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TRAINING OF OPERATORS AND MAINTENANCE PERSONNEL IN THE DIVISION OF RESEARCH REACTOR OPERATION, JAPAN ATOMIC ENERGY RESEARCH INSTITUTE

October 1973

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In the division of Research Reactor Operation at JAERI, three kinds of training courses have been provided for operators and maintenance personnel of reactors. These are the courses for freshmen, for technicians and for emergencies. This paper describes the outline of these courses and also the procedures.

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** Div. of Radioisotope Production.

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日本原子力研究所東海研究所研究炉管理部における運転・保守要員の訓練について*

日本原子力研究所東海研究所研究炉管理部
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（１９７３年９月１９日受理）

研究炉管理部においては原子炉の運転・保守要員のために三種類の教育訓練を実施してきた。これらの訓練は大別して，新規配属者に対する訓練，中堅技術者に対する訓練，非常事故訓練に分けられる。本報告はこれらの訓練の内容や方法について述べたものである。

＊　本報告は１９７３年３月にインド国ボンベイ市のバーバ原子力研究所で開催された，「東南アジアおよび極東における研究炉の利用と経験に関する専門家会議」に提出したものである。

＊＊　アイソトープ事業部製造部

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I. INTRODUCTION

In the early years when a reactor went critical, many kinds of experiments were performed and the routine operation was started, it was not so necessary to train the personnel who operated the reactor or carried out maintenance works of the reactor. Because many of them were graduate engineers and they had designed and constructed this reactor, so they were skilled enough to operate and maintain this reactor. However, as many of them transferred to other sections and many freshmen came to this section little by little, it became very important to train the freshmen. In the early time when the training was started, principal procedures of the training were those on the job training. But nowadays, many kinds of training courses have been performing for the freshmen and the personnel who came from other sections.

Table 1 shows the organization of the research reactor operation at JAERI. A chief engineer (chief technician of reactors) has to be appointed in each reactor with the law in order to supervise the safety of the reactor operation. On the research reactors at JAERI, it should be emphasized that operators are also responsible for maintenance and all maintenance works are conducted by the operators. Besides the reactor operators, other support members who are health physisists, operators for the conventional equipments; air conditioner, electrical power supply, etc.; and others are required for the reactor operation. However these members do not belong to the division of research reactor operation. Therefore, only the training procedures for reactor operators will be mentioned.

II. TRAINING PROCEDURES FOR OPERATORS AND MAINTENANCE PERSONNEL

1. General

After the routine operation of the reactors was started, the number of the graduate engineers was decreased little by little. So almost all operators and maintenance personnel are high-school graduates in electrical course, mechanical course or others. Table 2 shows the classification of the operator school career. The average age of operators is about 28 years old. The youngest of

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1. General

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them is 20 years old and the oldest is 33 years old.

2. Training for freshmen

When some people graduate from high-schools or universities and are employed in JAERI, they will take many kinds of trainings.

First of all, they will take the elementary trainings for about one month. This trainings are as follows;

1) The outline of JAERI.

2) The outline of the works in every divisions of JAERI.

3) Some lectures and practical training in the Radioisotope School.

After that, they are assigned to each division of JAERI. When some people are assigned to reactor operation sections, they will take some job trainings by man to man system. About a half year later when they are assigned, they will enter the Nuclear Engineering School of JAERI in elementary course for about six weeks. Table 3 shows the lecture curriculum in the elementary course.

After taking many kinds of trainings above mentioned, they will enter into an operation group as an apprentice and will be trained in operations and maintenance techniques of reactors. It depends on their technical level how long they are trained as an apprentice. About three months later when they enter into the operation group, they will be engaged in reactor operation and maintenance works as a technician.

However, some personnel who come from other divisions at JAERI or other companies will be trained by nearly same methods according to their technical level.

3. Training for technicians

After some personnel begin to perform their works as technicians, they will take many kinds of trainings in order to grow up their technical level. They will be trained according to JAERI's training programme in necessary subjects. Main courses of the trainings for the technicians are shown in Table 4. Training courses and oppotunities for the technicians are as follows;

1) Basic and advanced courses in Radioisotope School at JAERI.

These courses will be taken by the personnel who have been engaged in

reactor operation and maintenance works for four or five years, as occasion demands.

Table 5 shows curriculums of the basic course in the Radioisotope School, and it takes about one month to be trained in.

2) General course in Nuclear Engineering School at JAERI.

This course will be taken by the personnel who have been engaged in reactor operation and maintenance works for seven or eight years. Before the personnel will become a sub-leader of a operation crew, they should be trained in this course. It takes about six months. Table 6 shows curriculums of the general course in the Nuclear Engineer School at JAERI.

3) Internal or external training course (use of electronic computor, nuclear material handling, non-destructive testing, etc.).

As occasion demands, the personnel will be trained in many kinds of training courses in order to grow up their technical ability. These courses are the training of the use of electronic computor, nuclear material handling, non-destructive testing, etc. and are held in the inside or outside of JAERI.

4. Training for emergencies

Training for emergencies is most important in order to give reasonable assurance that the personnel will react properly during different type of incidents. The training for emergencies will be held more than twice a year. Examples of trainings for emergencies are as follows;

1) Study of the proper reaction against many kinds of emergencies.
2) Practical training of emergency calling.
3) Realistic training.
4) Education for extra safety.

III. CONCLUSION

It is necessary for operators and maintenance personnel to be trained with many kinds of methods. Freshmen should be made to take some job trainings by man to man system as well as they should be made to take some lectures about nuclear engineering. Technicians should be made to attend to many kinds of training courses according to their technical levels and demands. Trainings for emergencies must be carried out frequently at every opportunity. In our division, while practical trainings for emergency have been carried out two times a year, growing up the knowledge for safety have lost no opportunity to be carried out.

IV. ACKNOWLEDGEMENT

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Table 1 ORGANIZATION CHART OF RESEARCH REACTOR OPERATION

- Division of Research Reactor Operation 181 (48)
  - Chief Engineers
  - Operation Sections JRR-2, JRR-3 or JRR-4
    JRR-2 30 (8)
    JRR-3 34 (8)
    JRR-4 14 (5)
  - Research Reactor Technology Section 20 (7)
  - Irradiation Service Section 21 (4)
- Division of Engineering 183 (19)
- Division of Health Physics and Safety 141 (63)
- Division of Reactor Engineering
- Division of Nuclear Fuel Research
- Division of Physics

	Group	Shift	Works	Number of persons ( ) graduate JRR-2	JRR-3	JRR-4
Chief Engineers	No. 1	A,B	Reactor, Operation, Maintenance and Refueling	4×2+1=9(2)	5×2+1=11(2)	7(1) (no shift)
Operation Sections JRR-2, JRR-3 or JRR-4	No. 2	C,D		4×2+1=9	5×2+1=11(1)	
	No. 3	-	Maintenance	5(0)	4(0)	3(1)
		-	Technical Staff	3(2)	5(2)	3(2)

	Group	Shift	Works	with JRR-2	with JRR-3	with JRR-4
Research Reactor Technology Section 20 (7)	No. 1	-	Gas Cooled Loop Operation	8(3)	———	———
	No. 2	-	Heavy Water and Helium Gas Treatment	6(2)		
	No. 3	-	Spent Fuel Management	4(1)		
Irradiation Service Section 21 (4)	No. 1 ~ 3	-	Handling of Isotope	6	7(1)	1
Division of Engineering 183 (19) ——— (Section)	No. 1 ~ 3	A~D	Utilities and Maintenance	3×4+2=14	2×4+1=9(1)	3
Division of Health Physics and Safety 141 (63) ——— (Section)	No. 1 ~ 3	A~D	Radiation Control	1×4+3=7	1×4+3=7	1

(Experiment groups)

Table 2. Classification of Operators School Career

	JRR-2	JRR-3	JRR-4	Total
I. High-school graduates				
1. Electrical course	11	9	1	21
2. Mechanical course	2	8	3	13
3. Others	2	2	2	6
II. University graduates	1 (physics)	1 (mechanical)	0	2
Total	16	20	6	42

Table 3. Curriculum of Lectures and Experiments in Elementary Course of Nuclear Engineering School at JAERI.

I. Lecture Curriculum

1. Fundamental Studies of Atomic Energy	23 units
1.1 Atomic physics	5
1.2 Reactor physics	10
1.3 Radiation Measurements	5
1.4 In-pile Dosimetry	1
1.5 Reactor chemistry	2
2. Nuclear Engineering	22
2.1 Outline of Nuclear Reactor	2
2.2 Heat Removal and Thermodynamics	3
2.3 Materials of Reactor Components	1
2.4 Reactor Fuels	2
2.5 Instrumentation and Controls of Reactors	5
2.6 Shielding	2
2.7 Reactor Operation and Safety	5
2.8 Radio-active Waste Disposal	2
3. Health Physics	5
3.1 Outline of Health Physics	1
3.2 Permissible Level of Radiation	1
3.3 Safety Handling of Radio-active Materials	1
3.4 Radiation Monitoring	1
3.5 Decontamination	1
4. Others	7
4.1 Production and Utilization of Radio-isotopes	2
4.2 The Law on Reactor Operation and Maintenance	2
4.3 Special Lecture	1
4.4 International co-operation for Peaceful Use of Atomic Energy	2
5. Exercise	5

II. Experiments

1. Radiation Measurements with GM Counter	9 units
2. γ-Ray Spectroscopy with Scintillation counter	6
3. Thermal Neutron Measurement with BF_3 Counter	6
4. γ-Ray Spectroscopy with Ge(Li) Detector	6
5. Practice of Reactor Simulater	6
6. α-Ray Spectroscopy with Si Detector	6
7. Dose Measurement with γ-Ray Ionization Chamber	3
8. In-pile Dosimetry	3

* 1 unit corresponds to 80 minutes of lecture or experiment

Table 4. Main Courses of Training for Operators and Maintenance Personnel

I. Training for Functions
1. Training for Working under Radiation
2. Training for Utilization of Electronic Computor
3. Training in Radio-isotope School (Basic, Advanced and Special Courses)
4. Training in Nuclear Engineering School (Elementary, General, Advanced, Health Physics and Nuclear Material Courses)
II. Training for Qualification
1. Licensed Supervisor (Cheaf Tecnician of Reactors)
2. Person in Charge of Handling Radiation
3. Person in Charge of Handling Nuclear Material
4. Person in Charge of Handling Dangerous Material
5. Fork-lift Driver
6. Crane-man
7. Person in Charge of Handling X Ray
8. Non-destructive Inspector

Table 5. Lectures and Experiments in Basic Course of Radio-isotope School

I. Lectures (36 units)

1. Common Subjects	32 units
1. 1 Nuclear Physics	2
1. 2 Radiochemistry	5
1. 3 Radio-isotopes	1
1. 4 Interaction of Radiation with Matter	1
1. 5 Radio-active disintegration	1
1. 6 Radiation Detectors and Method of Detection	2
1. 7 Measurement of Radiation Energy	1
1. 8 Introduction to Reactor Engineering	1
1. 9 Radiation Chemistry (1)	1
1.10 Radiation Shielding	1
1.11 Safe-handling of Radio-active Materials	1
1.12 Principle of Radiation Control	1
1.13 Radiation Monitoring	1
1.14 Radio-biology	1
1.15 Effects of Radiation to Human Body	1
1.16 Genetic Effects of Radiation	1
1.17 Facilities for Handling Radio-isotopes	1
1.18 Regulation for Prevention of Radiation Hazards	2
1.19 Radio-active Decontamination	1
1.20 Radio-active Waste Disposal	1
1.21 Autoradiography	1
1.22 Radio-isotopes in Organic Chemistry	1
1.23 Application of Radio-isotopes to Chemistry	1
1.24 Laboratory rules	1
1.25 Radio-activation Analysis	1
2. Optional Subjects	4
2. 1 Health Control	1
2. 2 Application of Radio-isotopes to Industry	1
2. 3 Application of Radio-isotopes to Medicine	1
2. 4 Application of Radio-isotopes to Agriculture	1
2. 5 Radio-isotope applying Machine	1
2. 6 Food Irradiation	1
2. 7 Fundamentals of Nuclear Reactor	1
2. 8 Radiation Chemistry (2)	1

II. Experiments and Exercises (79 units)

1. Common Subjects	66 units
1. 1 Experiment with GM Counter	5
1. 2 Experiment with Scintillation Counter	5
1. 3 Liquid Scintillation Counting	4
1. 4 γ-Ray Spectrometry	4
1. 5 Solvent Extraction of Iodine	4
1. 6 Correction Method for β-Ray Self-absorption	4
1. 7 Isotope Dilution Analysis	4
1. 8 Coprecipitation Method	4
1. 9 Chemical Dosimetry	4
1.10 Activation Analysis	5
1.11 Dosimetry and Surveying	5
1.12 Special Measurements (Rate Meter and Gas-flow Proportional Counter)	5
1.13 Separation of Fission Products by Ion Exchange Resin	5
1.14 Exercises in Physics	1
1.15 Exercises in Chemistry	1
1.16 Field Trip	5
1.17 Motion Pictures on Atomic Energy	1

Table 5. Lectures and Experiments in Basic Course of Radio-isotope School (Continued)

II. Experiments and Exercises

2. Optional Subjects	8 units
2. 1 Tracer Experiment (Chemical or Biological Subjects)	5
2. 2 Radiography or Tracer Experiment on Animal Tissue	5
2. 3 Metal-autoradiography or Micro-autoradiography	3

* 1 unit corresponds to 80 minutes of lecture and experiment

Table 6. Lectures and Experiments in General Course of Nuclear Engineering School at JAERI

I. Lectures (165 units)

1.	Atomic Physics	5 units
2.	Reactor Physics	13
3.	Radiation Measurement	7
4.	Reactor Instrumentation	13
5.	Nuclear Data	2
6.	Nuclear Fuel	14
7.	Reactor Material	9
8.	Heat Transfer and Thermodynamics	7
9.	Structure of Reactor	4
10.	Radiation Shielding	5
11.	Reactor Chemistry	5
12.	Health Physics	12
13.	Safety Evaluation of Reactors	3
14.	Reactor Operation and Maintenance	7
15.	Outline of Reactors	15
16.	Law for the Regulation of Reactors etc.	10
17.	Special Subjects of Nuclear Engineering	20
18.	Topics of Atomic Energy	8
19.	Special Lectures	6

I. Experiments (327 hours)

1.	Experiments during First Half Term	117 hours
1.1	Experiments with Pulse Type Electronic Circuits	18
1.2	Radiation Measurements with GM Counter	18
1.3	γ-Ray Spectroscopy with Scintillation Counter	9
1.4	Thermal Neutron Measurement with BF_3 Counter	9
1.5	Chemical Separation of Fission Products	9
1.6	Measurement of γ-Ray Dose and Neutron with Ionization Chamber	9
1.7	Fast Neutron Measurement	9
1.8	Experiment of Coincidence Method	9
1.9	Absolute Measurement of Radio-activity with 4 π Gas-flow Counter	9
1.10	α-Ray Spectroscopy with Semi-conductor Detector	9
1.11	Practice of Analog Computer	9
2.	Experiments During Second Half Term	210
2.1	Training of Reactor Operation at Zero Power	7.5
2.2	Control Rod Calibration	7.5
2.3	Training of Reactor Operation at Nominal Power	15
2.4	In-pile Dosimetry	7.5
2.5	Experiments of Heat Transfer	30
2.6	Exponential Experiments with Graphite	15
2.7	Experiments of Reactor Fuels and Materials	30
2.8	Experiment of Material Bucklingoon Sub-critical Assembly	15
2.9	Reactor Physics Experiment by Pulsed Neutron Method	15
2.10	Analysis of Reactor Engineering Subjects with Analog Computer	15
2.11	Caluculation of Reactor's Subjects with Electronic Computer	15
2.12	Practice of Reactor Simulater	15
2.13	Thermal Neutron Flux Measurement in The Core	7.5
2.14	Burn-up Measurement	15

* 1 unit corresponds to 80 minutes of lecture