ATOMIC ENERGY OF CANADA LIMITED
Power Projects, Sheridan Park, Ontario

Lecture 13

Nuclear power symposium

TRAINING

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NUCLEAR POWER SYMPOSIUM

LECTURE NO. 13: STAFFING AND TRAINING FOR A NUCLEAR-ELECTRIC POWER STATION

by

G. R. Howey

1. GENERAL

Staffing and training of personnel are essential factors in the life of any business organization. A utility that is contemplating the building of a nuclear electric power station must commit itself early to staffing and training. Staff planning is affected by the adoption of a new technology, additional participation in design, construction and start-up, and advanced involvement in project planning, scheduling, and auxiliary assignments. These conditions require efforts by utility management and engineers that normally exceed in magnitude the tasks for design, construction and start-up of a correspondingly sized fossil-fuelled power station. The additional conditions are imposed in part by physical size and engineering complexity of the project, and in part by the regulatory requirements of the Atomic Energy Control Board of the Federal Government of Canada.

Following successful completion of the design and construction of the nuclear station, one of the most important single factors contributing to providing assurance of continuous, long-term safe operation of the station is the competency of the operating organization. In this term is included consideration of the breadth, experience and ability in all aspects important to the operation of the station, including not only operations, but also technical support and maintenance. The individuals in the operating organization must possess an appropriate awareness of their responsibilities and the organization must have sufficient depth of resources to operate the station safely and competently. It is recognition of this need for good organization that the Atomic Energy Control Board regulations provide for an evaluation of the competence of the licensee's organization as a necessary and important determination in granting an operating license.

Although a competent organization as a whole is a means of providing assurance of long-term safe operation, we must recognize that on a minute-to-minute basis, the responsibility for safety of the station is

largely vested in the operator at the controls and the individual who immediately directs his activity. These are the individuals who must constantly survey and assess the station performance and take immediate corrective measures when necessary. The determination of the qualifications of these individuals is an important and necessary matter in providing safe operations.

To develop a staff of competent, experienced, agressive personnel in sufficient depth and qualification to assure wise use of resources prior to start-up and safe and economic operation after, the utility must set up a manpower development program. This program should take the following factors into account in developing a solution:

(1) Station staff and support staff organization.

(2) Types and availability of human resources.

(3) Hiring policies.

(4) Training program to meet short-term and long-term needs covering support sciences and technology.

(5) In-station training program on station equipment and systems.

(6) Staff rotation in the station to increase knowledge and experience.

(7) Additional staff to assist during commissioning and early operation.

(8) Job duties and qualifications for each position.

1.1 Station Staff Tasks

Personnel assigned to a station will participate in the planning and execution of the station training program, start-up or commissioning procedures preparation, start-up or commissioning testing, operating manual preparation, flowsheet preparation, AECB license commitments, equipment acceptance, start-up and commercial operation. These tasks augment the efforts of any support staff located elsewhere in the utility in the early stages of the project. As station start-up approaches, the station staff assumes an increasing proportion of the responsibility of the station. The primary responsibility of the station staff is to start-up, operate and maintain the station safely, efficiently and reliably. In addition to customary good operating practices and industrial safety procedures, the station staff will be responsible for conduct of an environmental surveillance program, in-service programs, in-station radiation safety, operator licensing, routine and special

operations, abnormal occurrences and performance testing and inspection and continuation of the quality assurance program with respect to maintenance, repair and station modifications. Over and above all these technical responsibilities, the station staff will find that it must bear the burden of a public information program: station tours, response to requests for information by the public and the like.

1.2 Station Staff Organization

To carry out the variety of station tasks, the station organization can be divided into six sections or units: administration, technical services, production, planning, training and health physics. The arrangement of station staff organization, shown in Figure 1, is typical with an appropriate assignment of personnel in each classification. Factors affecting staff numbers are contracted services (security, major maintenance, film badge service, building cleaning, etc.), bargaining unit constraints and operations policies developed by management.

1.2.1 Administrative Staff

This group performs the administrative duties of the station such as purchasing, accounting, records, payroll, storekeeping, janitorial services and security.

1.2.2 Technical Services Staff

This group provides technical assistance to the production section and includes fuel scheduling, heavy water inventory control and solutions to mechanical, control and chemical problems. It prepares all technical reports and carries out analyses of station performance.

1.2.3 Production Staff

The production staff, headed by the production manager, includes both operating and maintenance personnel. To include the maintenance unit with the production unit is not common practice: the only evidence of this organization arrangement is with nuclear operations of Ontario Hydro.

The operating personnel include the shift supervisor, first, second and assistant operators and fuelling operators. Only one operator (first)

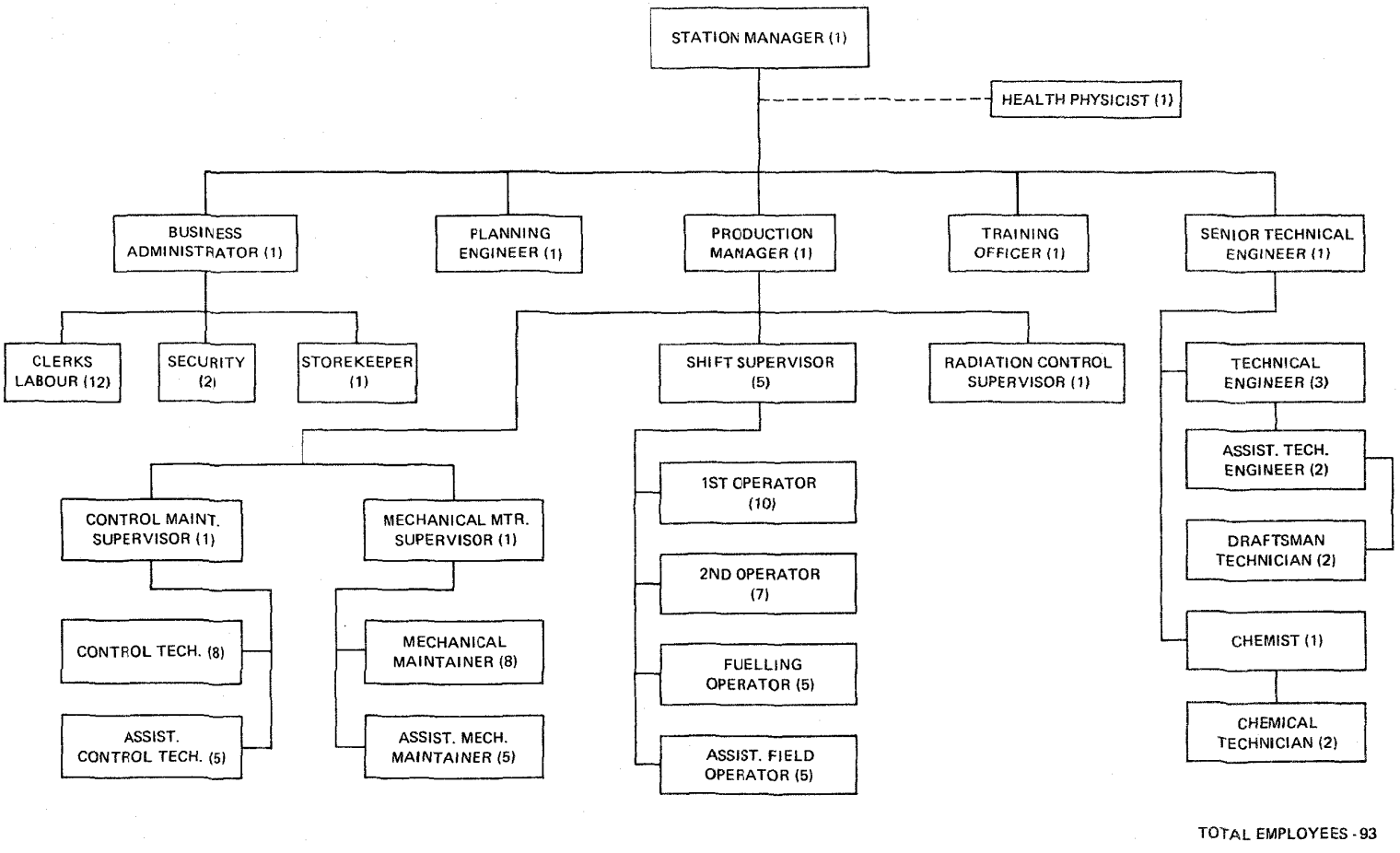

Figure 1 Typical Nuclear Station Organization Chart

is in the control room at one time. The second first operator on each shift acts as the lead hand in the field. The first operators rotate through the control room on alternate shifts. Only operators licensed by the Atomic Energy Control Board can act in the control room. To have two licensed first operators per shift gives increased security and permits full use of man-rems available. Many of the duties of the operator are similar to those in a fully instrumented conventional steam plant. The staffing numbers for the operator positions in Figure 1 are based on a forty (40) hour work week and seven day per week average.

The maintenance personnel include control and mechanical maintainer supervisors, control technicians and assistants and mechanical maintainers and assistants. The control technicians and assistants are charged with the responsibility of maintaining all process instrumentation, electric equipment and instrumentation, electronic instrumentation and computers. The mechanical maintainers and assistants are charged with the responsibility of maintaining all mechanical equipment, including welding, machining, pipefitting and mechanical fitting. Both groups are trained in the precautions to be employed in maintaining and servicing equipment located in radioactive areas.

1.2.4 Planning Staff

The planning engineer co-ordinates planning and scheduling of all production involving maintenance. He sets work priorities and monitors progress. He makes certain there are work programs laid out to take advantage of station outages.

1.2.5 Training Staff

The training officer is responsible for the preparation of training lessons on nuclear technology, station equipment and systems, operating policies and procedures and for the scheduling of lectures on these by station staff.

1.2.6 Health Physics Staff

This group is responsible to the medical director of the utility for health physics regulations governing radiation and radiation control in the station. They will carry out a training program to ensure all staff coming into contact with radiation are aware of the hazards and are able to take the necessary safety precautions.

Table 1 Nuclear Station Staff Requirements

1.	**PROFESSIONAL ENGINEERS**	
	Station Manager	1
	Production Manager	1
	Technical Engineer (including senior and assist.)	6
	Planning Engineer	*1*
	Health Physicist	1
	Training Officer	1
	* Shift Supervisor (1 per shift)	5
	Business Administrator	1
	Chemist	1
		18
2.	**TECHNOLOGISTS**	
	Radiation Control Supervisor	1
	Electrical/Mechanical	1
		2
3.	**TECHNICIANS**	
	Chemical	2
	Draftsman	1
		3
4.	**OPERATORS**	
	1st Operator (2 per shift)	10
	2nd (Field Operator) (1 per shift, 2 on days)	7
	Fuelling Operator (1 per shift)	5
	Assist. Field Operator (1 per shift)	5
		27
5.	**TRADESMEN**	
	Control Maintainer Supervisor	1
	Control Technicians	8
	Assistant Control Technicians	5
	Mechanical Maintainer Supervisor	1
	Mechanical Maintainers	8
	Assistant Mechanical Maintainers	5
		28
6.	**CLERICAL, LABOUR AND SECURITY**	
	Station Accountant	*1*
	Clerk/Typist	3
	Storekeeper	1
	Building Mechanic	1
	Security Guard	2
	Janitor	2
	Utility	5
		15
	TOTAL	93

* In later stages of operation shift supervisor could be made up from ranks of operators.

1.3 Staff Requirements

Table 1 gives a suggested list of staff requirements. A total staff of between 80 to 100 personnel is considered adequate to operate and maintain the station. This number does not include personnel hired as trainees, nor extra staff hired to assist with commissioning and early operations when teething troubles are greatest. This latter group would be available to meet later expansion needs and would have gained valuable experience on the start-up of the first station. Many of the extra staff could be hired at a more junior level of responsibility and pay.

1.4 Staff Hiring

Early involvement with design of the nuclear station forces the utility to appoint a liaison engineer with the designer. He might well be the future station manager. The station manager and some of his senior staff like shift supervisors should be appointed between 3 to 5 years before station start-up. Rather than select other key personnel early it may be prudent to hire additional shift supervisors and make senior appointments from this group following on-the-job assessments. The shift supervisors will be the commissioning engineers during start-up.

The initial staff should be carefully selected. The future station manager will in all likelihood be involved in making final decisions on the balance of the station staff. He should be selected not only with the view that he has the capability to bring the new station into service but has the capability to give the leadership and direction to the utility as it expands in the nuclear field. Many of the first professional staff should be viewed as potential managers of future stations.

1.5 Human Resources

A survey will show that few personnel are available in Canada with extensive nuclear power station experience, in fact, few are available with extensive fossil-fired thermal station experience. In the United States many key operators and engineers come from the navy's nuclear submarine program to man many of the nuclear stations being built. This manpower source is not readily available to us. Therefore, the utility must, of necessity, select key personnel such as first operators, maintenance supervisors, health physicists, radiation control supervisor, the majority of the senior engineers and shift supervisors, well in advance of the time they need to gain specific station training.

Table 2 Experience and Education at Hiring or Appointment

POSITION	INDUSTRIAL (INCLUDES NUCLEAR)	NUCLEAR STATION	EDUCATION
*STATION MANAGER	10 years	4 years	Professional Engineer or suitable equivalent.
PRODUCTION MANAGER	"	"	"
Senior Technical Engineer	8 years	4 years	"
Commissioning Engineer	"	"	"
Business Administrator	"	1 year	"
Technical Engineer	4-6 years	2 years	"
Planning Engineer	"	"	"
Training Engineer	"	"	"
Chemist	"	1 year	"
Assist. Engineer	2-4 years	0 years	"
Control Room Operator	6 years	1 year	Grade XIII or equivalent.
2nd Operator	4 years	"	"
Assist. Operator	2 years	0 years	"
Control Technician	6years (completed 4 year apprentice)	1 year	Grade XIII
Assist. Technician	4 years (4 year apprentice)	0 years	"
Mechanical Mtr.	6 years (plus apprenticeship)	1 year	Grade XII
Assist. Mtr.	4 years (plus apprenticeship)	0 years	"
Technician	2-4 years	1 year	Community College. School of Technology.

*Station & Production Manager - Experience likely to include both commissioning and shift supervisor.

The early background training would have to be done at a nuclear power station such as NPD Generating Station.

Tests should be used to aid in the selecting of personnel. They would serve to determine the applicant's aptitude and ability to successfully complete a nuclear training program.

Table 2 outlines the experience and education required for the operating personnel.

1.6 Training Needs

A nuclear station is designed to meet the most stringent requirements, but safe, efficient operation depends upon the competence of the operating staff. Some features of a nuclear power station are common to the fossil-fired station, many are not. For example, the reactor can respond much faster to load and control changes, and its controls are totally different and more complex. Inherent radioactivity requires that everyone be thoroughly familiar with radiation protection measures.

Personnel can learn the uncommon features and safety measures by on-the-job training, but cannot be expected to pick up the technical knowledge entirely through home study and night school. A more intensive and extensive program is required.

All nuclear training programs to train personnel to meet the needs of a utility's first nuclear power station follow much the same pattern. Upwards of 500 hours of classroom lectures are spent covering to some degree nuclear theory and technology, fluid mechanics, heat, mechanics and electricity, control theory, radiation theory, station equipment and systems. All key personnel will have spent time at a nuclear power station to become familiar with operations before proceeding to their station site for station training. The remaining staff will receive their initial training at the station site. Table 3 outlines, in brief, a training program for key personnel for a nuclear station.

Ontario Hydro recognized some years ago that if nuclear power were to play a major role in meeting its energy demands it would require a continuous manpower development program. Toward this end, it established in 1962 a Nuclear Training Centre. The remainder of this lecture will describe the Centre and Hydro's training program. It is not suggested that a utility follow Ontario Hydro's lead in training, but it can form a basis from which a utility can decide the trend of its own training program.

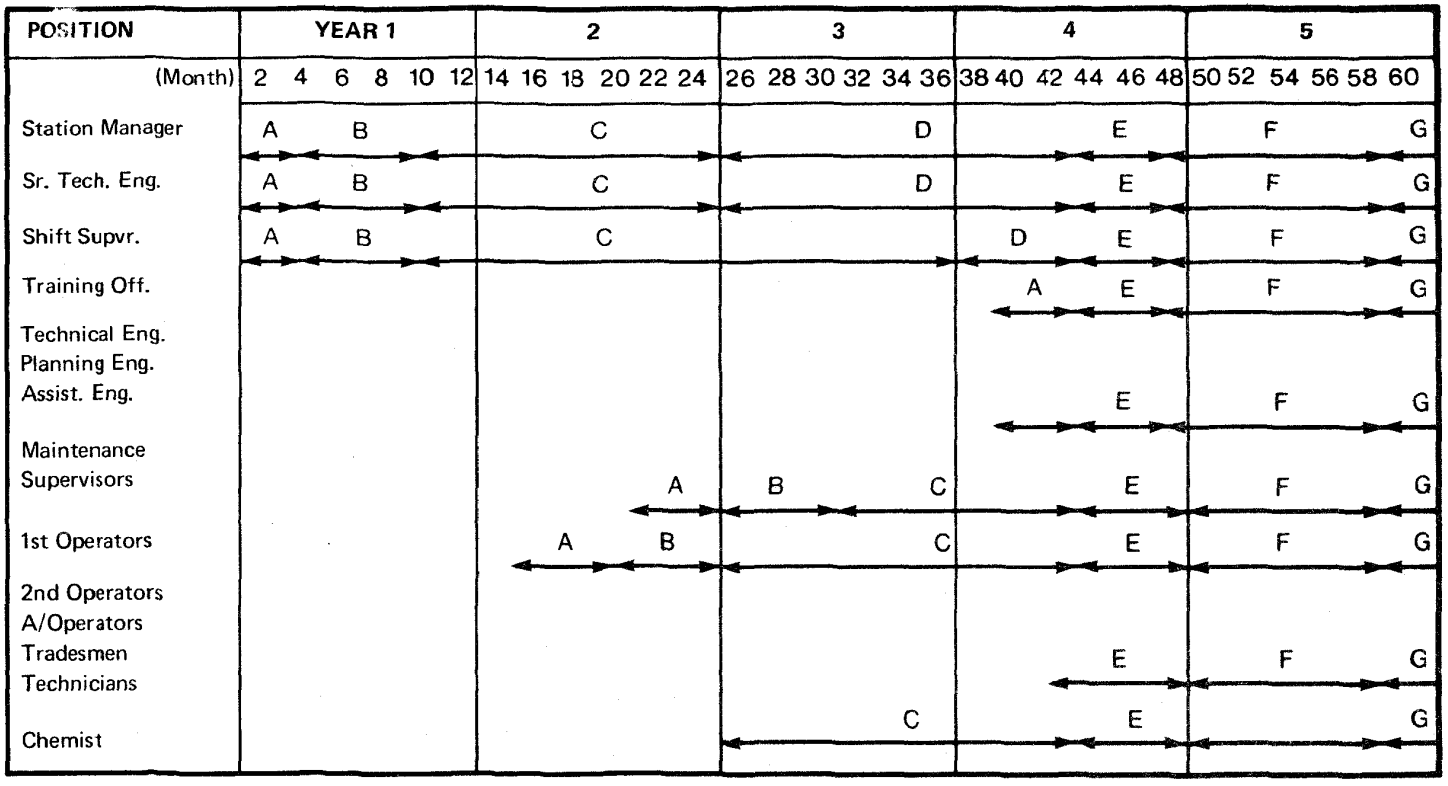

Table 3 Station Training Program for Staff for First Nuclear G.S.

2. ONTARIO HYDRO'S NUCLEAR TRAINING PROGRAM

Training of Ontario Hydro's operating personnel for its nuclear power stations is carried out under a formal training program, organized and directed through a Nuclear Training Centre. It is located near Canada's first nuclear-electric station, the Nuclear Power Demonstration (NPD) plant on the Ottawa River.

The Nuclear Training Centre, when formed in 1962, occupied a 4,300 sq ft building beside NPD G.S. It contained three classrooms and offices. It was expanded in 1965 by 12,000 sq ft and again in 1970 by 23,000 sq ft, giving a total of 39,300 sq ft of classrooms, workshops or laboratories, offices and administration area. Five portable trailers have been attached to the rear of the complex to provide overflow office space and study areas. The Centre (Figure 2) can handle up to 300 personnel under abnormal conditions and normally operates with 180 to 200 personnel present.

It has eight lecture rooms and laboratories or workshops for Health Physics (2), Electrical (2), Electronics (2), Process Instrumentation (2), Hydraulics (1), Safety (1), Welding (1), Machine Shop (1), Fitting (1), Pipe Fitting (1), Computer (2), Hydraulics and Heat (1).

In each laboratory the trainee finds equipment he needs to gain skills or demonstrate some principle covered in the classroom. Health Physics laboratory equipment: various types of radiation protection monitoring equipment and radiation sources to permit actual radiation experiments. Electrical laboratory equipment: latest type of test gear and instrumentation, and electrical breakers and relaying in 600 volt range. Electronic and Process Instrumentation laboratories: latest type of instrumentation for learning present day techniques, attention is focussed on digital circuits. Mechanical laboratories: drill presses, lathes, shaper, milling machine, welding machines, power tools, piping layouts, and configurations.

Hydraulics and Heat laboratory: hydraulic and heat loops with pneumatic instrumentation to demonstrate performance under operating conditions. Loops show the effects of pressure drops, changes in temperature, NPSH(1) problems, and a host of related problems. Computer laboratory two Bi-Tran Six Computers on which trainees learn programming, fault finding for control technicians, familiarity with computer language, and use of binary-octal number system.

Each laboratory is designed to handle 12 students at a session. The large classrooms hold 35 students, the smaller between 12 and 15.

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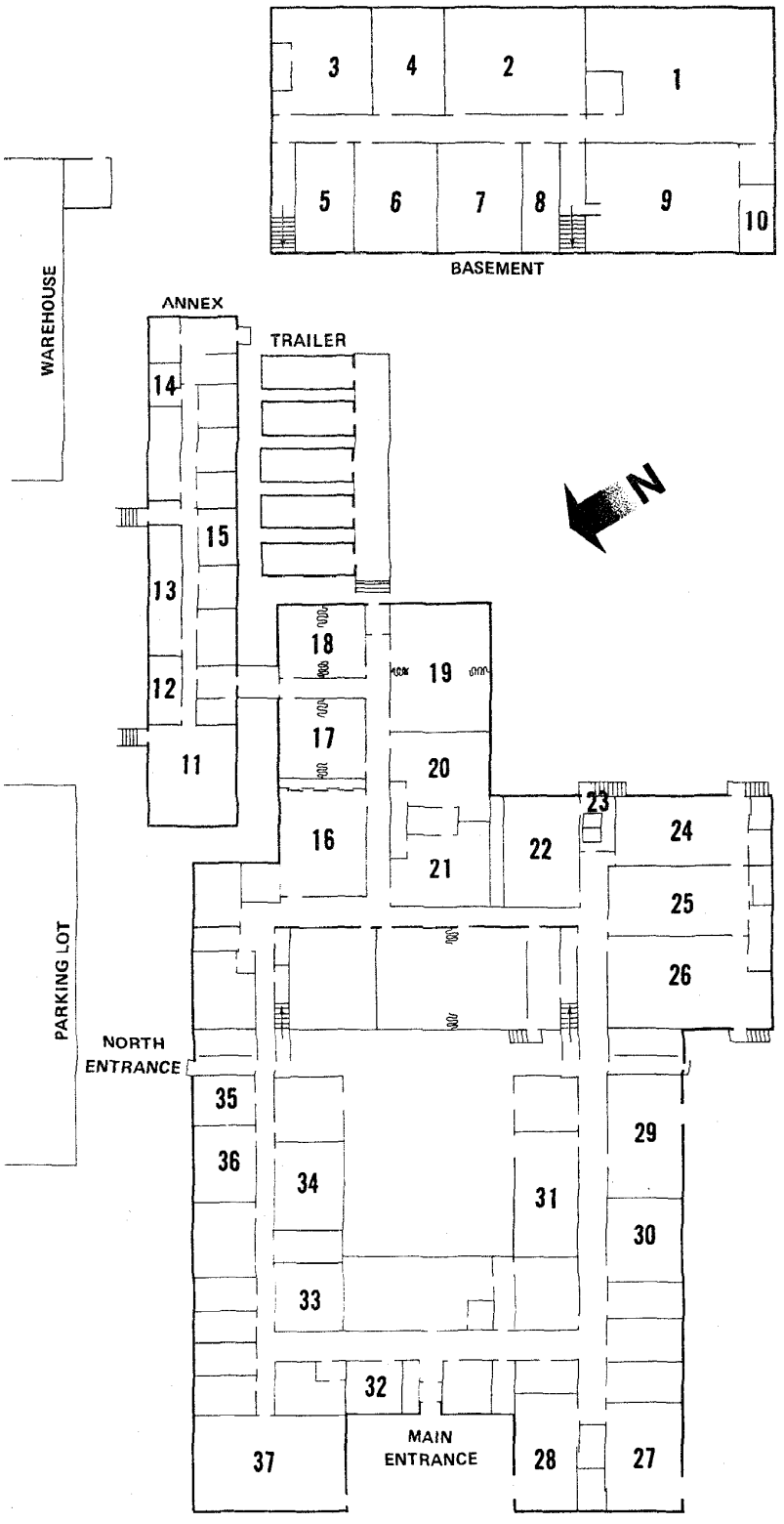
(1) Net Positive Suction Head (Pumps)



BASEMENT

1. PIPE FITTING SHOP
2. SERVICES ROOM
3. PRINTING ROOM
4. SAFETY LAB
5. AUDIO VISUAL LAB
6. RADIATION PROTECTION LAB
7. ELECTRICAL LAB
8. STORAGE ROOM
9. ELECTRICAL LAB
10. BATTERY ROOM

ANNEX

11. LECTURE ROOM
12. STUDY ROOM
13. LECTURE ROOM
14. *DARK ROOM*
15. SERVICES ROOM

MAIN BUILDING

16. RADIATION PROTECTION LAB
17. LECTURE ROOM
18. LECTURE ROOM
19. LECTURE ROOM
20. INSTRUMENT LAB
21. INSTRUMENT LAB
22. STORES
23. LOADING DOCK
24. WELDING SHOP
25. FITTING SHOP
26. MACHINE SHOP
27. ELECTRONICS LAB
28. ELECTRONIC LAB
29. COMPUTER LAB
30. COMPUTER LAB
31. HYDRAULIC HEAT LAB
32. MANAGERS OFFICE
33. SERVICES ROOM
34. LECTURE ROOM
35. LIBRARY - CONFERENCE ROOM
36. LECTURE ROOM
37. LECTURE ROOM

*ALL ROOMS NOT INDEXED ARE OFFICES, WASHROOMS ETC.

Figure 2 Nuclear Training Centre

2.1 Station Staff

The station staff chart (Figure 3) shows the different positions in our nuclear power stations. Table 4 describes briefly functions of these positions. Our training program is developed mainly to supply men for these positions.

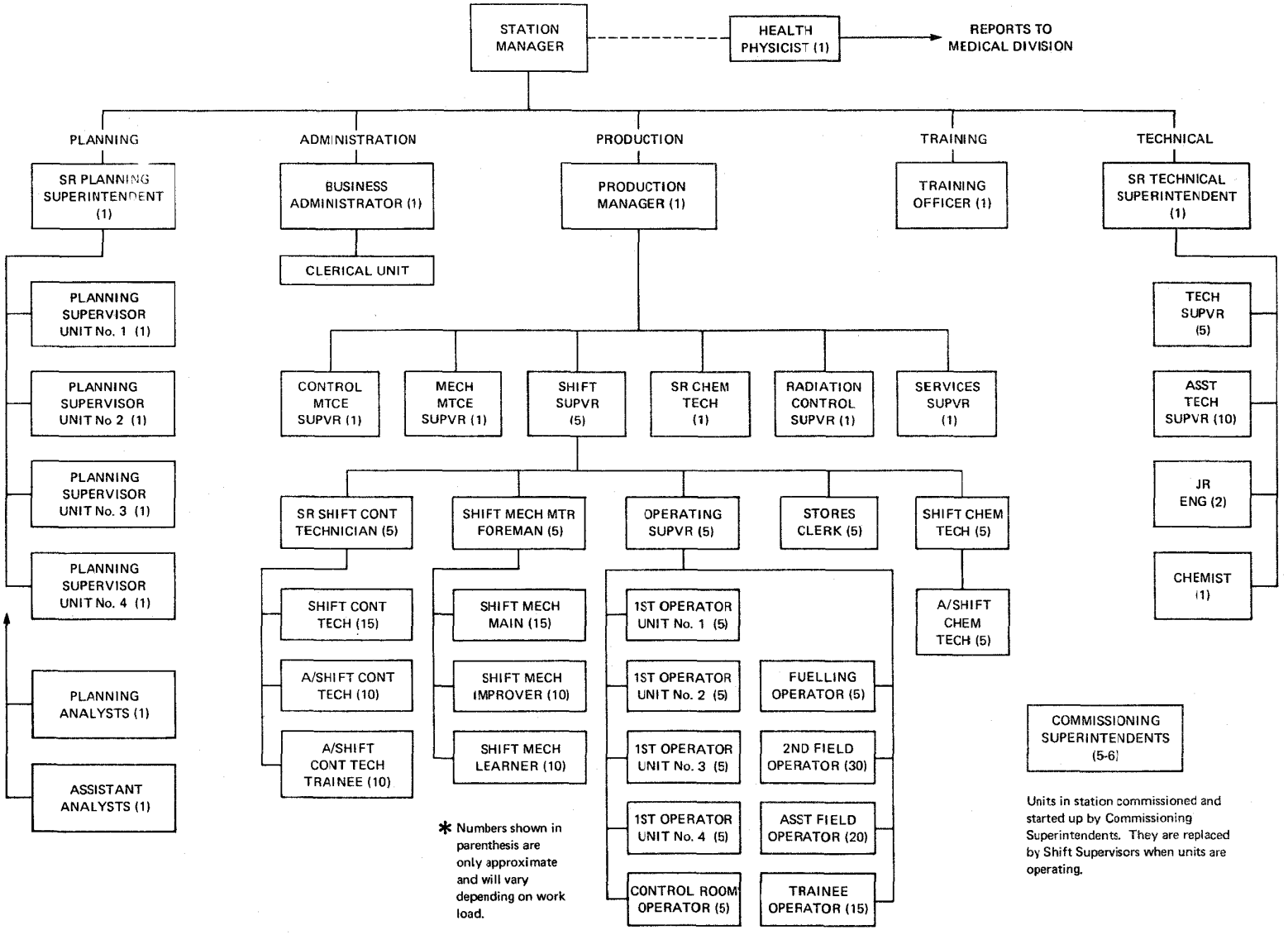


Figure 3 Station Staff - Multi-Unit Station

Table 4 Brief Description of Staff Functions

POSITION	RESPONSIBILITIES
Station Manager	*In charge of the entire station.*
Production Manager	In charge of execution of all field work including operations, maintenance, improvements, radiation control, chemical control, also acts as Manager in absence of Station Manager.
Technical Supervisor	Head of technical unit: Technical problem solutions, mechanical, electrical, control, fuel scheduling, heavy water accounting, losses, report writing, procedures writing.
A/Technical Supervisor	Assists Technical Supervisor.
Chemist	Chemical problems and analyses.
Planning Superintendent	Overall planning of station work, including overhauls, repairs, installations, using various scheduling techniques and evaluations.
Planning Supervisor	Planning co-ordination and scheduling, set work priorities and monitors work progress.
Planning Analyst A/Planning Analyst	Assists the planning supervisor in preparing critical path schedules or other type, analyze data, to improve planning.
Shift Supervisor	In charge of power production in station on a shift basis.
Shift Operating Supervisor	Assists shift supervisor.
Operators Control Room	In charge of control room.
First Field Operator	Foreman in charge of field operators work for one unit.
Second Operator A/Operator	Carry out field duties.
Mechanical Maintenance Supervisor	In charge of mechanical maintenance.
Control Maintenance Supervisor	In charge of control maintenance.
Commissioning Superintendent	Carries out commissioning of station systems assisted by staff. Prepares all commissioning, operating, training and maintenance manuals. Trains initial staff on station systems and equipment.
Control Technician A/Control Technician	Maintains pneumatic, electronic, electrical instrumentation, controls and equipment, including computers.
Mechanical Maintainer	Maintains mechanical equipment: Welding, machining, pipefitting, millwright work. Control Technician and Mechanical Maintainer both must be skilled in more than one trade.
Business Administrator	In charge of business administration including budget, cost control, union contract, personnel problems, contracts, equipment warranties and station stores.
Training Officer	In charge of station training, schedules and arranging for training assistance from Nuclear Training Centre.

2.2 Hiring of Personnel

The program of the Centre is divided into three phases: hiring of personnel, developing individual training courses and preparing training material, and training of personnel. Four classes of personnel are hired in the program: operators, maintainers, technicians and professional staff (Table 5).

Table 5 Hiring Practice

CLASS OF PERSONNEL	EDUCATION ASKED	YEARS OF INDUSTRIAL EXPERIENCE (MINIMUM)	POSITION OFFERED
Operator	Grade XIII	2-4 years 0-1	Assist. Operator Operator-in-Training
Control Technician	Grade XIII plus apprenticeship (Grade XIII course)	4-6 years 0-1	Shift Control Maintainer Trainee
Mechanical Maintainer	Grade XII plus apprenticeship (Grade XII course)	4-6 years 0-1	Shift Mechanical Maintainer Learner
Technician	Community College, School of Technology	0-2 years	Assist. Chem. Tech. Assist. Planning Analyst Assist. Rad. Control Technician
Professional	University Degree (preferably engineering)	2-4 years 0-1	Assist. Engineer Jr. Engineer-in-Training

Each station hires locally its own auxiliary staffs such as clerical, janitorial, labourers, etc. These are given only the minimum of training and mainly in radiation protection.

Our training program is strongly influenced by the experience available to us. Personnel with conventional thermal utility experience are not available in sufficient numbers nor with any depth of experience. The initial staff for NPD was selected from the best experience available in the thermal, electrical and nuclear fields, appointed to the various station positions and given considerable classroom and field training. Since then all personnel have been hired into a pool, initially attached to the Training Centre.

If a man has more experience than that asked, he cannot at present enter our nuclear program except through the positions offered. Experienced personnel are available from time to time with less than the Grade XIII or Grade XII in the operator and maintenance trades. Our training courses have, therefore, had to reflect the lowering of the educational standard.

2.3 Qualification Levels

Qualification levels are established for many of the positions shown in Table 6. Those levels, with the exception of 1A, closely parallel the four levels of stationary engineers used in conventional steam plants. Through experience and training, personnel may become qualified for promotion to higher levels. As most of the staff would have little pertinent experience at time of hiring, training must therefore be of a continuous nature. It is spread over many years with concentration at appropriate times on skills, knowledges and abilities to fit the man for higher level positions.

2.4 Training Course

The training course is subdivided into nine topics, with the topics further subdivided into subjects (Table 7). The first two topics, 0 and 1, are directly related to orienting the trainee into Ontario Hydro and teaching him about the management of a station. The next two topics, 2 and 3, are related to theory and the application of this theory to the understanding of various pieces of equipment seen in any nuclear power station, such as fans, motors, relays, pumps, instruments, etc., and when the pieces of equipment are joined together on how the various systems work. Topic 4 deals with skill training for the operators and maintainers. For the operators it is limited to the use of a few simple tools such as the screwdriver and wrench, the making of ice plugs for heavy water equipment isolation (practised in the hydraulics laboratory), the proper operation of valves, and the use of electronic and electrical wiring schematics. For the control technician and mechanical maintainer the full range of skill training is called for, designed to take the learner or apprentice to the journeyman level, i.e., the NC-3 or NM-3 level under our scheme as shown in Table 6. If the maintainer is already hired at the journeyman level, then he would continue his training in the skills in which he was deficient so as to meet his job responsibility. Topics 5 and 6 deal with the particular station training. Topic 5 deals with the classroom lectures on station systems and equipment and 6 deals with the field check-outs or demonstrations the trainee must go through

Table 6 Qualification Levels

POSITION	QUALIFICATION LEVELS	CODE
Technical Superintendent	Sr. Nuclear Tech. Supervisor-1A	NTS-1A
Planning Superintendent	" " " " -1A	NTS-1A
Commissioning Superintendent	" " " " -1A	NTS-1A
Business Administrator	" " " " -1A	NTS-1A
Technical Supervisor	Nuclear Technical Supervisor -1	NTS-1
Planning Supervisor	" " " -1	NTS-1
Shift Supervisor (Professional)	" " " -1	NTS-1
A/Technical Supervisor	Assist. Nuclear Technical Supervisor -2	NTS-2
Shift Supervisor (Non-Prefessional)	Nuclear Supervisor	NS-1
Shift Operating Supervisor	Nuclear Operator	NO-1
First Operator (includes control room)	Nuclear Operator -2	NO-2
Second Operator	" " -3	NO-3
Assistant Operator	" " -4	NO-4
Control Maintenance Supervisor	Nuclear Control -1	NC-1
Senior Control Technician	" " -2	NC-2
Control Technician	" " -3	NC-3
A/Control Technician	" " -4	NC-4
Mechanical Maintenance Supervisor	Nuclear Mechanical -1	NM-1
Mechanical Maintainer Foreman or Sub-Foreman	" " -2	NM-2
Mechanical Maintainer Journeyman	" " -3	NM-3
Mechanical Maintainer Improver	" " -4	NM-4
Radiation Control Supervisor	Nuclear Radiation Control -1	RC-1
Senior Radiation Control Technician	" " " -2	RC-2
Radiation Control Technician	" " " -3	RC-3
Assist. Radiation Control Technician	" " " -4	RC-4
Shift Senior Chemical Technician	Nuclear Chemical Technician -2	CT-2
Shift Chemical Technician	" " " -3	CT-3
Assist. Chemical Technician	" " " -4	CT-4
Planning Analyst	Nuclear Planning -2	PA-2
Assist. Planning Analyst	" " -3	PA-3

to prove his knowledge and skills on certain operations, e.g., the start-up and shutdown of a reactor. The NPD station systems number eighty, but at Douglas Point there are 150. There are 330 NPD station field check-outs which the operator must complete to reach the control room operator level. These take about 4 years to learn. Topic 8 deals with the whole field of Protection Training with extra emphasis on Radiation Protection. Radiation Protection training is under control of the station Health Physicist who is part of Ontario Hydro's Medical Division rather than station staff. This course alone takes 150 hours of training. Personal development, Topic 9, is mainly carried out through courses put on by Hydro's Manpower Development Section.

One important aspect of Personal Development is Personal Attributes. No employee can move up the ladder to a higher job position from the one into which he was hired until he has been judged satisfactory in a number of attributes. These are: inspire trust and confidence in others, co-operation and aggressiveness, judgment, intelligence and ability to reason logically, emotional control and stability, leadership (where applicable) and safety and general attitude.

Table 7 Training Course Breakdown

TOPIC	SUBJECT
0 General	0 - General
1 Management	0 - General 1 - Administration 2 - Organization 3 - Standing Instructions 4 - Production and Control 5 - Operating Policy and Principles 6 - Instructional Techniques
2 Science Fundamentals	0 - General 1 - Mathematics 2 - Mechanics 3 - Fluid Mechanics 4 - Chemistry 5 - Heat and Thermodynamics 6 - Electricity and Electronics 7 - Nuclear Theory 8 - Materials 9 - Economics

Table 7 (Cont'd)

TOPIC	SUBJECT
3 Equipment & System Principles	0 - General - 1 - Mechanical Equipment 2 - Electrical Equipment 3 - Instruments 4 - Computers 1 - Site 2 - Buildings and Structures 3 - Reactor Boiler and Auxiliaries 4 - Turbine Generator & Auxiliaries 5 - Electrical Systems 6 - Instrumentation and Control 7 - Common Processes
4 Skills	1 - Mechanical Skills 2 - Fitting 3 - Machining 4 - Machine Components 5 - Blueprint Reading 6 - Tubing & Pipefitting 7 - Welding 8 - Rigging 9 - Electrical Skills 10 - Electronic Skills 11 - Instrumentation Skills 12 - Chemical Skills 13 - Operational
5 Station Equipment & Systems	0 - General 1 - Site 2 - Buildings and Structures 3 - Reactor Boiler & Auxiliaries 4 - Turbine Generator & Auxiliaries 5 - Electrical Systems 6 - Instrumentation and Control 7 - Common Processes & Services
6 Station Equipment & Systems Field Check-Out	1 - Site 2 - Buildings and Structures 3 - Reactor Boiler and Auxiliaries 4 - Turbine Generator & Auxiliaries 5 - Electrical Systems 6 - Instrumentation and Control 7 - Common Processes & Services
7	- - - - - - - - - -
8 Protection Training	1 - Radiation 2 - Chemical 3 - Thermal 4 - Electrical 5 - Mechanical 6 - Fire 7 - Hydro Safety and Protection Code 8 - Resuscitation and First Aid
9 Personal Development	1 - Personal Attributes

2.5 Radiation Protection

Working on the principle that each nuclear plant worker should have direct responsibility for his own radiation safety under Radiation Protection Regulations set out by the Medical Division of Ontario Hydro, it became necessary to develop and carry out in-depth radiation protection training.

Under the station Health Physicist and health physics training officers, attached to the training centre, classroom and laboratory training is given to all personnel employed in a nuclear station with the exception of clerical staff and some janitorial staff. Station radiological procedures are developed under the station Radiation Control Supervisor and all personnel requiring radiation training are given the necessary training in these. Failure to pass the radiation protection training course can and has resulted in termination of employment of the employee. Table 8 gives an outline of the Medical Division Radiation Protection Training.

Table 8 Radiation Protection Course

THE ATOM
Atoms, Elements
How the Atom is Assembled
Isotopes
Molecules and Compounds

RADIOACTIVITY
Stable and Unstable Atoms
Radioactive Particles and Gamma Rays
Ionization
Penetrating Power of the Various Radiations
Shielding - Alpha and Beta Radiation
Shielding Neutrons and Gamma Rays
Summary
Strength of Radioactive Sources
Decay of Radioactive Sources
Half Life of Radioactive Sources
Summary
Fission
Fission and the Chain Reaction
Fission Products
Neutron Activation
Neutron Reactions
Radiations Produced in a Nuclear Reactor
Sources of Radiation Around a Heavy Water Power Reactor

Table 8 (Cont'd)

RADIATION EXPOSURE
External and Internal Exposure
Radiation Units - Roentgen and Rad
Radiation Units, Quality Factor, Equivalent Dose, rem
Quality Factors for Various Radiations
Summary
Dose and Dose Rate
Dose Rate in Mixed Radiation Fields
Maximum Permissible Doses
Methods of Reducing External Dose-Time, Distance, Shielding & Decay
Summary
Internal Radiation - Exposure
Critical Organ
Maximum Permissible Body Burden
Maximum Permissible Concentration
Exposure to Tritium
Dose from Tritium
Exposure to Radioiodines
Summary of Internal Exposure

BIOLOGICAL EFFECTS
Background Radiation
How Radiation Damages Our Body
Difference Between Acute Dose and Chronic Dose
Effects of Various Acute Doses
Effects of Chronic Doses
Summary

RADIATION MEASUREMENT
Types of Measurement Necessary in a Radiation Protection Program
Ionization Chambers as Gamma Dose Rate Meters
Ionization Chambers as Gamma Dosimeters
Geiger Tubes as Contamination Detectors
Geiger Tubes as Beta - Gamma Dose Rate Meters
Scintillation Detectors
Film Dosimeters
Solid State Detectors
Neutron Dose Rate Meters

CONTAMINATION DETECTION AND CONTROL
Introduction
Sources of Contamination
Protection by Design
Measurement of Airborne Contamination Levels
Measurement of Surface Contamination Levels
Protection Equipment
Decontamination Principles

PRACTICAL RADIATION PROTECTION
Attitude
Planning a Job - General
Planning a Job - Specific

RADIOACTIVE WASTE & EFFLUENTS
General

2.6 Course Preparation

At any qualification level, rather than write separate courses for each of the classes of personnel occupying the level, e.g. NM-4, NO-4, NC-4, only one course is prepared. In mathematics, for instance, there is only one course at the 4 level, and the same applies to all the other subjects. This particular course is designated 421. Mathematics at the 3 level is designated 321 and so on. There are 45 courses at the 4 level, 31 courses at the 3 level, 27 courses at the 2 level, 35 courses at the 1 level and 13 courses at the 1A level. No trainee is expected to do all the courses at any one level. He has only to do those particular to his calling.

For most of the subjects, the courses covering these are made up of a number of lessons. Each lesson is a typewritten handout, amply illustrated, of between 3-30 pages. Each lesson is followed by an assignment which the trainee must hand in for marking, or which he must carry out in the workshop or laboratory. Following the completion of the lessons in a course the trainee writes an examination of which the pass mark is set at 70. To qualify at the 4 level a trainee operator would write 50 examinations or check-outs, each one lasting 1 to 1-1/2 hours.

Referring again to course 421 as an example, all the mathematics required at this level would be contained in this course. However, all the mathematics might not be needed by each of the four groups of trainees, operators, control technicians and mechanical maintainers and technicians. Therefore, out of this course the trainee takes only the lessons appropriate to his training. The same applies to all other courses. By this method we have tied the various staff to a single overall training course, rather than have separate courses for each group.

We have prepared to date over 1,500 training lessons.

2.7 Licensing Requirements

The federal agency, The Atomic Energy Control Board of Canada, reviews the training methods, courses, etc., and in addition sets its own qualifying examinations for the shift supervisor and control room operator. Successful completion of these examinations is necessary before the men are allowed to function as shift supervisor, in charge of the station, or control room operator, in charge of the control room. The commissioning engineer must likewise be licensed by the federal

agency before being allowed to start up the station for the first time and carry out its initial period of operation. The examinations set by the AECB are:

Nuclear Theory and Reactor Technology	- General
Health Physics	- General
Conventional (non-nuclear)	- General
Nuclear Theory and Reactor Technology	- Station (specific)
Health Physics	- Station (specific)
Conventional	- Station (specific)

As long as the employee remains in the nuclear power program he need only write the general examinations once, but must rewrite the specific examinations for each station if he transfers from one to the other to a similar position or one requiring a license.

Approval must be sought from the AECB for appointments to positions of Station and Production Manager.

2.8 Level of Training

Regardless of whether a man is hired as an assistant operator, operator-in-training, control or mechanical maintainer or learner, he must take four level training at the Training Centre. The newly hired professional staff training starts at the two level. Each group spends between 5-9 months at the Centre and receives 500 hours of classroom instruction with a half day spent in the classroom and the other half day doing assignments or taking examinations.

Laboratory training at the four level for maintainers takes 1,000 hours and is spread over 2 years. Training at other levels is conducted at the station, or on periodic returns to the Training Centre for periods of 3 to 6 weeks. Training at the station is co-ordinated through a training officer. Training in Science Fundamentals and Equipment and Systems Principles is carried out at the stations above the four level for non-professional staff and the one level for professional staff by staff from the Training Centre in training facilities at each station. Each level of training above the four level of training requires 500 hours of classroom instruction, but is spread over several years.

2.9 Records

Records are kept of all training done, both at the stations and the Centre, as a man's promotion depends on how well he meets the higher qualification level requirement. The records also serve as indicators of the success of the overall training effort. All records are inputted to a computer that prints out each month each employee's training record, as well as the effort put into training by each location.

Training progress is measured through two indices: Job Qualification Index (JQI) and Promotability Qualification Index (PQI). The Job Qualification Index is defined as:

$$\frac{\text{No. of courses completed for present job qualification}}{\text{No. of courses required for present qualification}}$$

The Promotability Qualification Index is defined as:

$$\frac{\text{No. of courses completed for the next higher level qualification}}{\text{No. of courses required for next higher level qualification}}$$

Each higher level above the 4 level qualification includes all courses below the higher level as well as the courses at the higher level for the qualification at that level.

2.10 Training Centre Staff

The training program is directed by a manager, who also directs the Training Centre with a training staff of thirty-two (Figure 4), plus clerical, printing and cleaning staff. A senior supervisor and senior training officer direct the activities of the training officers, assistant training officers, training supervisors, and instructors in preparing training lessons, course curricula, laboratory or workshop experiments or skills training, and lecturing both at the Centre and the stations. Three training supervisors act as a liaison to provide direct feedback from station staff on suitability of content of lessons, they also supervise trainees at the Centre, except university graduates, and arrange for transfers to various locations of trainees from the Centre. A senior selection officer and selection officer carry out hiring of pool personnel assisted by other staff members when the hiring load becomes excessive.

2.11 Outside Training

In addition to providing training for the staff of Ontario Hydro, arrangements have been made from time to time to provide training and instruction to the employees of other utilities who are using or are interested in the CANDU reactor. Staff members from Hydro Quebec took part in such a program. Also, trainees from foreign countries such as India, Pakistan and Japan have received training at the facilities of Ontario Hydro.

2.12 Manpower Development

The foregoing essentially describes the mechanics of the training program carried out in Ontario Hydro to develop in its nuclear personnel the knowledge and skills needed to function at various job levels. What it does not describe is that training is only a part of manpower development. Only through work projects or assignments can a person's latent abilities be developed. One underlying feature of manpower development is to have every professional person (degree holder) have station experience by being rotated through various sections of the station, and the bulk of these personnel to actually qualify as a shift supervisor and be in full charge on a shift basis of a nuclear station for a period up to two years. Manpower development is carried out on a sub-division wide basis. Employees may be transferred or deployed to work in various locations to gain additional experience before promotion. Periodic audit of manpower skills and abilities are carried out to determine who need further development and who are ready for promotion.

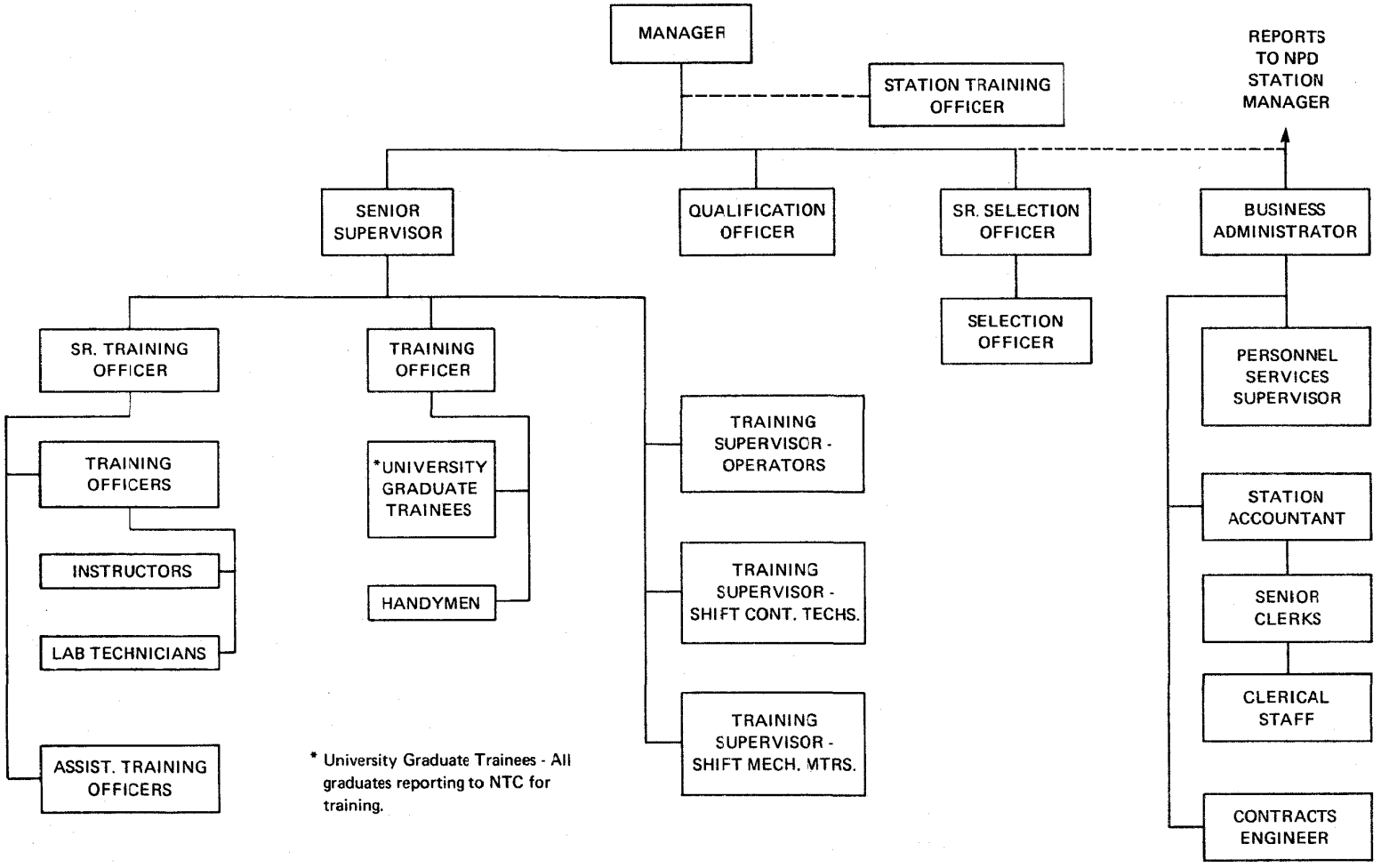


Figure 4 Nuclear Training Centre