidates, the initial pace of the program was too intense. The course delivery rate was initially planned for 10-12 lecture hours per week. The delivery rate has now been reduced to 6-8 hours per week.
2. Some attrition in the number of candidates is to be expected and will occur during the course of the program.
3. The program will produce a site engineering staff with a common technical background.
4. STA candidates who successfully complete the program will have a high degree of technical competence and determination to prevail.

It is our expectation that these last two results will contribute significantly to the successful operation of Zimmer Station.

Table 1

STA EDUCATION AND TRAINING
(Contact Hours)

1.	Education beyond high school diploma	270
2.	College level fundamental education	520
3.	College level plant specific education	120
4.	Additional STA education and training	480
	Total Contact Hours	1390
	Annual re-qualification training	80

Table 2

STA EDUCATIONAL REQUIREMENTS

Prerequisites Beyond High School Diploma	Contact Hours
Mathematics	90
Chemistry	30
Physics	150
Total	270

Table 3

COLLEGE LEVEL FUNDAMENTAL EDUCATION

Subject	Contact Hours
Mathematics	90
Reactor Theory	100
Reactor Water Chemistry	30
Nuclear Materials	40
Thermal Sciences	120
Electrical Sciences	60
Nuclear Instrumentation/Control	40
Radiation Protection/Health Physics	40
Total	520

Table 4

COLLEGE LEVEL PLANT SPECIFIC EDUCATION

Plant Specific Reactor Technology	
Plant Chemistry and Corrosion Control	
Reactor Instrumentation and Control	
Reactor Plant Materials	
Reactor Plant Thermal Cycle	
Total	120

Table 5

ADDITIONAL STA EDUCATION AND TRAINING

Subject	Hours
Management/Supervisory Skills	40
Plant Systems Training	200
Administrative Controls	80
General Operating Procedures	30
Transient/Accident/Emergency Procedures	20
Simulator Training (50/50)	100
Total	480

Table 6

ZIMMER STATION EDUCATIONAL PROGRAM COURSES

No.	Title	Lecture Hours
EC 1	Nuclear Radiation Protection and Health Physics	40
EC 2	Electronics for Nuclear Power Stations	30*
EC 3	Radiation Effects on Materials	30
EC 4	Nuclear Reactor Theory I	35
EC 5	Basic Electric Power Engineering	30
EC 6	Nuclear Reactor Theory II	40
EC 7	Reactor Water Chemistry	40*
EC 8	Principles of Instrumentation and Control Theory	30*
EC 9	Reactor Kinetics	35
EC 10	Nuclear Reactor Instrumentation	30*
EC 11	Reactor Thermal Sciences	40
EC 12	Applied Boiling Water Reactor Engineering	40
EC 13	Nuclear Radiation Detectors & Measurement	30*
EC 14	Boiling Water Reactor Safety Analysis	35

*Additional laboratory time required for these courses but not included in this figure.

Table 7: RELATIONSHIP OF ZIMMER STATION STA COURSES TO INPO TOPICAL REQUIREMENTS

STA Course Title Keyword Description & Contact Hours	Contact Hours Per INPO Topical Requirement
<u>Nuclear Radiation Protection & Health Physics</u> Principles of Radiation Protection, Dose Calculations, Radiation Measurements and Public Safety Standards, Dose Reduction Shielding. 40 contact hours.	Radiation Prot. & Health Physics, 40 Hours
<u>Electronics for Nuclear Power Stations</u> Diode and Transistor Fundamentals, Logic Functions and Boolean Algebra, Pulse Forming and Shaping, Multiplexing, Operational Amplifiers, Registers and Counters, D/A and A/D Converters. 30 contact hours plus labs.	Electrical Sciences (digital electronics), 30 Hours
<u>Radiation Effects on Materials</u> Fundamentals of Neutron and Gamma Radiation Interactions with Materials, Sensitivity of Materials to Radiation Effects, Effects on Electrical Components and Organic Materials. Fast Neutron Sputtering, Fuel Element Effects including Flux Depression, Fuel Densification, Thermal Spike, Stored Energy in Defects, Fuel Swelling, Steel Fatigue and Ductility Point Transition Effects. 30 contact hours.	Nuclear Materials (reactor material properties), 20 hrs. Plant Specific 20 hrs. Plant Specific Reactor Plant Materials, 10 hrs.
<u>Nuclear Reactor Theory I</u> Nuclear Physics, Chain Reactions, Neutron Flux Current and Reaction Rates, One Speed Diffusion Theory and Perturbation Theory, Multi-group Diffusion Theory. 35 contact hours.	Reactor Theory (Nuclear Physics, Statics), 35 hours.
<u>Basic Electric Power Engineering</u> A.C. Circuit Phasor Analysis, Real & Reactive Power, Synchronous Generators, Motors, Power Transformers, Switchgear. 30 contact hours	Electrical Sciences (Motors, Generators, Transformers, Switch-gear, 20 hours. Plant Specific Technology (Electrical), 10 hours.

Table 7 (Continued)

STA Course Title Keyword Description & Contact Hours	Contact Hours Per INPO Topical Requirement
Nuclear Reactor Theory II Multi-group Perturbation Theory, Slowing-Down Theory, Heterogeneous Reactors, Thermal Neutron Spectra, Reactivity Control and Core Composition Changes. 40 contact hours.	Reactor Theory (Statics, 2 Group Diffusion Theory), 35 Hours. Plant Specific Reactor Technology (Core Physics), 5 hours.
Reactor Water Chemistry Reactor System Inorganic Chemistry, Corrosion-reaction Rates, Power Plant Water Chemiatry, Corrosion Control, Hydrogen Generation, Solubility and Control. 40 Contact hours plus labs.	Reactor Chemistry, 30 hours. Plant Specific Plant Chemistry and Corrosion Control, 10 hours.
Principles of Instrumentation and Control Theory Laplace Transforms, Transient Response Analysis, Control Theory and Linear Stability Theory Analysis, Process Instrumentation (Temperature, Pressure Flow, Level) Principles of Neutron Reaction). 30 contact hours plus labs.	Electrical Sciences (I&C Theory), 10 hours. Mathematics (Laplace Transforms for Control Response), 5 hours. Nuclear Instrumentation & Control (Reactor Instrumentation), 10 hours. Plant Specific (Reactor Control), 5 hours.
Reactor Kinetics Zero Power Solutions, Derivation of Point Kinetic Equations Point Kinetics with Reactivity Feedback, Reactor System Dynamics, Site Specific ATWOS Events and Operational Transients. 35 contact hours.	Reactor Theory (Dynamics, Point Kinetics, Reactivity Feedback), 30 hours. Plant Specific Reactor Technology (FSAR Transients), 5 hours.
Nuclear Reactor Instrumentation NSS Specific Neutron Sensors and Neutron Signal Conditioning, Process and Neutron Monitoring Systems, Feedwater, Recirculation and Pressure Control Systems, Reactor Protection System, Instrumentation Standards, Codes and Technical Specifications. 30 contact hours.	Nuclear Instrumentation & Control (Reactor Instrumentation, Reactivity Control & Feedback), 10 hours. Plant Specific (Reactor Instrumentation and Control), 20 hours.

Table 7 (Continued)

STA Course Title and Keyword Description	Contact Hours Per INPO Topical Requirement
Reactor Thermal Sciences Heat Transfer, Fluid Flow and Pressure Drop in Reactor Thermodynamic Cycles, Boiling Heat Transfer, Two Phase Flow Pumps, Heat Exchangers, Cooling Tower Design. 40 contact hours.	Thermal Sciences (Steam Cycles, Fluid Friction, Pump Head Loss, Two Phase Flow, Boiling Heat Transfer, Heat Exchangers), 35 hours. Plant Specific Reactor Technology (Pumps & Cooling Tower), 5 hours.
Applied BWR Engineering BWR Thermal Cycle and Thermal Analysis Reactor Fuel Design, BWR Hydraulics, Void Distribution, Flow Redistribution, Reactor Vessel Design and Embrittlement Effects. 40 contact hours.	Thermal Sciences (Two Phase Flow, Boiling Heat Transfer, System Characteristics), 35 hours. Reactor Plant Thermal Cycle, 5 hours.
Nuclear Radiation Detectors & Measurement G.M. Counters, Scintillation Detectors, Proportional Counters, Seim-conductor Detectors, Ion Chambers. 30 contact hours plus labs.	Nuclear Instrumentation & Control (Radiation Detectors), 20 hours Plant Specific Reactor Technology (Radiation Detectors and Nuclear Instrumentation), 10 hours.
BWR Safety Analysis Radionuclide Transport, Core & System Behavior During LOCA and ATWOS Events. Startup Accidents, Power-Cooling Mismatch, Core Meltdown Consequences and Risk Assessment. 35 Contact hours.	Plant Specific Reactor Technology (FSAR material), 35 hours.

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2. J. M. Christenson & L. E. Eckart, "Nuclear Power Plant Shift Technical Advisor Educational Program," A report prepared for the Cincinnati Gas and Electric Co., (December, 1980).

3. "Letter to All Operating Nuclear Power Plants," Subject: Discussion of Lessons Learned Short-Term Requirements," H. R. Denton, U. S. NRC, (Oct., 1979).

4. "Letter to All Licensees of Operating Plants and Applicants for Operating Licenses and Holders of Construction Permits. Subject: Preliminary Clarification of TMI Action Plan Requirements," D. G. Eisenhut, U. S. NRC (Sept. 5, 1980).

5. "Nuclear Power Plant Shift Technical Advisor, Recommendations for Position Description, Qualifications, Education and Training," The Institute for Nuclear Power Operations, (Rev.0), April, 1980.

6. "Clarification of TMI Action Plan Requirements," NUREG-0737, Division of Licensing, U. S. NRC (Oct., 1980).

QUESTIONS TO J. M. CHRISTENSON

Gary Grant **Q:** Does the program you have described include a course, or courses, in deductive reasoning, logic, or methods for process analysis?

A: The educational program itself does not include any courses which have been designed with this particular objective. However, the STA candidates also participate in a number of other training courses which are administered by CG&E, including courses involving full-scope (or replica) simulators. I believe that such material will be covered in these courses.

Michael Stephens **Q:** I understand that STAs have been received with some reticence by control room staffs in various plants due to a lack of in-plant experience. You mentioned that the STA candidates for Zimmer have been drawn from the plant technical staff and will take their STA courses at

Zimmer. Could you comment on the practical experience that the candidates had before starting the course and will receive during the period of their STA training?

A: Their experience varies widely. Some have been on site for several years. Others are junior engineers who have just recently started working for CG&E. In all cases, the candidates have a college (or university) degree, and the candidates will be responsible for their normal on-site assignments while they are participating in the educational program. Since the program will be of at least two years duration, all candidates will have this much practical experience as a minimum.

Joel Kramer **Q:** What plan do you or Zimmer have to do follow-up evaluation of the STA program?

A: Specific plans for the follow-up evaluation of the STA educational program have not yet been made. However, both parties to the program are satisfied with the way the program has developed during its first year of operation, and such an evaluation would appear to be a likely development prior to any extension of the program.

Robert Mackie

Q: Is there any evidence or expectation that the acceptance of the shift technical advisor's role will be increased as a result of the type of training you describe? (U.S. power plant operators have not, to date, shown much inclination to utilize STA "expertise.")

A: The Zimmer plant has not yet loaded fuel, and therefore no information on this point is available since the STAs have not yet been placed on an "active duty" status. As an aside (as indicated by several of the responses from the audience), I

believe that there has actually been a diversity of responses to STAs by control room operators. In some instances at least, the STAs have been received quite positively by operating personnel.

OPERATOR TRAINING AND REQUALIFICATION AT GPU NUCLEAR

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I. INTRODUCTION

The operator training and requalification programs at GPU Nuclear's Oyster Creek (650 MWe BWR) and Three Mile Island-1 (776 MWe PWR)nuclear plants have undergone significant revisions since the Three Mile Island-2 accident. This paper describes the Training & Education organization, the expanded training facilities, including basic principle trainers and replica simulators, and the present operator training and requalification programs.

II. TRAINING & EDUCATION ORGANIZATION

The GPU Nuclear (GPUN) Group was formed in early 1980 to support and operate our nuclear generating stations. A number of the functions, e.g., training, radiation control and licensing, traditionally under the direction and control of the Station Manager were separated into a functional organization structure to provide the required intensity of direction and management involvement. Specifically, the Nuclear Assurance Division, headed by a vice president, included Training & Education, Quality Assurance, Emergency Preparedness, and Nuclear Safety Assessment.

A. T&E Organization

The director of Training & Education coordinates and administers four departments: Corporate Training Department, Three Mile Island Training Department, Oyster Creek Training Department, and the System Laboratory. Each of the training departments is at a different location, and each is managed by a training manager who provides the technical and administration direction of the training at that location.

The Corporate Training Manager coordinates common elements of the site training programs, but each training manager and his staff is responsible for providing the training needed at his respective location. The OC and TMI Training Departments are organized to provide administrative support; training and educational development activities; and training for operators, technicians, maintenance, security, supervisory and management personnel, and general employees/radiation workers.

B. T&E Staffing

Table 1 shows a comparison between the numbers of full-time training personnel before the TMI-2 accident and in September 1981. The very large increases shown here are representative of the significant commitment to improved training of all personnel involved in nuclear plant operations and support. Because of the breadth and level of training activities, most of the new instructional staff members hold 4-year baccalaureate degrees and a number hold master's level degrees.

The present Oyster Creek Operator Training Staff consists of seven instructors, including two who are in training for SRO licenses and two who are SRO-certified contractors. In 1982 we will have released the contractors and have a full complement of seven operator training instructors, with four devoted to licensed operator training and three to non-licensed operator training.

The present TMI Operator Training Staff consists of a manager, two supervisors and ten instructors, split evenly between licensed and non-licensed operator training. One supervisor and three instructors are SRO-licensed, two are RO-licensed and in training for SRO licenses, and the remaining five instructors are in training for RO licenses. One of these five was SRO-licensed at another facility.

III. TRAINING FACILITIES

The significant commitment by GPUN to training has also been reflected in the development of training facilities at the Oyster Creek and TMI sites.

A. Classroom/Training Centers

The TMI Training Department is housed primarily in a new Training Center, completed in August 1981, located across the river from the Island plant site. Twenty classrooms, modular offices, reproduction, library, and other service facilities are contained in the Center.

Training activities which remain on-site consist of laboratory and practical factor programs. Maintenance laboratories and radiation-worker practical factors are conducted in specially-outfitted trailers near the plant. Chemistry and radiological controlled laboratory exercises are conducted in areas of the actual in-plant facilities. A full-size TMI-1 control room mockup--made

TABLE 1

GPUN FULL-TIME TRAINING PERSONNEL

	PRE-TMI-2 ACCIDENT	09/01/81*	PROJECTED 12/31/82
Corporate Headquarters	0	7	8
Oyster Creek	3	33	42
Three Mile Island	7	51	62
Totals	10	91	112

*Includes 6 and 5 contractors at OC and TMI, respectively.

A. Classroom/Training Centers (Continued)

of photographs, plywood and a mini computer-driven annunciator panel simulator - is currently located on the TMI-1 turbine deck and is available for training control room operators

The Oyster Creek Training Department is housed in several buildings on the Forked River* site, immediately adjacent to the Oyster Creek plant. Ten classrooms, modular offices, reproduction, library and other service facilities are located in the Administration Building, along with other Oyster Creek support groups.

An adjacent building houses facilities for laboratory and practical factor training programs. This includes radiation worker practical factor training, maintenance program laboratories, a chemistry laboratory, and a full-size Oyster Creek control room mockup - made from photographs and plywood - and housed in a room replicating the actual control room.

B. Basic Principle Trainers

The various investigations of the TMI-2 accident, including GPUN's own internal review, indicated the need for a special emphasis in operator training programs on basic principles of plant system behavior and interactions. In the summer of 1981, GPUN placed an order with Electronic Associates, Inc. for a Basic Principles Trainer (BPT) for the Babcock & Wilcox pressurized water reactors at TMI. The delivery date is late 1982.

The BPT simulation of plant operation is based on full-scope simulator software of a nuclear generating station similar in design to TMI-1. It provides the capability to simulate in real time normal and abnormal conditions, both transient and steady state. The trainee console consists of a vertical display panel and horizontal control panel. The display panel contains a mimic drawing illustrating TMI systems and appropriate actuation switches, parameter display meters and annunciators. The control panel contains major controls and some parameter displays. Two CRTs are also available for trend display of plant parameters as well as selected calculated data like spatial xenon concentration or axial and radial core power distribution.

* GPUN cancelled construction of the Forked River Nuclear Plant after the TMI-2 accident.

B. Basic Principle Trainers (Continued)

An instructor's console with a CRT provides a means of controlling and monitoring the BPT's operation. The instructor can utilize such features as:

- initialization to 1 of 30 plant conditions
- backtrack or ability to return to prior conditions
- manual time delay or insertion of malfunctions
- fast time - slow time capability
- control of certain functions external to the control room

A very important element in the development of the BPT specifications has been the development of detailed behavioral learning objectives for the BPT training program. These objectives are stated in the form of learning goals, describing the specific concepts which the BPT is intended to convey, followed by a statement of the behavioral learning objectives for each concept, describing the specific actions which the student is expected to take at the BPT console in order to demonstrate understanding of the concept. In some cases the actions involve presenting explanations of particular evolutions. In other cases, the actions require manipulation of the BPT controls to accomplish a stated objective. The 18 topics covered by the learning objectives are displayed in Table 2. After the learning objectives were formulated, they were used to evaluate the proposed design of the BPT simulator in order to ensure that the BPT could accomplish these objectives. Thus, the statement of the learning objectives is an integral part of the BPT design process.

The Oyster Creek BPT specifications will be issued in the next month or two and have required a longer development time because of the unavailability of a boiling water reactor model BPT. It will also be based on behavioral learning objectives, although the topic organization (see Table 3) evolved around the basic principles taught in the Oyster Creek operator training programs, as compared with the systems organization used for the TMI BPT. A delivery time of 16 - 18 months should make the OC BPT available in early 1983.

TABLE 2

TMI BPT LEARNING OBJECTIVE TOPICS

Reactor Principles

Integrated Plant Operations

RCS Pressurizer Operations

Feedwater System

Emergency Feedwater

Main Steam System

Turbine Generator System

Make-up and Purification System

Emergency Safeguards Actuation System

Decay Heat Removal System

Integrated Control System

Core Flood System

Condensate System

Condenser Circulating Water (Vacuum) System

Reactor Coolant System

Reactor Coolant System Drain Tank

Control Rods, Reactor Core

Once Through Steam Generators

TABLE 3

OYSTER CREEK BPT LEARNING OBJECTIVE TOPICS

Reactor Principles

Reactor Kinetic Principles

Thermodynamic Principles

Fluid Flow Principles

Physical Science Principles

Electrical Principles

Instrumentation Principles

Control System Principles

Integrated Relationship of Overall Plant Principles

C. Replica Simulators

The 1981 GPUN capital equipment budget included funding for the preparation of specifications for replica simulators of the Oyster Creek and TMI-1 control rooms, to be located at the respective reactor sites. The orders for these simulators will be placed early in 1982, and delivery is anticipated in the first-half of 1985.

Detailed attention is being given to the development of requirements for the plant process model. The development of behavioral learning objectives will also be used to help specify training features and in the development of lesson plans for replica simulator training.

D. P-T Plot Trainer

The TMI-1 Pressure-Temperature (P-T) Plot Trainer is the first of a variety of part-task training devices to be developed. A dynamic plot of hot leg temperature vs. primary system pressure and cold leg temperature vs. steam generator pressure has been introduced into the TMI-1 control room to assist operations personnel - including the shift technical advisor - to analyze plant transients (Reference 1).

Using a dedicated minicomputer and interactive color CRT display terminal, a Computer Assisted Instruction (CAI) program has been developed to train personnel in the use of the P-T plot in analyzing plant transients. The display on the trainer is an exact duplicate of the CRT presentation in the control room. The trainer can simulate various "canned" transients in half, double or real time.

Through the use of CAI, the student is guided through a series of graduated exercised and tested for mastery. The record keeping and test results are automatically maintained in the computer. The instructional design is such that the student knows what the objectives for each segment are, and the student is tested for mastery of these stated objectives. No knowledge of computer programing is required by the student using the system. By a branching process the program can meet the needs of a wide range of students, from the inexperienced to very experienced users. The end result is that everyone can achieve the minimum goal of the program that, "Operators will be able to evaluate plant performance during transients, identifying abnormal performance by comparing displayed parameters to limiting values in real time."

IV. OPERATOR TRAINING AND REQUALIFICATION PROGRAMS

The operator training and requalification programs at Oyster Creek and TMI have been undergoing significant changes since the TMI-2 accident. In the Fall of 1979 all licensed TMI-1 personnel were placed in an Operator Accelerated Retraining Program (Reference 2), in preparation for relicensing examinations administered by the Nuclear Regulatory Commission. This Program served as a model for the subsequent training program developments.

At the present time at TMI-1, all operators - licensed and unlicensed - as well as all plant maintenance, radiation control, and chemistry technicians are on a six-shift rotation. One week in six each of these worker categories are in the Training Center for 4-5 days of requalification instruction. Oyster Creek is in the processs of manning up to six shifts and will follow a similar rotation.

A. Oyster Creek Operator Training

The Oyster Creek Equipment Operator "B" initial training program consists of eight weeks of guided self-study covering the design, location, and operation of seventeen plant systems that are the responsibility of "B" Equipment Operators. The trainee studies a plant system using materials provided by training and walks the system down in the plant. Then the trainee goes to a Group Shift Supervisor (GSS) or Group Operating Supervisor (GOS) for an oral exam on the system. At the successful completion of the oral exam, the GSS/GOS sign the system off on the trainee's system checkoff sheet. When the trainee has all seventeen systems signed off, he returns to the operating group as an Equipment Operator "B." This program is being reviewed and will be revised to provide more classroom fundamentals training, similar to the auxiliary operator program at TMI-1.

The Oyster Creek Reactor Training Program is approximately eight months long and consists of 15 weeks of classroom training and 13 weeks of on-the-job training. The classroom training includes BWR plant fundamentals, Oyster Creek systems and operating characteristics, plant procedures and radiation protection and safety. During the on-the-job training, trainees are expected to enhance system and operational knowledge by studying lesson material, tracing out stems and instrumentation, becoming familiar with operating procedures, and reviewing all emergency procedures. The major factors in the successfulness of shift time are shift evolutions, careful planning of time, and trainee completion of an OJT Signoff Sheet. Finally, all

A. Oyster Creek Operator Training (Continued)

candidates participate in a six-day simulator "hot license" training program at the GE BWR Simulator, Morris, Illinois. An approximately three-week review program precedes sitting for the NRC examination.

The Oyster Creek Senior Reactor Operator Training Program consists of a minimum of 4 weeks of study assignments and 13 weeks of on-shift training as an extra person in the control room. The study program emphasizes advanced level knowledge of theory and system applications required for the SRO. The on-shift assignment provides the candidate with first-hand exposure to the operation of the station. The candidate participates in surveillances, testing, system trace outs, and other tasks that add to the candidate's knowledge and ability to serve as a senior reactor operator. Each candidate participates in a pre-NRC exam review program, including one week at the simulator.

All Oyster Creek licensed operators participate in an annual requalification training program which includes classroom lectures, on-the-job training, and three days at the simulator. The training schedule is arranged to allow time for presentation of the lecture series for each shift of operators during each shift cycle.

B. TMI Operator Training

The TMI-1 Auxiliary Operator Training Program is two years in duration, with the first year devoted to classroom training in areas such as math, reactor physics, thermodynamics, heat transfer, and fluid flow, chemistry and radiological controls, electrical theory and fundamentals, plant systems and equipment, and plant procedures. The second year is spent in the plant in on-the-job training, completing task sheets on practical factors, leading to final qualification as Auxiliary Operators.

The TMI-1 Reactor Operator Training Program is 9 months long and consists of two 6-week classroom phases, each followed by a 12-week on-the-job training cycle. The classroom training is designed to complement the training the individual has received as an auxiliary operator with more in-depth training in the theoretical areas and focusing on instrumentation and control systems and overall plant operations from the control room. Included in the second 12-week on-the-job training is a 3-week B&W simulator start-up

B. TMI Operator Training (Continued)

certification program. Provisions are made for candidates with prior experience, e.g., in the nuclear navy or at other plants, to participate in plant-specific portions of the auxiliary operator training program as part of their reactor operator training.

The TMI-1 Senior Reactor Operator Training Program is six months long and consists of two weeks of classroom training in supervisory development and decision analysis; six weeks of on-the-job training, eight more weeks of classroom training, six more weeks of on-the-job training, then two weeks of B&W simulator training. The first on-the-job training phase is designed to get the former control room operator back out in the plant and refamiliarize him with the duties and responsibilities of the auxiliary operators. The classroom training includes both a review and more in-depth study of pertinent theoretical material, and study of administrative controls, procedures, technical specifications, and other aspects of overall plant supervision. The second on-the-job training phase is spent completing selected practical factors.

When the operators have completed their respective training programs and are assigned to operating shifts, as mentioned earlier, they participate in requalification programs one week out of every six. For auxiliary operators, this requalification program consists of review of both theory and systems, changes in the plant and associated procedures, and industry experiences. Licensed operators attend requalification together and receive training at the same areas as auxiliary operators, but at the licensed operator level.

All shift supervisors and shift foremen at both Oyster Creek and TMI also participate in a five-day Basic Supervisory Development Course. This course is designed for first-line supervisors who have responsibilities for directly supervising non-bargaining and/or bargaining unit personnel. The course introduces supervisors to the fundamental concepts and related managerial techniques relevant to the supervisor of GPUN employees, e.g., planning, organizing, directing and controlling. Subject specialists present topics such as union relations, safety, human resources, budget, purchasing and administration. Also, the use of a panel of senior management personnel to which participants can direct questions and identify concerns has been a very effective part of the program.

B. <u>TMI Operator Training</u> (Continued)

Also at TMI, as a direct result of the evaluation of the TMI-2 accident, all shift supervisors and shift foremen - as well as many other plant supervisory personnel - have participated in a three-day Decision Analysis Course. This course is designed to involve participants in thinking about the decisions they make, how they make them, and why. The course examines in detail the theory, techniques, and methodologies relating to the decision analysis process. The respective strengths and weaknesses of various approaches to problem solving are discussed to stimulate consideration of each. During the course the participants use these ideas in practice decision making, with reflection on which they can use in their own job environment.

V. SUMMARY

GPUN has made a significant commitment to improved training of all personnel involved in nuclear plant operations and support. This is demonstrated by the large increases in the numbers and quality of training personnel, the improvements in training facilities, the commitment to purchase basic principles trainers and replica simulators, the implementation of a six-shift rotation with a five-day training week, and the revision and upgrading of operator training and requalification programs.

While this paper has focused on operator training, these programs and training programs for other support personnel at both the plant site and corporate headquarters are an integral part of accomplishing the mission of GPU Nuclear, which is to:

> Manage and direct the nuclear activities of the GPU System to provide the required high level of protection for the health and safety of the public and employees. Consistent with the above, generate electricity from the GPU nuclear stations in a reliable and efficient manner in conformance with all applicable laws, regulations, licenses and other requirements and the directions and interest of the owners.

References

1. T. G. Broughton and P. S. Walsh, "A Real Time Method for Analyzing Nuclear Power Plant Transients," Nucl. Tech., 53, 217 (May 1981).

2. R. E. Uhrig, et al, "Report of the TMI-1 Operator Accelerated Retraining Program Review Committee," General Public Utilities (June 1, 1980). Also see R. L. Long, "An Accreditation Type Evaluation of a Nuclear Power Plant Training Program," ANS Trans., 35, 514 (November 1980).

PAPER II-6

Training and Requalification of Operation Personnel for RWE Nuclear Power Plants

K. Distler and D. H. Kallmeyer
Rheinisch-Westfälisches Elektrizitätswerk AG

1. Legal and Historical Background

In the Federal Republic of Germany the development of commercial nuclear power plants and the development of training and qualification standards for operation personnel have experienced a parallel evolution (fig. 1). The commissioning of the first German experimental commercial nuclear power station, VAK, KAHL (15 MW) took place in 1961. Plant technology was produced in the USA and so was the major part of the personnel training. In 1966 the utilities established the first guideline dealing with the qualification and training of operation personnel. Eight years later - in 1974 - authorities and the utilities jointly formulated and the authorities issued the basic guideline
'Proof of the Requisite Competence of the Responsible Personnel in Nuclear Power Plants'.

Since 1974 seven years have passed, seven nuclear power plants have been commissioned and four more guidelines have been issued.

1978 'The Contents of the Examination of the Responsible Shift Personnel'
1979 Revised edition 'Proof of the Requisite Competence of the Responsible Personnel of Nuclear Power Plants'
1979 'Requirements for the Requalification Programmes for the Responsible Shift Personnel'
1980 'Criteria for the Acceptance of Nuclear Training

Courses as Means for the Proof for the Requisite Competence of Basic Knowledge for the Responsible Shift Personnel in Nuclear Power Plants'.

To achieve a uniform implementation of these official guidelines in 1980 the association of utilities 'TECHNISCHE VEREINIGUNG DER GROSSKRAFTWERKSBETREIBER' (VGB) developed and published a guideline 'Basic Training Programmes for the Responsible Shift Personnel in Nuclear Power Plants'.

Already in 1956 German utilities recognized the necessity to establish a training center for power plant operation personnel and founded the KRAFTWERKSSCHULE e.V., the 'POWER PLANT SCHOOL' in Essen. Since 1970 the KRAFTWERKSSCHULE is also engaged in the theoretical and practical training of nuclear power plant personnel. Since 1978 and 1979 a PWR (Biblis-type) and a BWR (Brunsbüttel-type) simulator are available at the KRAFTWERKSSCHULE. Five working groups monitor and improve quality and state of the art of the training programmes at the KRAFTWERKSSCHULE.

2.0 Initial Training for Operation Personnel

Let me go into more detail in the training field for nuclear power plant personnel. Whereas training courses at the KRAFTWERKSSCHULE focus on the teaching of basic principles and simulator courses the plant specific and practical training is performed at each power plant. For this purpose at each nuclear site a training supervisor is nominated who is responsible for the organization, implementation and quality of the training programmes for the shift personnel. Basic standards for these programmes are laid down in the relevant authority guidelines and

the utility association (VGB) training programmes. In order to explain the organization of training programmes for operation personnel in our company let me start by describing the technical organization of a RWE nuclear power plant (fig. 2).

Reporting to the station manager four department managers are in charge of the departments

- operation
- engineering
- maintenance
- monitoring and health physics.

Within the operation department the training supervisor is responsible for all training activities. This organization ensures that the training programmes meet the precise demands of the department that is responsible for the safe operation of the plant.

2.1 Task Description of the Training Section

The main duties of the training section are:

- plant specific initial training for shift supervisor (SS), deputy shift supervisor (DSS), control room operators (CRO), shift mechanicians (SM), shift electricians (SE)
- retraining of SS, DSS, CRO, SM, SE
- simulator training during initial and retraining
- optimization of operation manuals
- evaluation of abnormal occurrencies and malfunctions in the own plant and other relevant plants.

Another main duty of the training section is the realization of the training programmes for TRAINEE ENGINEERS. It is our experience that graduate engineers from the university or technical colleges lack a good overall view of the technical disciplines present in a power plant.

Company policy therefore requires every engineer without professional experience to participate in a training programme for 'TRAINEE ENGINEERS'. This programme lasts for 2,5 years, covers all technical and operational aspects of the plant and comprises the theoretical and practical qualification for the shift supervisor in accordance with authority regulations.

A task description of the main tasks of the operation personnel is a good tool to arrive at valid training objectives.

2.2 Task Description for Shift Supervisors (SS), Deputy Shift Supervisors (DSS) and Control Room Operators (CRO)

Major tasks of the SS, DSS and CRO are:

- operation of the plant in accordance with valid procedures of the operation manual
- analysis of the operation mode of the plant
- assignment of valid operation procedures to the analysis operation mode
- monitoring of automized plant functions
- in the case of disturbed operation activation of appropriate corrective action
- initiation of repair work etc.

2.3 Training Objectives for SS, DSS and CRO

Major training objectives for SS, DSS and CRO derived from the above mentioned task description are:

- knowledge of every power plant system with respect to
  - purpose, design specifications, design limits
  - operation modes, locality
  - and behaviour in the case of malfunctions
- knowledge of

- functional relationships between the power plant systems
- system design limits under normal and abnormal operation

- knowledge of all operation instructions and rules (federal law, state law, manufacturer instruction, internal instructions)

2.4 Initial Training for SS, DSS and CRO

Utilization of these training objectives lead to the formulation of the INITIAL TRAINING PROGRAMME for SS and CRO. This curriculum covers a period of 28 months and consists of

65 weeks of theoretical training (classroom, power plant school etc.)
41 weeks of practical training on the job
8 weeks of simulator training

Structure and termination of the INITIAL TRAINING PROGRAMME are described in fig. 3

The INITIAL TRAINING PROGRAMME can be devided into five major sections:

Phase 1: description of the entire power plant
Phase 2: operation of the plant under normal conditions
Phase 3: fundamentals of reactor technology
Phase 4: operation of the plant under disturbed conditions, plant behaviour under disturbed conditions
Phase 5: repetition, preparation for the examination.

Fig. 3 demonstrates the frequent change of theoretical and practical training phases to ensure the practical application of theoretically acquired knowledge.

In summary the main objective of the INITIAL TRAINING

PROGRAMME for SS , DSS and CRO is the flawless capability to operate the plant under normal conditions and in the case of malfunctions.

A very important aspect of training programmes is the availability of suitable training documents. It is our experience that technical documents supplied by the manufacturer of the plant equipment are only of limited value for training purposes. Our company therefore has adopted the policy of developing separate textbooks for training programmes. These textbooks are structured in accordance with the system of 'Programmed Learning' and contain tests at the end of each chapter to facilitate self-checks of the students.

As I mentioned earlier the training section is also responsible for the training programme for TRAINEE ENGINEERS. This programme is more or less similar to the INITIAL TRAINING PROGRAMME for SS and CRO. It lasts for 30 months and additionally comprises training phases at the informative level in the engineering-, maintenance- and monitoring and health physics department.

3.0 Retraining

To finish my talk let me describe RWE activities in the field of retraining.
The general frame for retraining activities in Germany is set by the authority guideline 'Requirements for the Re-qualification Programmes for the Responsible Shift Personnel'. This guideline requires a minimum of 100 hours retraining per year.

The RETRAINING PROGRAMME of our company is revised every year and reflects the latest operating experience in our own and other relevant plants of the world.

3.1 Topics in Retraining

Main topics in our RETRAINING PROGRAMME are:

- basics of the plant
- behaviour of the plant under abnormal occurrencies and incidents and appropriate operating procedures (operation manual)
- recent modifications of the plant
- operation experience in the own and other relevant plants
- conditions of the operation licence and the operation manual
- realization of functional tests within the safety systems

SS, DSS and CRO attend between 100 and 200 hours of retraining programmes per year according to circumstances.

3.2 Retraining Procedure

The RETRAINING PROGRAMME comprises 40 hours of simulator training per year. The simulators used are full scope full mission simulators and are located at the KRAFTWERKS-SCHULE in Essen.

Within the RETRAINING PROGRAMME the simulator is mainly used for training the skills of the operation personnel in the field of abnormal occurrencies and incidents.

For this purpose

- unforeseen operation situations are statically and dynamically simulated
- the personnel under training is required to analyse the operation situation and then formulate and activate appropriate action
- the performance of the shift crew under training is recorded and later evaluated in the classroom.

3.3 Evaluation of Shift Personnel

In order to assess the quality of our training activities a yearly evaluation of the performance of each member of a shift crew is carried out.

To arrive at meaningful judgements of the competence of each individual

- daily routine performance
- performance during simulator training
- and capabilities to analyse malfunctions and abnormal occurrencies during retraining

are taken into account.

4.0 Conclusions

In conclusion this paper described in detail the RWE approach for training and retraining of our shift personnel. The essential features of this programme are:

- carefully prepared curriculum and teaching papers
- well balanced relationship between classroom - on the job - and simulator training
- retraining programmes with the use of simulator that mainly comprise
  - disturbance evaluation
  - handling of precalculated incidents
  - handling of unforeseen operation conditions
  - analysis of the operational state of the disturbed plant

RWE feels confident that its training programmes and -activities are suitable to ensure the successful and safe operation of our nuclear power plants.

Nuclear Power Plants			Legal requirements	
			1959	Atomgesetz (Atomic Law)
1961	VAK Kahl	15 MW		
1966	KRB Gundremmingen	237 MW	1966	Utility guideline 'Qualification and Training of Operational Personnel'
1968	Obrigheim	328 MW		
1972	Stade	630 MW		
1973	Würgassen	640 MW		
1974	Biblis A	1145 MW	1974	'Proof of the Requisite Competence of the Responsible Personnel'
1976	Brunsbüttel	770 MW		
			1978	'The Content of the Examination of the Responsible Shift Personnel'
1979	Philippsburg 1	864 MW		
			1979	Revised edition 'Proof of the Requisite Competence of the Responsible Shift Personnel'
			1979	'Requirements for the Requalification Programmes for the Responsible Shift Personnel'
			1980	'Criteria for the Acceptance of Nuclear Training Courses as Means for the Proof for the Requisite Competence of Basic Knowledge for the Responsible Shift Personnel in Nuclear Power Plants'

Fig. 1: History of Commercial NPP Authority Guidelines

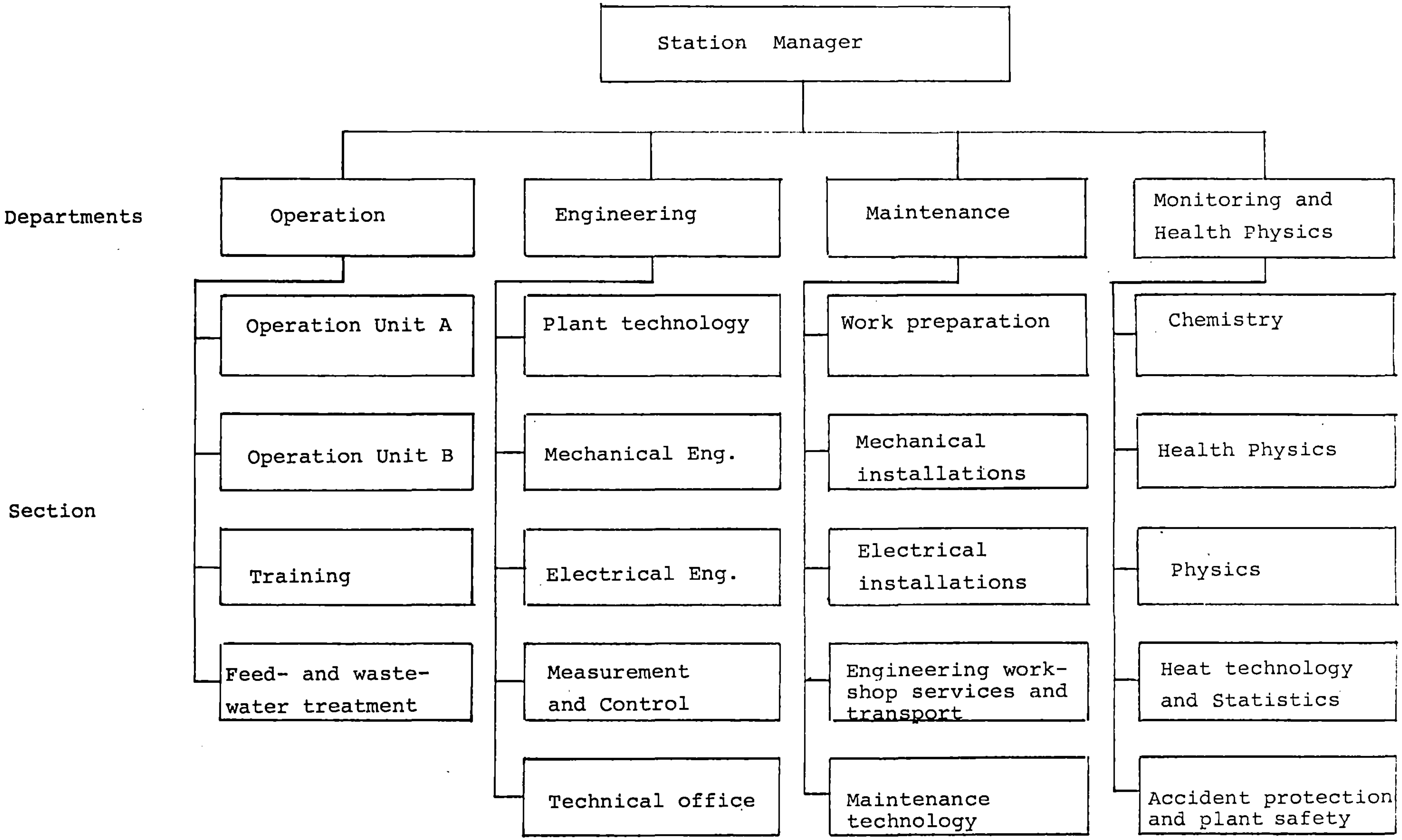

Fig. 2: Basic Organization of a RWE Nuclear Power Plant

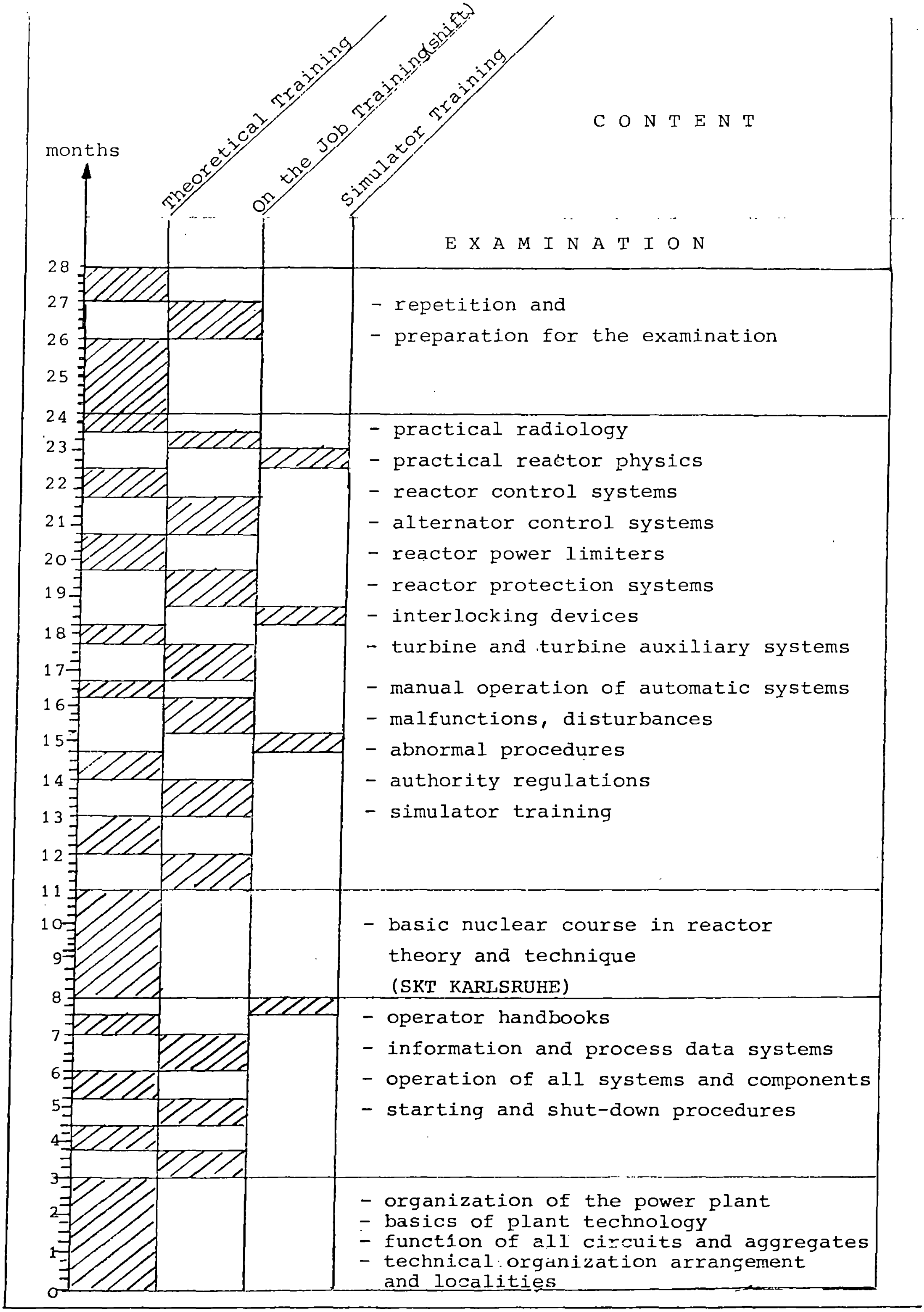

Fig. 3: Initial Training Programme for Reactor Operators and Shift Supervisors

QUESTIONS TO DR. KALLMEYER

Robert Mackie

Q: You mentioned that crew performance in the simulator is recorded and later evaluated. What aspects of performance are recorded: How? How do the evaluations take place?

A: Relevant plant parameters are recorded on strip chart recorders. Evaluation takes place in the classroom by the training instructor. Group dynamic behavior is recorded on videotape.

A. Alonso

Q: Could Dr. Kallmeyer discuss the relationships between the Kraftwerksshule - instructors, training programs, textbooks and the like - and the reaktorsshule at Karlsruhe Nuclear Research Center and training programs at German universities?

A: No formal relationships exist between the above mentioned institutions. Experience exchange

is achieved through working groups of the utilities, members of which collaborate with all institutions. Courses of all above mentioned institutions are supervised by competent working groups of the utilities and government bodies.

John Christenson **Q:**

1. Do "trainee engineers" have other assignments during their 30-month training program?
2. What is the educational background of trainee engineers when they start the program?

A:

1. The major part of the "trainee engineer" training program consists of the curriculum to become a shift supervisor. Additionally, the "trainee engineer" is required to perform independent tasks of daily routine work in all departments of the nuclear power station. This enables him to acquire detailed knowledge of the organization of the plant.

2. Different backgrounds are possible:

a) 9 years school, 3 years apprenticeship in a technical subject, 3 years advanced school, 3 years technical college. A degree in mechanical, electrical or nuclear engineering.

b) 12 years school - 3 years technical college.

c) 12 years school - 4-5 years (technical), Degree: major of science or equivalent.

ACCOUNTABILITY IN POWER INDUSTRY TRAINING

PAPER PRESENTED FOR

CSNI SPECIALIST MEETING

ON

OPERATOR TRAINING AND QUALIFICATIONS

(CHARLOTTE, NORTH CAROLINA OCTOBER 1981)

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ACCOUNTING IN POWER INDUSTRY TRAINING

Accountability in power industry training translates to the moving away from purely subjective mode in development and evaluation to a more performance-based objective orientation. The performance-based approach increases the visibility of training through the specification and publication of training goals, procedures, and outcomes. The major thrust of accountability is in actually being able to see and therefore judge how well training dollars are being spent. This change in focus which addresses the functional concerns of the industry, what training is needed, its cost, how well it works, has brought about important innovations to industry training. The innovations have taken the form of a systematic design of training which employs concepts and approaches from educational psychology, industrial psychology, and human engineering.

While there are numerous models of instructional system development available, Arkansas Power and Light has chosen to pattern its approach after a model developed by the U.S. Air Force. This particular model was chosen as a guide to instructional development because it is based on a task analysis approach. The task analysis technique first determines precisely what a skilled performer does when doing a particular job, how well he or she must do it, and the conditions under which the job is performed. The approach allows the developer to prepare the task analysis not only from incumbent input, but with reference to some inventory or taxonomy of learning types as well.

The model is comprised of five steps. Each step is tied to the other steps by a process of feedback and interaction, and each step depends on all other steps. The five steps of the model include:

- analyze system requirements
- define education/training requirements
- develop objectives and tests
- plan, develop, and validate instructions
- conduct and evaluate instruction

(See Appendix A for a copy of the model.)

The first step, analyze system requirements, primarily involves data collection. For Arkansas Power and Light Company, this step translates to a comprehensive position task analysis for all employees in the company. The task analysis yields data on specific knowledge, skills, and abilities necessary to perform adequately on the job. It also includes a task list broken down into degree of importance to the job and frequency of each task, daily, weekly, quarterly, or yearly. Also included in the analysis are the conditions under which the tasks are performed and the standards that are to be met. These data comprise the foundation upon which the remaining four steps are built.

Once the data have been collected for the first step, then the second step's decision process follows. Once job performance

requirements have been identified, decisions can be made on how to get qualified personnel to do the job. In some instances no training may be required. When it has been determined that training is in order, then the task is to analyze and compare the job tasks with the knowledge, skills, and abilities the persons to be trained already possess. The difference between what the persons already have, in contrast with what they should have, determines what instruction is needed. This approach of course saves money and time and further allows the company flexibility in granting credit for skills already in someone's repertoire.

The third step is in the development of objectives and tests. Developing instructional objectives is a process of incorporating the education or training requirements identified in step two with taxonomies of learning. The instructional objectives are specified in terms of the expected behavior or performance of the trainee. They identify what the trainees are expected to do, the conditions under which they are expected to do it, and the acceptable standard of performance.

A functional aid to the third step is the employment of learning taxonomies, especially those of Gagne, (1970); and Bloom, Hastings, and Madaus (1971). These two taxonomies, while somewhat different, have a common core in that they both provide descriptions of relationships among their components to resolve hierarchial relationships among the learning types, and as to the learning factors influencing each type. This kind of information

provides guidelines for optional sequencing of different learning types and for instructional arrangements which most likely will facilitate the respective types of learning.

The most complete description of Gagne's classes of behavior appears in his The Conditions of Learning (1970). He distinguishes eight types of learning, beginning with the simple forms and ending with the complex. Gagne refers to the classes as learning types; however, he is primarily interested in the observable behavior which is the product of each class. Gagne's eight classes of behavior include:

- Signal learning - In this type of learning, often referred to as classical conditioning or respondent conditioning, the organizer acquires a conditioned response to a given signal.
- Stimulus - response learning - In this kind of learning, often referred to as operant conditioning, the organism makes a precise response to a specific stimulus.
- Chaining - In this type of learning, the organism links together previously learned S-R components.
- Verbal Association - This learning is a more sophisticated chaining in that the links are verbal units.
- Discrimination Learning - In this learning, the organism must learn different responses for stimuli which might be confused.

- Concept learning - In concept learning, the organism responds to stimuli in terms of abstract characteristics like color, shape, position, and number as opposed to concrete physical properties like specific wavelengths or particular intensities.
- Rule learning - In this learning, the organism relates two or more concepts.
- Problem solving - This is a set of events where the organism uses rule to achieve some goal.

Benjamin Bloom and his associates developed a method of classifying educational objectives for instructional and test purposes. Like the system developed by Gagne, the different classes of behavior are arranged in hierarchical order from the most simple to the complex: Behaviors in one class are likely to borrow from and build on behaviors in preceding classes. This system includes two broad categories - (a) knowledge and (b) intellectual abilities and skills - which produce six classes of behavior. Bloom's classes of behavior include:

- Knowledge - This class involves the recall of specifics and generalizations.
- Comprehension - This class is the lowest level of understanding.
- Application - This class of behavior requires the organism to use abstractions in particular and concrete situations.

- o <u>Analysis</u> - This behavior requires the organism to make clear the relative hierarchy of ideas in a body of material or to make explicit the relations among the ideas, or both.
- o <u>Synthesis</u> - This behavior class requires the organism to assemble parts into a whole.
- o <u>Evaluation</u> - This class of behavior consists of judgments about the value of material and methods used for particular purposes.

The second part of the third step is to develop a means of testing to measure the attainment of the developed objectives. The tests that fit the model scheme are called criterion-referenced tests, since they test against prescribed criteria for successful performance that are identified in the objectives. With the criterion-referenced tests, the trainees are rated on their ability to achieve the objectives. How other trainees score on the tests has no bearing on the individual's grade.

The criteria test items may be used in several ways. They may be administered to trainees at the beginning of class or unit of instruction to determine where the trainees are in reference to the goals for the unit or course. This approach facilitates the skipping of material already mastered by the trainee.

The fourth step is in planning, developing, and validating instruction. This step requires the careful planning of instruction to match and satisfy the stated objectives. This involves the careful placing of learning activities or exercises in a schedule that produces the required learning within an optimum time frame. The step also includes the selection and planning of instructional methods, media, and equipment which most effectively support the learning objectives. An integral part of this step is the development and validation of instructional materials. The validation process makes sure that the instructional materials and the way the instruction is presented teach the trainees what they <u>need</u> to know. This process is achieved through pilot testing. That is, tryouts of the materials on representative samples of trainees using the criterion test items as the measuring device. Changes are made to the materials until the proper match can be made between instructional materials presented and subsequent test performance.

The final step is in conducting and evaluating instruction. After the instruction has been developed and validated, it is ready to be employed. To make sure the trainees learn what they need to know, once instruction is started, it must be continually evaluated. This evaluation looks at the conduct of instruction, how well the trainees do on training tests, and their job performance subsequent to the instruction.

The model's continuity is guaranteed in part by the feedback and interaction loop mentioned material earlier. This process is often referred to as a formative evaluation since it is evaluation exercised during the formative stages of system development. Formative evaluation is en route evaluation much like product quality control in the sense that each phase of product development (here the steps in the system) must pass through a number of inspections as it moves along the assembly line toward completion.

The evaluation in the fifth step is often referred to as summative evaluation, since it evaluates a completed and delivered program. Summative evaluation for Arkansas Power and Light uses as benchmarks of training effectiveness the following:

- o interviews
- o test results
- o job performance ratings
- o course critiques
- o cost reports
- o plant performance reports

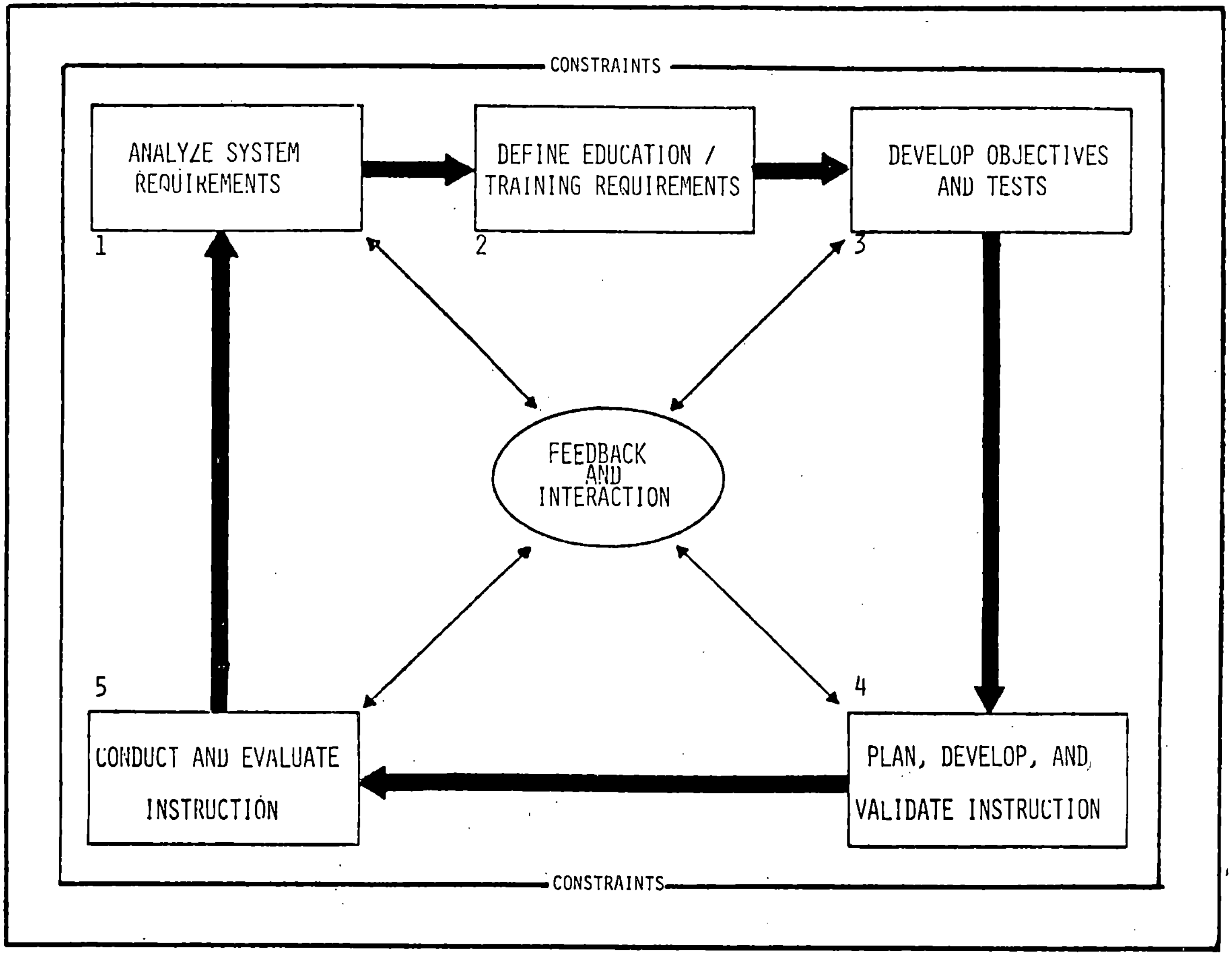
The data generated from these benchmarks of effectiveness are fed back into the system to bring about necessary change(s) in any one or a combination of the steps in the model. This approach is dynamic in that it is receptive to changes in regulatory requirements, company requirements, and training requirements.

Evaluation, whether formative or summative, is a constant component of the system, feeding data into the system continuously.

This system approach to instructional development and evaluation has placed Arkansas Power and Light Company on the leading edge of the new training and evaluation movement within the nuclear power industry.

APPENDIX A

MODEL FOR TRAINING DEVELOPMENT


CONSTRAINTS
ANALYZE SYSTEM REQUIREMENTS
1
DEFINE EDUCATION / TRAINING REQUIREMENTS
2
DEVELOP OBJECTIVES AND TESTS
3
FEEDBACK AND INTERACTION
4
PLAN, DEVELOP, AND VALIDATE INSTRUCTION
5
CONDUCT AND EVALUATE INSTRUCTION
CONSTRAINTS

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QUESTION TO DR. ROBERT C. EVANS

Robert Mackie **Q:** Since you use criterion-based tests, what criterion measures do you use to ensure that the trainee has performed in accordance with the desired outcome?

A:

1. Pencil & paper tests: (Questions)
   a. multiple choice
   b. short answer fill-in
   c. true/false
2. Performance on simulators for operators
3. Performance on the job as assessed by supervisory ratings employing the assessment toll anchored to the knowledge, skills, abilities, taken from the position task analyses are used.

Performance levels are pre-set. The goal is to ensure that training brings about the desired outcomes - safe and efficient power generation.

A COMMAND ROLE - STRESS DECISION PROGRAM

Herb J. Worsham, Jr.
John L. French
MANAGEMENT ANALYSIS COMPANY

I. INTRODUCTION

With so many technical training programs required it is all too easy to forget the "subjective," non-technical, training needs of the plant operating staff. These needs encompass what the various committees and task forces studying the Three Mile Island (TMI) incident identified as the "command role." The "command role" includes the proper making of decisions, communications under stress, proper location of the shift supervisor and his people, and how to maintain a proper level of "operational readiness."

This paper describes a program designed to meet these plus operations/management team building needs. This program was originally developed in three phases and presented in conjunction with the TMI-1 operations staff as part of their post-incident requalification program.[1,2]

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1 Robert J. Long (GPU Nucl Assurance Corp), "An Accreditation-Type Evaluation of a Nuclear Power Plant Training Program," ANS Transactions, Volume 35 (November 1980)

2 R. E. Uhrig et al., "Report of the TMI-1 Operator Accelerated Retraining Program Review Committee," General Public Utilities (June 1, 1980)

II. PHASE 1 - PREPARATION

A team is used to interview selected people from management down to helper. This information is used to specify the exact content of the balance of the programs.

III. PHASE 2 - SEMINARS

The team presents seminars to classes of 12-20 persons. The class makeup should include senior reactor operators (SROs), shift technical advisors (STAs), plant management, selected support managers, and (representative) senior management.

The Command Role/Decision Analysis Seminar topics are as follows:

Command Role

- Command Perspective
- Resource Utilization
- Decision Authority
- Management Value Structures
- Execution

Decision Analysis

- Generation of Alternatives
- Organization of Information
- Ranking Potential Outlines
- Dealing with Uncertainty
- Value of Additional Information

The Command Role/Decision Analysis Seminar topics are presented using a variety of instructional techniques, including:

- Stress Decision Simulations
- Role Playing
- Lectures
- Team Problem Solving
- Team Presentations
- Round Table Discussions
- Group Problem Solving

Decision Analysis

Two key elements in the success of the Command Role/Decision Analysis Seminars are: (1) Decision Analysis training and (2) Stress Decision simulations.

The decision analysis training stressed in the above seminar topics address the major elements of good decisions. They are:

Alternatives - the available options, or what can be done

Preferences (or value structures) - the measures of desirability the decision maker applies to outcomes

Decisions - an irrevocable commitment of resources to an alternative

Outcome - answers the question "what happened" as a result of making the decision--Because of uncertainties faced in realistic situations, the quality of the decision-making process should be judged by the quality of the decision as well as the outcome.

Stress Decision Simulations

To achieve the multiple objectives of decision analysis and command role training, a training process has been developed which is added to standard lectures on fundamental principles. This process is stress decision simulation and diagnostics.

By "stress decision" we do not mean stress resulting from lack of basic knowledge or ability to perform decision analysis but rather identifying stress for the decision-maker in the command role who understands decision analysis, knows the plant, knows procedures, and generally is proficient in his job. Sources of such decision stress are:

- timing demands
- uncertainty
- conflict

To simulate these conditions, scenarios of operations are developed that set the stage requiring stress decisions to be made. For the training seminar, a broad set of scenarios is developed that simulate a range of the causes of stress in decision making. Each one is sufficiently detailed so that utility personnel can picture themselves in that situation.

Because of the realism, the scenarios are an effective vehicle for not only decision analysis but for dialogue and instruction regarding Lessons Learned Task Force recommendations, e.g.:

- o role playing of Operations Superintendent or Station Superintendent decisions to gain more job perspective
- o clarifying what decisions should be made at what levels
- o utilizing resources available to the information gathering process
- o dealing with multiple stress decisions simultaneously
- o maintaining a command posture during abnormal events
- o effective status reporting
- o implementation and follow-up after decisions are made

IV. PHASE 3 - FOLLOW-UP

Training should not be presented without follow-up. We recommend that the utility continue training by conducting approximately four hours of practical exercise every six weeks.

The program is expected to:

- o teach practical decision analysis methods
- o facilitate the discussion and resolution of command role issues
- o obtain a start toward a long-term building effort
- o allow management to discover potential problem areas before they have those problems in the plant
- o serve as the basis for an on-going program

Following the program completion, a report is produced regarding the as-performed course. This report gives feedback on performance and unresolved issues observed during the seminars.

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The events during the accident at TMI-2, along with others identified in retrospect at other nuclear plants, re-emphasized the critical role of the reactor operator. Many countries are focusing greater attention on the capabilities of control room operating staff and on the problems they face. In view of the importance to safety on the subject, the CSNI Subcommittee on Licensing decided that a specialist meeting should be held on the broad aspects of operator selection and training and the functions and organization of operating staff. The meeting focused on the functions, role and organization of control room personnel as a crew and as individuals; selection and qualifications of personnel; operator training and requalification; evaluation of crew and individual performance; professional and career alternatives for control room personnel; and "concepts for the future" (e.g., implementation and impact of computer technology, advanced simulator concepts, off-site monitoring and support). Fourteen countries and three international organizations were represented. This report consists of two volumes.

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