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ADMINISTRATION OF ORNL RESEARCH REACTORS

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I. INTRODUCTION

The three routinely operated research reactors at the Oak Ridge National Laboratory, namely the Oak Ridge Research Reactor (ORR), the Low Intensity Testing Reactor (LITR), and the Oak Ridge Graphite Reactor (OGR) are under the jurisdiction of the Operations Division. Of the five Departments of this Division, three, Reactor Operations, Development, and Technical Assistance, are directly involved with the operation of these reactors. The organization of the Operations Division is given in Figure 1.

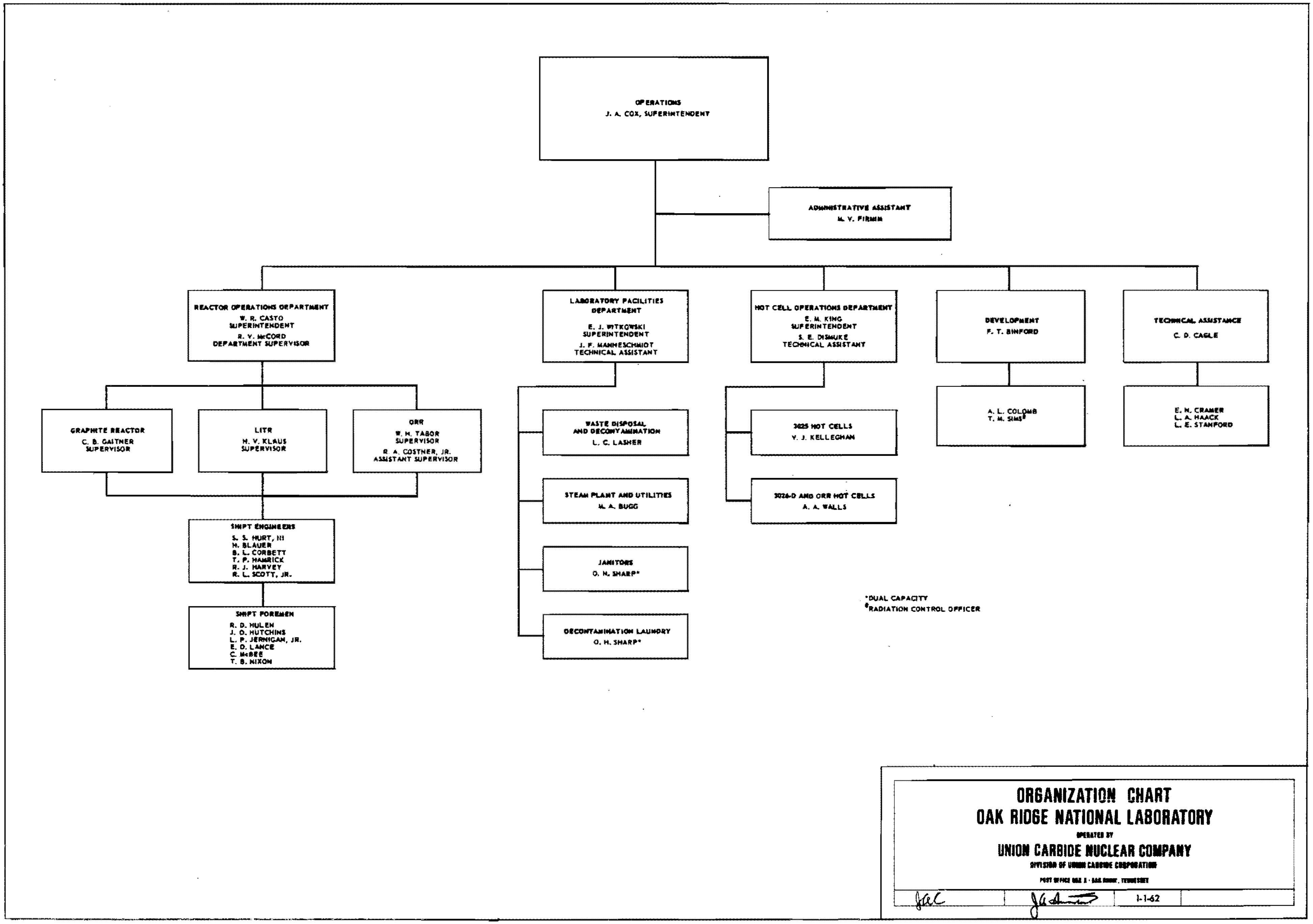
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FIGURE 1

-2-

II. MANPOWER AND ORGANIZATION

A. Reactor Operations Department

1. Function

The Reactor Operations Department is responsible for the direct day-to-day operation of the ORR, the LITR, and the OGR. Operating procedures are established with the assistance of the Technical Assistance and Development Departments. In addition, various safety committees of management may review operations and make recommendations.

It is the responsibility of the Reactor Operations Department to conduct the operation of the reactors within the limits outlined in the operating procedures. The Department is primarily concerned with production but in a different sense than is the case with a power reactor, where a good record is usually measured in terms of megawatt days per year. With a research reactor the product is the scientific and engineering data compiled by investigators using the reactor, and this is often augmented by occasional reactor shutdowns. Safety also plays an important role throughout the operation of the reactors, and the Department must remain sensible to its responsibility in this respect.

2. Supervision

In general there are three levels of skill necessary for the operation of nuclear reactors.

a. The Nuclear Reactor Engineer.--"This category demands a high degree of technical competence and knowledge including the ability to analyze and treat with the various aspects of reactor technology. The nuclear-reactor engineer must have a thorough working knowledge of the physical principles associated with the design and operation of a nuclear reactor and its ancillary facilities. His educational background will include an undergraduate degree in engineering or one of the physical sciences plus considerable specialized work at the graduate level in reactor technology. From the ranks of the nuclear reactor engineers are drawn the reactor designers, experiment designers, safeguard specialists, technical support personnel, and often top operations supervision."[3]

b. The Operation Engineer.--"The operation engineer is distinguished from the nuclear engineer in that the former is generally charged with the direct responsibility of supervising the implementation of procedures established by the latter. It is not so necessary that the operation engineer have a profound knowledge of the physical principles underlying his operation; however, he must be thoroughly familiar with the machinery under his control and must understand its behavior and, in particular, its limitations. Usually the operation engineer is required to have an undergraduate degree in engineering and some specialized training, often acquired on the job, in reactor engineering."[3]

c. The Reactor Technician.--"The reactor technicians are the individuals who, under the supervision of the reactor engineer or the operating engineer, perform the actual manipulations required to operate the facility. In general, these persons are trained on the job to perform essentially repetitive tasks. They must be emotionally stable, intelligent, and have a reasonable degree of manual dexterity. The educational requirements vary with the particular facility; however, at ORNL a high school diploma is the maximum."[3]

All of the supervisors employed in the Reactor Operations Department, with the exception of the foremen, have degrees in one of the physical sciences. It has been found that undergraduate degrees with a broad base in the physical sciences, such as physics or engineering, seem to offer the best background for reactor operations supervision. A reactor operations supervisor needs not only technical training but also experience, and the Reactor Operations Department supervisors above the foremen have an average of five years reactor experience. All the foremen have a high school education. These men started as reactor operators and were promoted to the position of foremen. As foremen they have accumulated an average of seven years of reactor experience. Previously, as reactor operators, they had also worked an average of seven years.

3. Organization

Organization of the supervision of the Reactor Operations Department is shown in Figure 1. Operation of the ORR is so complex that an Assistant Reactor Supervisor and an extra foreman are required. The four shift crews that are used to man the reactor continuously, on rotating eight-hour shifts, report to the three reactor supervisors. Each shift is composed of a reactor engineer, a shift foreman, and four reactor operators. At the ORR the line of authority is through the chief shift engineer who is responsible to the assistant reactor supervisor and does relief work for the four shift engineers. The relief foreman is the substitute for the shift foreman and for the reactor supervisors of the LITR and OGR. When not occupied in this manner, he works on special assignments at the three reactors.

4. Reactor Operators

Reactor operators are required to have at least a high school education or to pass an examination proving high school equivalence. In recent years, an I.Q. test and a mechanical-comprehension test have also been given to applicants for the operator job. People of average intelligence make a score of 90 to 100 on the Otis test used at ORNL. The average grade on the Bennett Mechanical-Comprehension test used is 62.

All operators who have been employed since use of the tests has been initiated have achieved an I.Q. score of at least 100 and a mechanical comprehension score of at least 80. Men with experience in chemical plants, where they have worked with control and indicating instruments, can easily be trained as reactor operators.[4] Experience with equipment associated with heat transfer, fluid flow, and mechanical operations is also valuable background for a reactor operator.

A labor union, Atomic Trades and Labor Council, represents nonsupervisory employees in discussions with ORNL management, Union Carbide Nuclear Company.

A labor contract agreed to by the Company and the union, provides that "Supervisory personnel shall not do nonsupervisory work which will deprive employees of jobs regularly performed by them. This does not prevent such supervisory personnel from performing necessary functions of instruction or assistance to employees, or from operating equipment or processes in emergencies or for experimental purposes."

In general, reactor operators discharge many tasks requiring manual labor, in addition to operating reactor controls, such as starting pumps, opening and closing valves, handling fuel, obtaining water samples, recording data, executing housekeeping duties, etc. All the aforementioned jobs are performed under the guidance and direction of the supervisors.

B. Technical Departments

1. Function

In addition to the Reactor Operations Department, the Technical Assistance Department and the Development Department devote their time almost exclusively to reactor operations. In general, the Technical Department gives aid on technical problems of operations and reviews proposed reactor experiments from a safety viewpoint. The Development Department deals with technical problems that do not immediately affect the reactors. Typical projects are as follows:

1. Preparation of reactor experiments for safety review,
2. Review of reactor experiments for safety,[1]
3. Development of a hydraulic test facility for ORR core pieces,
4. Development of procedures for annealing the Graphite Reactor,
5. Training,[4]
6. Development of fuel-loading cycles for the ORR,[6]
7. Development of a boiling-detection device for water-cooled reactors,[7] and
8. Development of specifications for reactor fuel.

C. General Manpower

Forty-eight people in the Operations Division are engaged in the operation of the three research reactors. The distribution is broken down in Table 2.

Table 2. Manpower for Operation of ORNL Research Reactors

Department	Technical Staff and Supervision	Foremen	Reactor Operators	Clerical
Reactor Operations	9	7	22	1
Technical Assistance	4			1
Development	4			
Total	17	7	22	2

Because many of these people have responsibilities at all three reactors, an exact delineation of manpower required for each reactor is not possible. An estimate is shown in Table 3.

Table 3. Estimated Manpower per Reactor

Reactor	Reactor Operators	Clerical	Supervisors	Technical	Total
ORR	14	2	9	6	31
LITR	3		3	1	7
OGR	5		4	1	10

Obviously, it would not be possible to operate a single isolated reactor similar to the LITR continuously with only three reactor operators and three supervisors. However, this is done at the LITR by sharing personnel with the other reactors. The 31 people required for the ORR operation is similarly low. Part of the explanation of these low manpower requirements is due to the physical proximity of the reactors. These three reactors share manpower and, therefore, make more efficient use of the personnel. Reactor Operations Department employees are not considered fully trained until they can work effectively at any of the three reactors; thus, greater efficiency is attained. It is never necessary to hold specially trained reactor operations personnel in reserve, in idleness, until a given reactor requires their particular talents.

The proximity of the reactors to each other has also made it surprisingly easy to operate the LITR and the OGR from the same control desk for the past six years. A reduction in personnel requirements of approximately four men resulted from the combination of these two control desks.

It should be pointed out that reactor experiments are not operated by the operations group. However, at times, Operations provides assistance to experimenters for certain routine tasks.

D. Mechanical Maintenance Manpower

During operation of the reactors, approximately eight manhours per day are required at the LITR and the OGR for reactor mechanical maintenance; whereas, 48 manhours per day are required at the ORR. Maintenance of ORR experiments requires approximately 170 additional manhours per day.

Maintenance work at the ORR is initiated by the reactor supervisor through the day foreman who provides a list of required work to an assigned maintenance foreman one week prior to the time the job is to be done. In addition to a maintenance foreman, an engineer is available to provide technical assistance. The engineer, foreman, and craft personnel are furnished by the Engineering and Mechanical Division.

A long shutdown is scheduled every four weeks at the LITR and every eight weeks at the ORR. During the monthly two-to-three day shutdown at the LITR, an average of 30 manhours of reactor maintenance and an average of 50 manhours of experiment maintenance is required. During the one-week shutdown at the ORR an average of 200 manhours on reactor maintenance and an average of 800 manhours of experiment maintenance is required.

Because of the smaller number of experiment facilities at the LITR, a less detailed shutdown work schedule is required than for the ORR.

Due to the amount of work and the number of people with different interests involved in an ORR shutdown, much more careful scheduling is necessary. Here the schedule must include craft requirements, manhours, timing, and the level of the pool water necessary for each task.[8] Approximately 100 manhours are required by members of the Operations, Engineering and Mechanical and Instrumentation and Controls Divisions to prepare a detailed schedule for the one-week shutdown. During an average shutdown, the Engineering and Mechanical Division assigns four engineers and five foremen to provide field engineering and supervision. Shutdown information for the three reactors is listed in Table 4.

Table 4. Operating Data

Reactor	ORR	OGR	LITR
Power, Mw	30	3.5	3
Operating time, %	~80	~90	~88
Maintenance shutdowns per year	6	52	13
Duration of maintenance shutdowns--days	~7	~0.5	~2

In Table No. 5 a complete breakdown of all maintenance labor for a one-year period is given. The ORR utilized 7191 mandays, the LITR 1402, and the OGR 1125.

Table 5. Breakdown of Reactor Maintenance Labor for One Year

	ORR Mandays	OGR Mandays	LITR Mandays
Mechanical Engineers and Craft Foremen	1433	261	587
Instrumentation and Control Engineers	342	27	52
Draftsmen	571	6	50
Machinists	1764	4	126
Sheet Metal Workers	97	8	8
Welders	200	10	7
Instrumentation Mechanics	595	329	374
Electricians	434	108	85
Pipe Fitters	439	51	21
Millwrights	511	258	87
Riggers	58	4	4
Laborers	291	4	2
Carpenters	74	42	3
Painters	5	2	1
Utility Mechanics	100	5	2
Equipment Operators	51	5	4
Boiler Makers	24		
Electroplaters			11
Total	7191	1125	1402

OGR manpower requirements for maintenance is somewhat less than that for the LITR because after 18 years of operation most necessary changes have been completed and most of the unreliable equipment has been replaced. The reduced number of changes is further illustrated by the fact that the number of manhours of drafting time was 671 for the ORR, 50 for the LITR, and 6 for the OGR.

Table 6 shows the number of mandays expended by instrument engineers and instrument mechanics on the three reactors for this twelve-month period.

Table 6. Instrument-Maintenance Manpower Used in One Year

Reactor	Instrument Engineers Mandays	Instrument Mechanics Mandays
ORR	342	595
LITR	52	374
OGR	27	329

The disparity of electronic-engineering needs between the three reactors is easily explained. The ORR, being a high-flux reactor with all of the attendant xenon problems, cannot tolerate frequent shutdowns. To avoid unnecessary shutdowns, a program of preventive maintenance has been developed and is still being improved. After the reactor has been operated for a number of years, these engineering requirements should decrease.

III. OPERATING PROCEDURES, THEIR DEVELOPMENT AND REVISION

A. The Need for Procedures

Operation of the research reactors is continuous; 24 hours a day, seven days per week. Jobs must often be passed from shift to shift, and a system of unambiguous communication is necessary to ensure that every supervisor has the necessary information. Also, reactor operation is accompanied by all the normal industrial hazards. Coupled with these are the problems of radiation, contamination, and criticality. Furthermore, it is usually important that the reactors be operated at full power as much of the time as possible.

B. Description of Procedures

1. Published Procedures

In order to ensure that the operation of the reactors is carried on in a well-regulated manner, arrangements must be made for providing the proper procedures and for revising them as needed. The operation of research reactors should be made as routine as possible so that the customers (the experimenters) can predict with some confidence the future conditions of the reactor. Well-developed procedures for operation help establish this routine and also help ensure safe operation. Because they are written for use by the reactor operators the procedures must (to some extent) be prepared in non-technical language. Procedures, aside from outlining the step-by-step operation, contain the following three categories of information:

1. Understandable reasons for the method of operation;
2. Special hazards, if any; and
3. References to descriptive material, blueprints, etc.

The operating manual for the Oak Ridge Research Reactor[9] is divided into the following sections:

a. Operating Procedures,

b. Instrumentation and Control,

c. Fuels and Refueling,

d. Research,

e. ORR Water Cooling System,

f. Special Procedures,

g. Emergency Procedures, and

h. Records.

In Appendix I there is a brief description of each section.

2. Procedure Changes

With new reactors many special procedures must be developed in addition to those prepared at the time of initial startup. Table 7 shows the number of procedures and procedure revisions written for the ORR during each year from 1958, when the reactor first went critical, to the present. As would be expected, many new procedures were necessary during the first year. In September of 1960, the power level of the ORR was increased from 20 to 30 Mw. This caused an increase in the number of procedural changes in 1961. New procedures are needed for a variety of reasons including:

1. Design changes,
2. Desire to standardize certain procedures to increase safety,
3. Need for transferring operating responsibility from the technical staff employed during startup to the operating staff which includes many nontechnical reactor operators, and
4. New personnel taking over jobs perviously held by more experienced people.

Table 7. Number of New ORR Procedures Issued Per Year

Year	Number of New Procedures
1958	94
1959	57
1960	36
1961	57
1962 (through April)	9

As changes and additions to the procedure manual become necessary, they are issued as procedure memoranda, so called because they are written in a somewhat less formal manner than the procedures themselves and are not edited as carefully as the published procedures. Each procedure memorandum is issued separately, as needed, and is assigned a number, in series, for the reactor it concerns. Any supervisor may originate a procedure memorandum, but the reactor supervisor must review and approve all memoranda which affect his area. In addition, approval by the Reactor Operations Department Superintendent is required for all procedure memoranda issued within his department.

3. Checklists

The checklist is a special type of procedure. Usually those procedures chosen to be issued as checklists apply either to complex operations where mistakes cannot be tolerated or are for the purpose of checking important details of the operation. Some of the checklists, such as those used during reactor startup, are considered so important that the supervisor must complete the list himself. Most of the lists, however, are completed by a reactor operator and reviewed by the shift engineer.

Following is a list of the titles of the 13 checklists in use at the ORR (At the LITR there are 10; at the OGR, 5.):

1. Startup checklist,
2. Shutdown checklist,
3. Daily water system checks,
4. Weekly checks,
5. 12-8 shift daily checklist,
6. 8-4 shift daily checklist,
7. 4-12 shift daily checklist,
8. Daily instrument checklist,
9. North and south facilities,
10. Shim-rod removal checklist,
11. Shim-rod insertion checklist,
12. Experiment safety checklist, and
13. Beam-hole status checklist.

In Appendix II there is a set of the checklists for the ORR.

IV. DISTRIBUTION OF INTERNAL INFORMATION OF TEMPORARY IMPORTANCE

A. Needs for Temporary Information

As outlined under Manpower and Organization, many people are required in order to operate a reactor. Good distribution of information among personnel is, therefore, imperative. The supervisor must make his orders known and understood, and each person must, in turn, keep his supervisor informed about the progress of the work. Most of the knowledge transmitted during daily operation can be compared to news in a newspaper. It is useful, educational, and interesting at the time but usually not of continuing value. On the other hand, procedures as described above contain more lasting material. One might compare internal information to newspapers and procedure manuals to textbooks.

B. Methods for Communicating Internal Information

1. Logbooks

The basic method for keeping abreast of detailed information whether temporary or not is by use of logbooks. Such a book is kept for each reactor, and the daily work of the shifts is described in these books. The result is a minute history of the operation. Much of this passes into oblivion and is not used after the next day of operation; however, at times apparently useless observations, properly documented in the logbook, become most important in explaining an unusual occurrence. Categorizing the ORR logbook information under the following headings has been found to help the reader:

1. Operations,
2. Shutdowns,
3. Trouble,
4. Maintenance,
5. Service to research,
6. Routine checks
7. Irradiated samples, and
8. Miscellaneous.

Frequently, it is necessary to search through the logbook to find such things as the number of instrument failures, the number of times the reactor has been scrammed through human error, the extra hours of work for a special project, or exactly when some phenomenon occurred. To facilitate searches of this type, it is helpful to have the material of the log divided into general categories.

2. Operating Instructions

Instructions to shift crews are written on a form provided for this purpose and titled Operating Instructions. Operating instructions are conspicuously posted in each of the reactor control rooms. They are among the first items to be examined when the shift supervisor comes on duty. For clarity and emphasis these instructions are typed if possible.

3. Experiment Information Sheet

As outlined in Section IIC, the Operations Division does not have responsibility for operating experiments. Most reactor experiments at ORNL are provided with instruments which make continuous surveillance unnecessary; however, certain experiments may require constant attention. It is important that the experimenter and the Reactor Operations Department have procedures detailing the action required under various conditions. Experiment Information Sheets are used for this purpose and a compilation of these sheets is kept in each control room.

4. Sample Scheduling

Target materials for exposure in the ORR on a short-term basis (usually in the hydraulic tubes) are delivered to the day foreman who assigns them a serial number and has this number inscribed on the specimen container. An individual specimen sheet is filled out giving complete information for the insertion and removal. These sheets are consulted at the beginning of each shift by the shift engineer or the shift foreman as they begin planning the work of their shift.

5. Shutdown Schedules

During shutdowns it is sometimes necessary to accomplish a great many tasks that can only be done during this period and have therefore accumulated since the last one. For all scheduled shutdowns, the reactor supervisor prepares a detailed schedule of the work to be done, including the tests required to assure that the work was properly done.

V. ADMINISTRATIVE CONTROL OF SAFETY

A. Reactor Safety

Accidents that occur in nuclear installations usually receive more attention than those that happen in other industries. Table 8 contrasts the safety records of the AEC contractors and of the chemical industry.

Table 8. Safety Record Compairson for 1950-1960

Organization	Disabling Injuries Per 1,000,000 Manhours	Days Lost Due to Injuries Per 1,000,000 Manhours
Chemical Industry	3.53	528
Union Carbide Corporation	2.10	429
AEC Production	1.13	178
AEC Research	1.86	274
ORNL	1.07	113

It is evident that all AEC work has a better safety record than that of the Union Carbide Corporation which is considerably better than the chemical industry of which the corporation is a part. It is significant that over its 19 year operating history the ORNL record contains no incident of a lost time accident for nuclear cuases.

Even with this enviable safety record, reactor safety must continue to be one of the important problems of operation. There are four parts to the problem:

1. Proper selection and design of safeguards,[1]
2. Detection of safeguard failures,
3. Checking of safeguards, and
4. Administration of the preceding three.

B. Administrative Support for Mechanical and Electronic Safeguards

Procedures for effecting reactor safety are well covered in "General Standards Guide for Reactor Experiments at ORNL"[1], "Personnel Exposure and Contamination Control in the Routine Operation of the ORNL Research Reactors"[2], and "Problems Encountered During Four Years of ORR Operation"[8]. The final list of all the procedures, checklists, training manuals, safety reviews, safety reports, etc., is impressive; but these alone do not ensure safety. People must read, understand, and follow the principles, rules, and directions that are contained in these documents. It is not possible for a supervisor to be absolutely certain that all operations are always performed correctly. The personnel who execute the tasks must be trained so that they understand and accept their responsibility.

An axiom of reactor operations is: A safeguard that cannot be tested is worse than none. For this reason a reliable system for performing such tests must be maintained. Administrative support helps guarantee that approved safeguards are properly employed and checked.

VI. COSTS OF REACTOR OPERATIONS

A. Simplified Descriptions of Various Types of Cost[10]

At the Oak Ridge National Laboratory, reactor operating costs include all direct and indirect costs associated with the routine maintenance and operation of the reactor. Costs of uranium, depreciation, and interest charges are not included, however.

Equipment items purchased in connection with reactor operations are customarily capitalized and are not charged to operating funds if they cost more than $100 and have an estimated life greater than one year. However, equipment which will be rendered unfit for other application by some result of their original usage is not capitalized. An example would be induced radioactivity or radioactive contamination of equipment.

B. Description of Operating Costs

1. Total Operating Costs for Reactor Operation Department

Table 9 summarizes the total operating costs of the ORR, LITR, and OGR for the year from September, 1960, through August, 1961.

Table 9. Reactor Operations Department Operating Cost

From September 1960, through August, 1961

	Oak Ridge Research Reactor	Low-Intensity Test Reactor	Oak Ridge Graphite Reactor
Labor	$420,000	$96,500	$118,300
Material	268,000	23,500	31,600
Overhead	286,000	65,100	79,500
Other	111,000	42,300	112,500
Total	$1,085,000	$227,400	$341,900

2. Breakdown of Operating Costs for the ORR

A more complete breakdown of ORR costs developed from the monthly operating costs reports is given in Table 10.

Table 10. Breakdown of ORR Costs:

September 1, 1960, through August 30, 1961

Labor			
Operating	$198,000		
Maintenance	200,000		
Other	22,000		
Total		$420,000	
Material			
Operating	168,000		
Maintenance	80,000		
Miscellaneous	20,000		
Total		$268,000	
Overhead		286,000	
Health Physics		23,000	
Worked Material		61,000	
Utilities		27,000	
Total			$1,085,000

Labor costs have been divided into the following categories: departmental or operating, maintenance (including mechanical, electrical, and instrument), and other or miscellaneous labor.

Material costs are those incurred in the performance of the labor outlined above. Maintenance material cost covers the normal wide variety of supplies required for any major maintenance work. Expense allocation or overhead costs are distributed as a percentage of the labor charged to the account. For the year considered that amount was approximately 64% of the labor costs.

Utilities include charges for electricity, water, and steam. The ORR is charged approximately $1000 a month for water at the rate of 13 cents per thousand gallons. All other utility costs are allocated to the ORR on the basis of labor costs.

Of the Health Physics costs, surveying and monitoring for radiation and radioactive contamination around the reactor accounts for 70% of the charges. Area monitoring, health physics laboratory analysis, and personnel monitoring, about evenly divided, make up the remaining 30% of ORR costs from this source.

The costs of fissionable-material accountability, equipment decontamination, demineralized water, and radioactive-waste disposal are collected under "Worked Material".

3. Variable Costs

Operating costs for a research reactor such as the ORR tend to be fairly constant. Fuel costs, however, are variable because fuel elements are purchased commercially in large numbers.

Another source of unusual costs occurs when equipment wears out or new developments and designs require replacement. Most of these variations in costs come from the maintenance of the reactor.

D. Distribution of Costs

1. Background

During the last 19 years of operation of research reactors at ORNL various systems of cost distribution have been devised. The first was based on reactor space, thermal-neutron flux, and reactivity effects of the experiment. In the beginning this was reasonable because most experiments at that time consisted mainly of irradiating an apparatus in the reactor. However, beam experiments did not have any effect on reactivity; and installations such as the thermal column used no reactor space, had no effect on reactivity, and had a flux much lower than the average for the reactor.

Next a method that was based on space and thermal-neutron flux was developed. For the LITR this system worked well until complex experiments requiring coolant and information leads were installed in the reactor. It soon became obvious that using only space and flux also resulted in inequities in cost distribution. The system finally developed for the ORR is more empirical than the initial methods.

2. ORR Cost-Distribution System

To make the ORR a highly versatile and adaptable reactor for use in experiments in basic science and engineering, many types of facilities were provided. All these facilities have been assigned relative cost units which are utilized to allocate costs to the experimenters. A close examination of units as shown in Table 12 reveals that there is a degree of relationship between space and the value of units for reactor facilities. There is no formula for arriving at this however. The beam holes and the pool facility occupy opposite sides of the reactor and have been assigned roughly equivalent cost units. This also applies for the other two sides--the large beam holes having the prefixes HN and HS. Core positions total 20 cost units which is less than the total for all facilities on the periphery. In addition to these units, there are those for the hydraulic tubes, reactor-tank ports, standpipes, and floor space. The hydraulic tubes occupy only one core position, but they use a reactor tank port and are operated by the department. Therefore, the cost units are higher than for a single core position. It was possible to provide only 10 exit ports in the top of the reactor tank for experiments which require continuous monitoring. Because of the short supply of the important type of facility and because the complicating factors introduced into the operation of the reactor by experiments of this type, extra charges are made for these ports. Standpipes are large 24-inch conduits which permit experimenters to have access to the ORR basement with loop cooling lines. Charges are made for the use of these standpipes for the same reasons that increase the cost to experimenters who use reactor tank ports. Around any reactor, floor space in the immediate vicinity of the reactor facilities is in high demand. Laboratories in the building have a somewhat lesser demand. Special facilities such as the counting room and the hot laboratory had a higher initial cost than offices and normal laboratories and therefore have higher cost units assigned to them.

This system has worked exceptionally well and has proven quite simple.

Table 12. ORR Cost Units

	Units for Each	Total		
Reactor Space				
20 Core positions	1.0	20		
HB-1, 2, 5, and 6 beam holes	2.0	8		
HB-3 and 4 beam holes	2.5	5		
HS large beam hole	7.0	7		
HN-1 and 4 beam holes	3.5	7		
HN-2 and 3 beam holes	0.5	1		
Pool Facility				
P-1, 2, 3, 7, 8, and 9	1.0	6		
P-4, 5, and 6	2.0	6		
Hydraulic Tubes (Including one reactor tank port and one core position)				
#1, #2, and #3	1.0	3		
#4	2.0	2		
Subtotal			65	
Reactor Tank Ports (Used for experiments having tubes connected to core positions)				
V-1, 3, 7, 8, and 9	0.5	2.5		
V-2, 5, 6, 10, and 11	1.0	5.0		
Subtotal			7.5	
Standpipes (Used for loop piping to equipment cubicles in basement)				
South	5.0	5		
North				
N-1, 2, 6 and 7	1.0	4		
N-3, 4, and 5	0.33	1		
Subtotal			10	
Floor Space				
8 (plus) Basement bays	0.5	4.05		
4 Beam-hole areas	0.25	1.00		
1 Beam-hole area (HB-2)	0.13	0.13		
1 Beam-hole area (HB-6)	0.5	0.50		
2 Large-facility areas	0.5	1.00		
1 Counting room	1.0	1.00		
1 Hot laboratory	1.0	1.00		
7.8 First-level bays	0.25	1.96		
12.5 Second- and third-level labs	0.25	3.15		
Subtotal			13.79	
Total				96.29

VII. ADMINISTRATIVE CONTROL OF RADIOACTIVE WASTE

A. Types of Radioactive Waste Produced at the ORR

Liquid radioactive wastes at the ORR are classed as: process waste and intermediate-level waste. Gaseous wastes are termed off-gas and cell ventilation.[12] Process-waste water may contain small amounts of radioactive contamination but has a possibility of becoming more contaminated. Intermediate-level-waste water is defined as having a concentration of less than ten curies per gallon but, in practice, that produced at the reactor averages about 10^{-4} of this value. Off-gas wastes may contain a large amount of contamination but volumes are low and the system pressure is quite negative. Cell ventilation, on the other hand, is characterized by small amounts of contamination and large volumes, at relatively low negative pressure.

Tables 13 and 14 show the estimates of the volumes of intermediate-level waste (sometimes called hot waste), process, and gaseous wastes produced by normal ORR operation. There are two designations for off-gas in Table 14, normal and pressurizable.[8] The pressurizable system is capable of containing gas at pressures up to 100 psid with respect to atmospheric pressure.

B. Control of Radioactive Wastes at the ORR

Primary control of radioactive wastes is exercised administratively. On a monthly basis a material balance between the measured total volume from the reactors and the estimated total volume from individual sources is made. Usually it is not possible to account completely for the measured total. If there is an urgent need to reduce volumes, a determined effort is made to identify all sources and to reduce the discharge from as many sources as possible. This is done by rechecking all of the tabulations

Table 13. Sources and Volumes of Radioactive Liquid Waste

Source	Volume gallons/month	
ORR Intermediate-Level Waste		
Degasifier effluent	22,000	
Demineralizer regeneration effluents	6,000	
Underwater saw purge	2,000	
Total		30,000
ORR Process Waste		
Water-sealed vacuum pump seal flow	130,000	
Demineralizer regeneration effluents	7,000	
HB-3 diffusion-pump coolant	302,000	
HB-1 diffusion-pump coolant	129,000	
Degasifier condenser coolant	130,000	
Miscellaneous[a]	2,130,000	
Total		2,828,000

[a]Unmeasured and unestimated amounts of water go into the process waste system from the following sources: corrosion test stand, HB-1, HB-6, HB-5, Loop No. 1, MSR Experiment, drinking fountains, wash basins, laboratory sink, welding machines, underground water seepage, air compressor, pump leakage, and Loop No. 2. Thus far it has not been necessary to go to the expense of obtaining accurate information on these flows.

Table 14. Radioactive Gaseous Waste

Source	Volume scfm	
ORR Cell Ventilation		
MSR Experiment equipment chamber	1,000	
B-9 Experiment equipment chamber	900	
Building ventilation vents	4,500	
Total		6,400
ORR Off-Gas, Normal[a]		
Loop No. 1	30	
P-6 (pool-side experiment)	< 1	
B-8 (in-reactor experiment)	< 1	
Beam holes	Unknown	
Total		~ 30

[a]Pressurizable off-gas system is not in service yet.

of volumes of waste and by sampling wherever possible. A multichannel analyzer is used for quick qualitative identification of the radionuclides. Samples are also submitted for a more quantitative analysis by beta counting.

In designing waste systems, it is important to include means for visually checking the flow at as many points as is economical. Also any new design should include sampling points and, in some cases, facilities should be provided for future installation of continuous monitoring systems for measuring flow and/or radioactivity. Since the volume and degree of contamination of radioactive waste dictates the stringency of control, it should be possible to completely stop any radioactive waste effluent if necessary. Furthermore, the designer of waste systems should remember that the established limits for disposal of wastes may be lowered and, thus, the system may require closer control in the future.

VII. SUMMARY

The administrative methods for the operation of ORNL research reactors necessarily apply to those specific reactors. There is enough similarity among reactors, however, that the principles of administrative control should be applicable on a broad scale. Many of the methods of administration of research reactors are similar to the approach for most types of operating organizations: a system of ideas is assembled for accomplishing the goals in a safe, efficient manner, and a staff which has the responsibility for attaining these goals is selected and trained.

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IX. APPENDIX 1

A. Description of ORR Procedures

The operating manual for the ORR is divided into eight sections:

Operating Procedures,

Instrumentation and Control,

Fuels and Refueling,

Research,

ORR Water-Cooling System,

Special Procedures,

Emergency Procedures, and

Records.

1. Operating Procedures

In a detailed, step-by-step manner, procedures for reactor start-up, shut-down, and steady-state operation are given. Responsibilities and hazards are outlined and specific instructions are given for special startups such as those following a fuel reloading and those following a shutdown due to an accidental dropping of the shim rods. Also, detailed information is given for shutting the reactor down and for disassembling the reactor for shutdown work. The system for reporting accidental shutdowns is described. Duties of the operating crews are outlined giving proper instruction for heat-power calculation, adjustment of instruments, and procedures for continuous operation.

2. Instrumentation and Control

All the reactor instrumentation is explained in enough detail that the operating crew can detect malfunctions as well as use the instruments in the operation of the reactor. Separate detailed maintenance manuals are prepared for the maintenance staff.

3. Fuels and Refueling

Handling and storage rules and procedures are included along with methods for reloading the core.

4. Research

Procedures for the routine operations connected with research facilities are found in this section. Also covered here are the tasks to be performed for the isotope production program.

5. ORR Water Cooling System

Complete information for the operation of the reactor and pool primary and secondary water systems and the reactor and pool demineralizers is given.

6. Special Procedures

Procedures for such jobs as working in the ORR pool, detecting water leaks at large facilities, and operation of the pneumatic doors and air conditioning systems are included.

7. Emergency Procedures

Operation of the emergency power and ventilation systems is explained. The equipment provided for "after-heat" protection is described, and procedures for operation are given. Emergency evacuation procedures also appear in this section.

8. Records

A complete description of each data sheet is given along with instructions and procedures for their use.

X. APPENDIX 2

A. ORR Checklists

A set of 13 ORR checklists is included in this appendix.

CHECK LIST 1

NOTE: Person making startup checks initial each check after completion.

	Date							
A. Tank Area								
1. All core pieces in place and properly seated.								
2. Experiments properly arranged in reactor tank.								
3. Hold-down arms properly seated and locked.								
4. All work in core completed and final inspection made.								
5. Access cover replaced and bolted down.								
B. Experimental Facilities (At start of cycle)								
1. All experimental changes completed.								
2. Experimental information sheets completed.								
3. Individual experiments safety check sheets completed by instrument engineers.								
C. Water Systems								
1. Reactor pool filled to proper level.								
2. All pool alarms cleared.								
3. Pool circulating system ready for service.								
4. Pool demineralizer in service.								
5. Reactor system filled and vented.								
6. Reactor water flow established.								
7. Degasifier in service.								
8. Reactor demineralizer in service.								
9. Both secondary coolant loops filled, treated, and ready for service.								
10. Flow through bypass filters.								

11. Reactor primary bypass valve system in automatic and temperature setpoint established. ____ ____ ____ ____ ____ ____ ____ ____

12. Reactor secondary system in automatic; temperature setpoint established. ____ ____ ____ ____ ____ ____ ____ ____

13. Cooling water to horizontal beam holes (refer to status sheet). ____ ____ ____ ____ ____ ____ ____ ____

14. Cooling water to north facility. ____ ____ ____ ____ ____ ____ ____ ____

15. Cooling water to south facility. ____ ____ ____ ____ ____ ____ ____ ____

16. Subpile room:
    --Demineralized water supply to drive seals. ____ ____ ____ ____ ____ ____ ____ ____

    --Demineralized water supply to annulus of bottom plug. ____ ____ ____ ____ ____ ____ ____ ____

    --Demineralized water supply to fission chamber. ____ ____ ____ ____ ____ ____ ____ ____

    --Servo tachometer plug connected to servo rod drive motor. ____ ____ ____ ____ ____ ____ ____ ____

D. <u>Instrumentation Checks</u> (*Before start of cycle)

1. All utility services in order:
    --Power circuits L-31 through L-38 plus L-39 and L-41; located in front power cabinet. ____ ____ ____ ____ ____ ____ ____ ____

    --LX-1 through LX-6; located in front power cabinet. ____ ____ ____ ____ ____ ____ ____ ____

    --L-1 through L-12 plus L-14 and L-16; located in rear power cabinet. ____ ____ ____ ____ ____ ____ ____ ____

    --Air supply. ____ ____ ____ ____ ____ ____ ____ ____

2. All nuclear instruments turned on at least 1/2 hour prior to operation of the reactor. ____ ____ ____ ____ ____ ____ ____ ____

3. Ionization chamber positions. Check log book for any movement during shutdown. ____ ____ ____ ____ ____ ____ ____ ____

4. Log N calibrated and set on "operate". ____ ____ ____ ____ ____ ____ ____ ____

*5. Safety channels #1, #2, and #3 calibrated. ____ ____ ____ ____ ____ ____ ____ ____

*6. CRM calibrated by recorder and set on "USE". ____ ____ ____ ____ ____ ____ ____ ____

*7.	Rod-drive raise test performed following any work on the drive units.								
*8.	Magnet drop current checked and adjusted properly.								
9.	Rods raised off seat positions and scrammed with the Jordan button on each of the three sigma amplifiers in turn.								
10.	Step 9 repeated but rods scrammed with Log N amplifier by turning switch from "Operate" to "HI Calibrate". (Reset to "Operate" position.)								
*11.	Check any one experiment scram to insure rods drop.								
12.	Air monitors "Normal".								
13.	$\mu\mu$ ammeter range switch set properly.								
14.	$\mu\mu$ ammeter set on "Recorder".								
15.	PA system operating properly.								
16.	All instrument channels working properly and corresponding recorders tracking.								

E. Other Checks

1.	Next cycle power schedule reviewed and understood.								
2.	Both water activity electrometers operating. (Also common power supply)								
3.	Scrubber checked and operative.								
4.	Establish flow in the hydraulic tubes.								
5.	Ten-minute prestartup warning issued over PA system.								
6.	At 5 Mw inspect the core through the porthole for obstructions.								

F. Shielding Checks

/

*1. HB-1 through HB-5 shield blocks in place.	____ ____ ____ ____ ____ ____ ____ ____
*2. HB-6 shield closed and key in possession of Operations.	____ ____ ____ ____ ____ ____ ____ ____
3. HN shielding in place.	____ ____ ____ ____ ____ ____ ____ ____
4. HS shielding and monitrons in place and checked.	____ ____ ____ ____ ____ ____ ____ ____
5. Pipe chase closed.	____ ____ ____ ____ ____ ____ ____ ____

---

*Or collimator flooded with water valves locked open

G. Checks on Count Rate Channels

1. Pool side fission chamber inserted.	____ ____ ____ ____ ____ ____ ____ ____
2. Pool side count rate speaker activated and working.	____ ____ ____ ____ ____ ____ ____ ____

CHECK LIST 2

ORR SHUTDOWN CHECK LIST Date ___________

Initial

_______ 1. Scram handle in "scram" position.

_______ 2. Key switch in "off" and key removed.

_______ 3. All rods in seat position and seat lights "on".

_______ 4. All rod mode switches in "off" position.

_______ 5. Servo demand at N_L.

6. After 30-Mw operation:

_______ A. Continue normal circulation of reactor water for 30 minutes or until the temperature of the reactor water is equal to the pool temperature; i.e., 78°F < outlet temperature < 100°F.

_______ B. Complete the "test" on emergency cooling units (end-of-cycle shutdowns only).

_______ C. Unit #1 }
_______ Unit #2 } Check to determine that DC motors turn the pumps after AC motors are stopped.
_______ Unit #3 }

_______ D. Unit #1 }
_______ Unit #2 } "Charger-battery" disconnects closed.
_______ Unit #3 }

_______ E. Unit #1 }
_______ Unit #2 } "Battery-motor" disconnects opened.
_______ Unit #3 }

7. Reactor secondary loop.

_______ A. Fans in "off".

_______ B. Pumps in "off".

_______ C. Blow-down valves closed.

_______ D. Acid addition system "off".

8. Pool secondary loop.

_______ A. Fan in "off".

_______ B. Pump in "off".

_______ C. Blow-down valve closed.

_______ D. Acid addition in "off".

_______ 9. Main pumps "off".

_______ 10. Shutdown pump "on".

_______ 11. Main pump test blocks removed.

_______ 12. Channel #1 }
_______ Channel #2 } Log-N amplifiers on ground position.

_______ 13. Subpile fission chamber inserted to give 20 cps.

_______ 14. Pool-side fission chamber inserted to give 20 cps.

_______ 15. CRM speaker at pool-side activated.

CHECK LIST 3

Day ____________________

Operator ________________

ORR DAILY WATER SYSTEM CHECKS

Reactor System — Control Room | Pump House

Tank ΔP ________ psi. — Bypass filter flow (gpm) ________ ________

Tank top pressure __________ psi. — Primary flow (gpm) ________ ________

Facility cooling flow ______ gpm. — Reactor exit temp. °F ________ ________

North demineralizer flow ______ gpm, Integrator (   ) x (1.5) = ________gals.

South demineralizer flow ______ gpm, Integrator (   ) x (1.5) = ________gals.

Stringer ΔP (inlet) _________ - (exit)_________ = _________ psi.

Primary Pumps	#1	#2	#3	Shutdown	Emergency
Exit psi					
Inlet psi					
Motor amps					
Bearing temp. (North					
Bearing temp. (South					

Secondary mean temperature ____________°F — Pump exit (P156) _________ psi.

Return line (PI   ) _________psi.

Pool System

Primary flow __________ gpm — Secondary flow __________ gpm

Demineralizer (flow _________ gpm

Demineralizer (integrator (   ) x (1.8) = __________gals.

Recorded in Log Book

___ (Sump counts, demineralizer data,
(All main pump DC battery cells SpG read, lowest logged

TX-3080
(9-61)

Leak-Detector System for Large-Facility Plug

Inlet air press ________

Color of dryrite ________

Check for proper air purge through the beam-hole liner.____________

CHECK LIST 4

WEEKLY CHECKS

Check if "OK" Date ________________

_____ 1. Underwater lights check

_____ 2. Secondary system supplies, check and reorder

_____ 3. Pool tools check

4. "Teletalk" system check

_____ A. Room 307

_____ B. Room 305

_____ C. Room 303

_____ D. Room 301

_____ E. North side of pool

_____ F. South side of pool

_____ G. Health Physics Office

_____ H. Second floor, west end

_____ I. First floor, north

_____ J. First floor, south

_____ K. Subpile room

_____ L. Outside subpile room door

_____ M. Pipe tunnel

_____ N. Reactor pump house

_____ O. Reactor secondary pump house

_____ P. F-2 control room

_____ Q. Trane Coolers

(Clear contact must be established between the control and the point in question. The ability of the control room to contact each area should be tested as well as the reverse condition.)

5. PA system check

_____ A. Third level

_____ B. Second level

_____ C. Toilets in 3042 Building

_____ D. First level

_____ E. Basement

_____ F. Area outside northeast corner of building

_____ G. Pump house

_____ H. Storage tank area

_____ I. Reactor heat exchanger area

_____ J. Cooling tower area

(A man should be able to hear the PA clearly and distinctly in any and all of the locations listed.)

(Calls should be made from all Operations Division microphones.)

_____ 6. Run emergency gasoline pump one hour

_____ 7. Gas cylinder check

CHECK LIST NO. 5

12-8 SHIFT ORR DAILY CHECK SHEET

DATE	FILLED OUT BY						
	SATURDAY	SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
*Area checked for malfunctions							
*EMERGENCY POWER SYSTEM:							
a. Transfer mode switch in "normal"							
b. Diesel mode switch in "auto"							
c. Fuel Valve of diesel pointed West							
*Log and Clipboards checked for spec. assignments							
*Batteries on DC 1 and DC 2							
*Check sumps							
*Experiment checks where necessary							
*Demineralizer's pH and resistivities logged							
*Yellow hot cans emptied							
*Daily report for previous day complete							
*Building CAMs and monitors operating							
*All supplies checked							
*Cutie-pies and survey meters							
*Off gas water traps							
a. Blow down catch tank							
b. Fill seal tank							
*Storage tank level							
Reactor and pool secondary system readings logged							
Corrosion test experiment							
Degasifier in proper operation							
Cold traps, read and serviced							
Hyd. tube sample "in" and "out"							
Purge specified Beam Holes							

** To be performed during shutdowns*

UCN-2275A
(3 10-60)

CHECK LIST NO. 6

8-4 SHIFT ORR DAILY CHECK SHEET

DATE	FILLED OUT BY						
	FRIDAY	SATURDAY	SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY
*Area checked for malfunctions							
*EMERGENCY POWER SYSTEM:							
a. Transfer mode switch in "normal"							
b. Diesel mode switch in "auto"							
c. Fuel Valve of diesel pointed West							
*Log and Clipboards checked for spec. assignments							
*DC battery check made and Sp. G. taken							
*Check sumps							
*Experiment checks where necessary							
*Demineralizer -- Reactor							
In Use							
Ready TEST SCRUBBER PUMPS							
Being regenerated							
*Demineralizer -- Pool							
In Use							
Ready							
Being regenerated							
*Daily water system readings							
*Storage tank level							
*Supplies ordered or obtained							
*Radiation survey							
Pool and reactor secondary system readings logged							
Reactor "on" lights checked							
Corrosion experiment							
Degasifier in proper operation							
Check cold trap readings and service							
Hyd tube samples "in" and "out"							

** To be performed during shutdowns*

UCN-2275B
(3 10-60)

CHECK LIST NO. 7

4-12 SHIFT ORR DAILY CHECK SHEET

DATE	FILLED OUT BY						
	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY	MONDAY	TUESDAY
*Area checked for malfunctions							
*EMERGENCY POWER SYSTEM:							
a. Transfer mode switch in "normal"							
b. Diesel mode switch in "auto"							
c. Fuel Valve of diesel pointed West							
*Log and clipboards checked for spec. assignments							
*Batteries on DC #1 and DC # 2 Motors							
*Check sumps							
*Experiment checks where necessary							
*Demineralizer's pH and resistivities logged							
*Third floor level straightened up							
*Weekly Checks							
*Storage tank level							
*Equipment placed in cabinets where possible							
GASOLINE DRIVEN EMERGENCY PUMP:							
a. Motor run for 5 minutes							
b. Check level in gas tank							
c. Check radiator water level							
d. Check oil level							
e. Check water level in batteries							
f. Valve on pump opened to bleed off air							
Pool and Reactor sec. system readings logged							
All flashlights in control room and operating							
Corrosion experiment							
Degasifier in proper operation							
Check cold trap readings and service							
Hyd tube samples "in" and "out"							

* *To be performed during shutdowns*

UCN-2278
(3 10-60)

CHECK LIST 8

DAILY ROUTINE INSTRUMENT CHECK LIST FOR ORR

Date ______________________________

Instrument Technician ________________

Shift Engineer ______________________

Power Level __________________________ Mw   Charts on All Recorders ________

Check Standard Motors, Model H ______________   Ink on All Recorders ____________

Check Batteries __________________________

	1	2	3	4	5	6	
Magnet Amplifiers							A / B
Magnet Current							

PA System __________________________   Sound Powered Phones ______________

Gamma Chambers:

NE __________

SE __________

Log N Channel No. ______________   Percent Power ______________

Sigma Amplifiers	No. 1 Safety	No. 2 Safety	No. 3 Safety	Period
Heater Cathode Short				
B + Unregulated				
B + Regulated				
B + Current				
Power				

Condition of Trouble Monitors ____

____

Remarks ____

____

____

____

CHECK LIST NO. 9

ORR NORTH AND SOUTH FACILITIES

Check List for Filling and Draining- - Use with ORR Memo No. 59 (Rev. October, 1960)

DATE	TIME	SUPERVISOR

Facility to be drained: ☐ North ☐ South ☐ Both

- ☐ Main pump test blocks pulled
- ☐ Pump switches tagged
- ☐ Cut off facility cooling pump and valve shut
- ☐ H. P. or monitron above tank
- ☐ Operator at poolside

DRAIN NORTH FACILITY	DRAIN SOUTH FACILITY ANNULUS
☐ Fill valves S-730 and S-750 closed	☐ Fill valve N-1 closed
☐ Fill valve N-1 closed	☐ Fill valves S-730 and S-750 closed
☐ Grinnel valve 303 closed	☐ Grinnel valve 303 closed
☐ North Hoke vent valve open	☐ South vent valve and Hoke valve open
☐ Drain valve N-2 open	☐ Annulus drain valve S-706 open
☐ Drain valve N-3 open	☐ Plug drain valve S-707 closed, locked
☐ Restart facility pump for demineralizer	☐ Restart facility pump for demineralizer
OPERATOR	OPERATOR
SUPERVISOR	SUPERVISOR

FILLING THE FACILITIES

- ☐ Drain valves N-2 and N-3 closed
- ☐ Drain valves S-706 and S-707 closed and locked
- ☐ Grinnel valve 303 open
- ☐ Fill valve N-1 open
- ☐ Fill valves S-703 and S-750 open
- ☐ Valve facility pump open and restart pump
- ☐ Adjust south facility flow per MSR
- ☐ Close vent valves

South facility flow ______________ gpm

North facility flow ______________ gpm

OPERATOR

SUPERVISOR

UCN-2342
(3 10-60)

CHECK LIST 10

Shim Rod Removal Check List

In preparation for this operation, the necessary tools should be checked, balcony cleared and roped off, the procedure for rod transfers (1.3.3f) reviewed, etc. Shift engineers must closely supervise all parts of operation and initial at completion of operation.

____ 1. Assure that all seat lights are showing, and that drives are near lower limit and drive unit is in locked position. Assure that magnet current is off. Seat switch actuating lever should be checked to assure that the shim rod is actually resting on the seat switch actuating rod.

____ 2. Raise both hold-down arms by catching bail of arm with a hook and tilting the arm east.

____ 3. Remove the 4 fuel elements immediately (N, S, E, W) adjacent to the rod or rods to be moved. (This insures subcriticality.)

____ 4. Position bridge above core, winch on bridge above rod, with cable directly over rod.

____ 5. Unlock safety hook and lower into tank. Engage fuel hook in round locking pin eye.

____ 6. Lower safety hook to rod and engage in rod handle. Lock hook by lifting safety pin eye slightly and rotating counterclockwise. Remove auxiliary fuel hook.

____ 7. Raise drives enough so that 3 reclutching prongs clear 3 studs. Unlock rod by rotating locking handle. Leave drive unlocked.

____ 8. Station a man to watch the count rate recorder. Raise rod slowly about 1 foot until sure rod is unlocked and free of the drive.

____ 9. Clear bridge and poolside of unnecessary people. Make certain bridge can be moved.

____ 10. Under radiation surveillance raise rod enough so that piston will clear top of tank. Move bridge west promptly, until rod can be lowered. Lower rod until radiation level tolerable. ________ maximum reading mr/hr.

____ 11. Identify rod.

____ 12. Move rod to storage location and place there.

____ 13. Unhook from rod and complete transfer memo.

A rod that is replaced in core must be locked and checked by the crew putting it in the core.

Date ____________________ Engineer ____________________

Shift ____________________ Rods Moved ____________________

TX-2764
(2-61)

CHECK LIST 11

Shim Rod Insertion Check List

In preparation for this operation, make sure the necessary tools are checked and available, the balcony cleared and roped off, the procedure for rod transfer (1.3.3f) reviewed, etc. Shift engineers must closely supervise all parts of operation and initial at completion of operation.

____ 1. Assure that the 4 fuel elements (N, S, E, W) immediately adjacent to the rod have been removed, the rod drive is unlocked and near lower limit, the hold-down arms are raised.

____ 2. Place shim-rod winch on bridge, so cable will be directly over the future position of the rod.

3. (a) Applies to irradiated rods.

____ (1) Unlock safety hook and lower to rod. Engage in rod. Lock by lifting and turning latch eye counterclockwise.

____ (2) Under radiation surveillance raise the rod from storage location. Identify rod.

____ (3) Move bridge eastward. When near tank, raise rod under radiation surveillance enough to clear tank top. Immediately lower rod when above access flange until radiation subsides. Maximum reading ________ mr/hr.

(b) Applies to unirradiated rods.

____ (1) Assure that rod is secure in the carrier.

____ (2) Engage locking hook of winch on rod and thread the special wire choker through the shim rod. Attach choker to crane hook and lift unit to vertical position. Remove carrier.

____ (3) Raise rod, move over pool, and lower into water until winch supports the rod.

____ (4) Remove the wire choker.

____ 4. Position bridge so that rod is directly above the core position it will go in. Station a man to watch the count rate recorder while lowering rod.

____ 5. Engage a fuel hook in the eye on the back of the hook to keep the rod from twisting while entering lower grid. The rod must hang vertically.

____ 6. When the rod has entered the lower bearing properly, take the fuel hook off the safety hook. Continue lowering slowly until the rod is down and cable slacked. A seat light will show if drive was truly unlocked.

____ 7. Send an operator to subpile room to lock the drive by rotating the locking handle.

____ 8. The locking of the rod must be checked by lifting up gently on the rod with the winch. A small upward movement will indicate the rod is free to move between seat and cross. If the upward movement is not stopped by the cross, the rod is free and must yet be locked.

____ 9. An additional check can be made by raising the drive 5 inches and noting that the rod now can be raised some 5 inches also. Run drives back down, and assure that rod can no longer be raised.

____ 10. Unlock safety hook from rod and remove.

Other fuel or rod movements may now be made.

A ROD THAT IS REPLACED IN CORE MUST BE LOCKED AND CHECKED BY THE CREW PUTTING IT IN THE CORE.

Date ____________________ Engineer ____________________

Shift ____________________ Rods Moved and Checked ____________________

CHECK LIST NO. 12
EXPERIMENT SAFETY CHECK SHEET

EXPERIMENT	CHECKED BY
REACTOR & FACILITY	DATE CHECKED

INSTRUMENTATION

INSTRUMENT IDENTIFICATION	PROPERTY MONITORED	TRIP POINTS			BATTERY CONDITION	COMMENTS
		ALARM	SETBACK	SCRAM		

CHECK LIST 13

BEAM HOLE STATUS SHEET

Oak Ridge Research Reactor

Date	Shift	*HB-1		*HB-2		*HB-3		*HB-4		*HB-5		*HB-6	
		Plug	Liner	Plug	Liner	Plug	Liner	Plug	Liner	Plug	Liner	Plug	Liner

*Indicate status: Ex. H_2O, He, MT, etc.

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