APAE No. 36

THE ALCO PRODUCTS INC. CRITICALITY FACILITY

DESCRIPTION AND OPERATION

ALCO

ALCO PRODUCTS, INC.
POST OFFICE BOX 414
SCHENECTADY, N. Y.

DISCLAIMER

APAE #36

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Description and Operation

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by

John W. Noaks

Alco Products, Inc.
Post Office Box 414
Schenectady, New York

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SUMMARY

The Alco Products Criticality Facility, site location, and operating procedures are described in detail, including the handling of fissionable material and the operating procedures for the safe performance of critical experiments.

ACKNOWLEDGEMENT

Chapter IV of this document is taken almost in its entirety from Alco Products, Inc. document APAE No. 5, "Hazards Summary Report on the Zero Power Experiments for the Army Package Power Reactor", by Dr. J. L. Meem.

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CHAPTER III - DESCRIPTION OF THE FACILITY

The Alco Products Criticality Facility is located on the bank of the Mohawk River within the confines of Alco Products, Inc., Schenectady, New York, Plant. Figure 1 is a photograph of the facility described in this chapter in detail.

A. Building Structure

Figure 2 describes the facility floor plan as an aid to the readers understanding of the following paragraphs.

Reactor Room

A reactor room 40 feet long, 30 feet wide, and 30 feet high is provided with walls of reinforced concrete. Concrete block outer walls on two sides of the building contain the supporting facilities. The reactor room, three sides of which consist of one foot reinforced normal concrete, is separated from the office, control room area, and men's room by three feet of reinforced normal concrete. The counting room is shielded by a total of five feet of concrete on the reactor room side, two feet of concrete on the adjacent sides and by a one foot concrete ceiling. The roof, with the exception of the portion above the counting room is of the steel deck type, with two inches of light-weight concrete for insulation and fire protection. On top of the concrete are laid five plys of felt, tarred between each ply and the final ply covered with gravel.

A stack extending to 50 feet above ground level is provided and contains a CWS filter for removing the small amount of fission products which might evolve from a maximum credible accident. Except for the stack, the reactor room is sealed during operation and will stand a pressure of four inches of water. Access is through an eight foot wide sealed sliding door for material and a three foot sealed personnel door in this material access door. The reactor may be viewed through a 2 feet by 3 feet, 3/8 inch safety glass window located adjacent to these doors.

The floors are constructed of poured concrete and are covered with asphalt tile laid in mastic. In the event that the floor becomes contaminated, this tile may be removed and replaced.

Approximately in the center of the reactor room is an opening 14-1/2 feet by 19-1/2 feet by 12 feet deep of which a section 9 feet by 14-1/2 feet is covered with a removable slab. This pit houses a 3500 gallon water storage tank, sump pump and associated plumbing.

A metal plate covered concrete trench extends from the pit, along the reactor room floor, under the three foot concrete wall, and to the control console in the control room as a runway for instrument cables. All cables are carried thru the three foot wall in sealed conduits. The conduits are embedded in the

Figure 1 - Criticality Facility

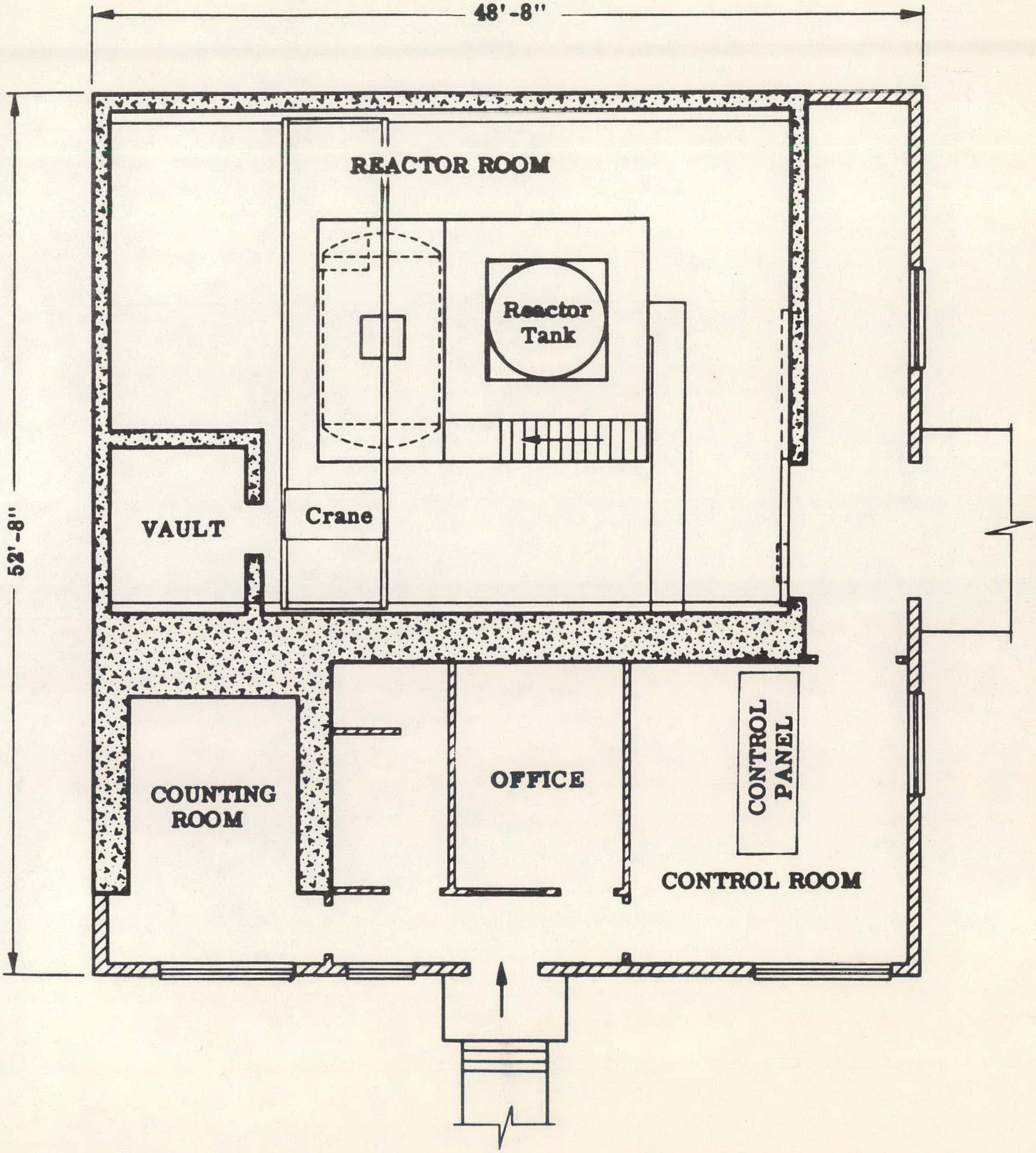

Figure 2 - Plan View of Building

plaster of paris sealing the trench on the reactor room side. This arrangement allows for future wiring replacements or alterations with minimum leakage probability.

All process plumbing entering or leaving the reactor room is valved and operating procedures require closure and locking of these valves prior to reactor operation.

Ventilation of the reactor room during normal shut-down periods is accomplished by fans with the access door open. A 7-1/2 ton dehumidifier maintains a relative humidity of less than 40%. The dehumidifier condensate is returned to the sump tank in the pit.

Heating is accomplished by two unit space heaters and wall finned tube radiators.

Security and fire protection is provided by proper placement of ultrasonic alarm units which are connected in series with the facility access doors.

Adjacent to the pit a terminal box is provided to accept control and power circuits entering the room in sealed conduits through the pit wall below floor level. In this manner the power leads and signal cables enter the room separately, the latter via the trench, to minimize A. C. interference.

A five ton capacity manually operated overhead crane is provided. Other equipment includes an air compressor in the pit, several tables and chairs for assembly work, storage racks for experimental equipment and miscellaneous supplies, scales, a vacuum cleaner, small tools, and CO_2 and Met-L-X fire extinguishers, and a small fan and C. W. S. filter assembly atop the vault for emergency clean up of reactor room air.

Source and Special Nuclear Material Vault

In one corner of the reactor room, an 8 by 10 foot S. S. storage vault is provided with walls, ceiling, and floor of 12 inches reinforced normal concrete. A Class B merchandise type vault door with one-half hour fire rating supplies the appropriate security closure. As additional fire protection, a two hour rated fire door is also provided. Ventilation is accomplished by forced convection with the door open.

Ultrasonic alarms are provided within the vault and in series with the other facility alarms.

A storage rack constructed of unistrut is mounted against one wall of the vault opposite the vault access door. Figure 3 is a photograph of the storage arrangement. For conservatism the storage conditions were calculated on the basis of contiguous 6 inch x 6 inch x 22 inch cells each lined with 0.005 inch cadmium sheet. If each of the 240 such cells (allowed against an 8 feet x 10 feet wall)

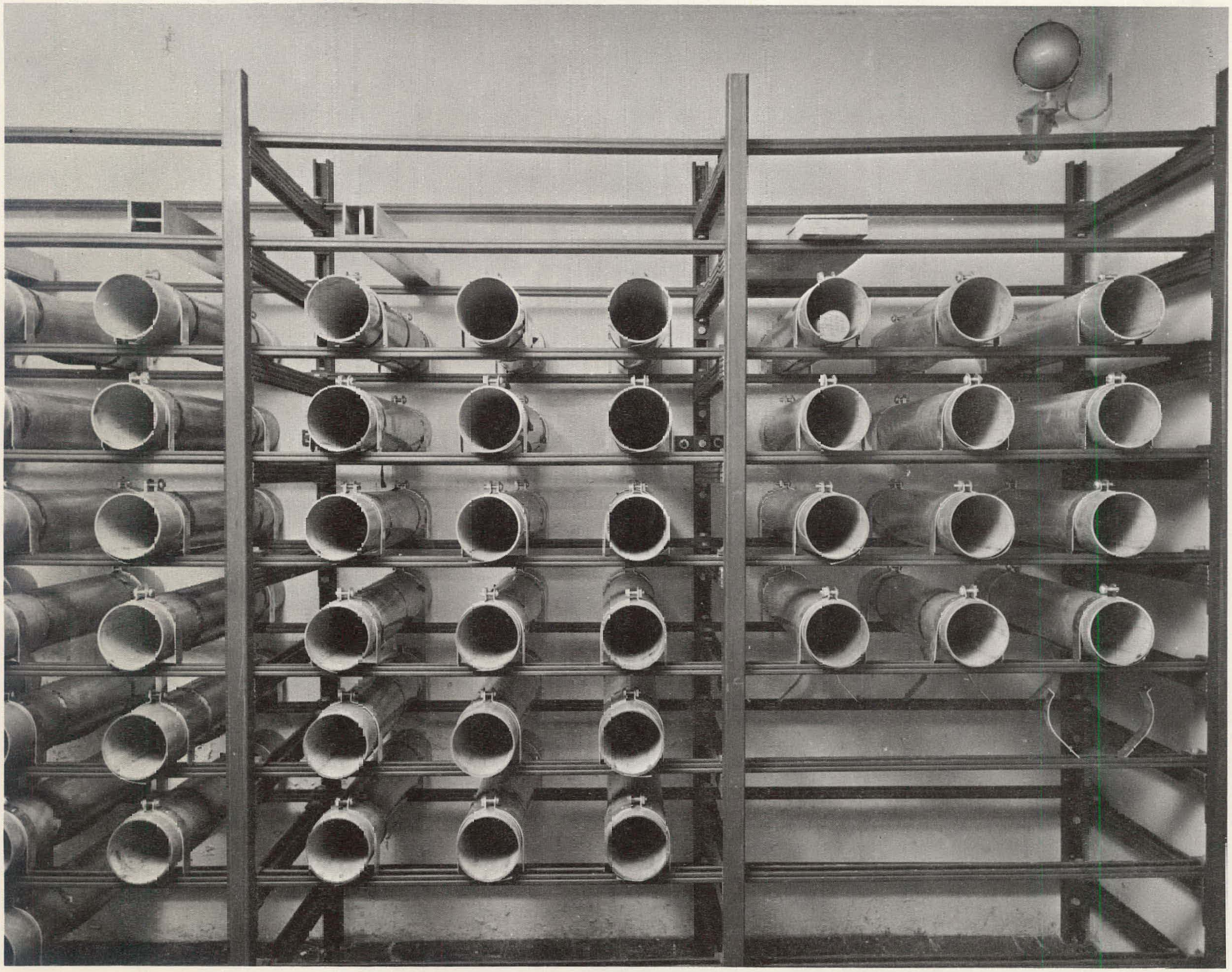

Figure 3 - Storage Vault

were filled with a homogeneous aqueous solution of 500 grams U_{235}, assuming the flooded condition, calculations for the thermal neutron group result in an infinite multiplication of about 0.90. The homogeneity of fuel introduces a major conservatism since fuel units will always involve self shielding factors and usually quantities of stainless steel and sometimes boron.

The actual storage conditions provided allow for uncertainties in calculation techniques. Stainless steel tubes 5 inches in diameter surrounded by 0.015 inches of cadmium metal are bolted to the unistrut frame in parallel rows. These rows are spaced 8.5 inches center to center with adjacent tubes on a given row spaced on 12 inch centers.

Assuming a storage of 500 grams U_{235} or equivalent per cell a total of 40.5 kilograms of U_{235} or equivalent may be safely stored, even under flooded conditions, in the present 81 cells. If future needs require closer spacing, calculations indicate a similar safe condition for cells on 6 inch centers.

Equipment Area and Facility Services

The equipment area is defined as the corridor parallel to the reactor room leading to the control room. Through this area process water and steam are supplied to the facility via a 1-1/2 inch pipe and a 3 inch steam line at 2 psig and 500 lbs per hour. Steam condensate is fed into the river and process wastes are contained within a septic tank of 500 gallon capacity.

A 3 phase, 440 volt line fed by a 2300 volt, 3 phase, 60 cycle transformer and main line from the plant power house bus supplies power to the facility. Purchase power is connected in parallel to the power house bus and carries the major plant services. In the event of purchase power failure the critical facility will continue to load the plant bus. A 30 KVA 440 V to 110 V transformer and a 5 KVA voltage regulator are provided to supply suitable power outlets.

Other equipment contained in this area includes circuit breakers for all equipment and outlets, a 400 cycle motor generator set, a water softener and miscellaneous equipment. A service truck door is provided directly opposite the access truck door to the reactor room.

Control Room

Figure 4 is a photograph of the control and counting rooms. Major features of the control room are the sealed instrument cable trench, an enclosed glass sight glass vented to the reactor room, the control console and the auxiliary electrical panel. The latter two items will be discussed in detail under Section E of this chapter. An Aerovane anemometer, mercury barometer, reactor room intercom, reactor "on" lights, fire alarms, and fire extinguishers are part of this rooms equipment. Supply cabinets, desks and chairs are provided.

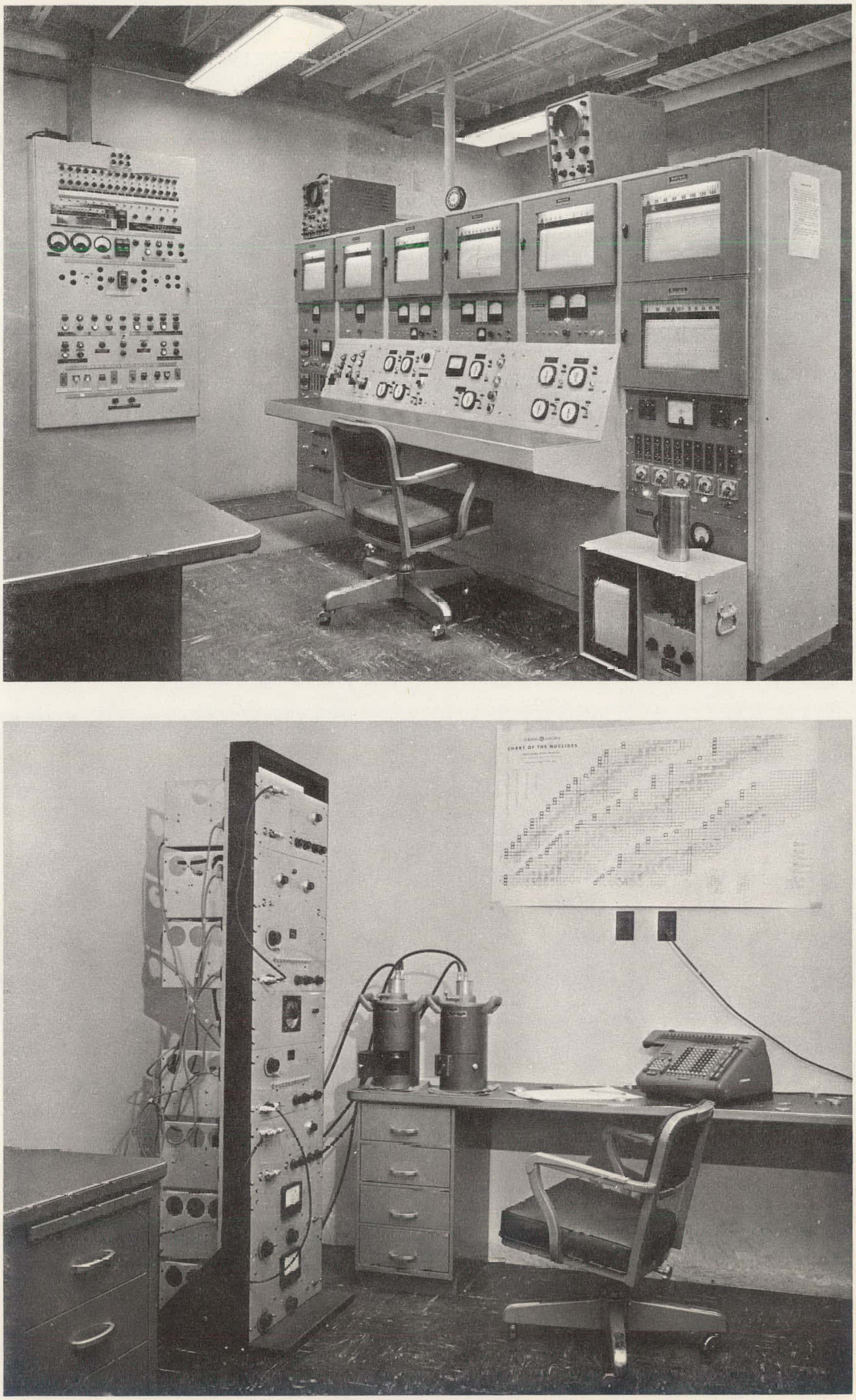

Figure 4 - Control Room - Counting Room

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Office Area

A small office is provided for the facility supervisor and contains combination safe files for classified material.

Men's Room

A janitors wash basin, personnel wash basin, W. C., and shower are provided. Five metal lockers contain personnel uncontaminated clothing.

Counting Room

The additional shielding for the counting room has already been described. This room contains counting equipment, a Mettler balance, desk space and cabinets.

Facility Access

The area around the facility is fenced in with access thru a gate between the facility and a guard house. Warning signs are located around the fenced area and a reactor "on" light is mounted over the entrance to the facility. Windows are of glass block construction.

B. Reactor Tank and Piping

The reactor tank, sump storage tank, pump, valves, and all system piping are of stainless steel. The reactor tank structure, Fig. 5, is mounted at floor level and supported by sturdy I beams bridging the reactor room pit. A welded steel catwalk structure and staircase provide access to the tank rim seven feet above floor level. The tank is constructed with an 84 inch I. D. and a center mounted lower extension of 27-1/2 inch I. D. and 65 inch depth hung from the tank floor. This extension is provided with lateral ports and blank flanges to allow for mounting of APPR-1 control rod drives and seals, in the APPR-1 control rod arrangement. Most experiments are conducted using the overhead drives, to be described, however with the experimental cores mounted about 18 inches above the tank floor, the tank extension often provides space for control rod guide shafts and bearings. The reactor tank capacity is about 2500 gallons.

The sump storage tank mounted horizontally and straped to the depressed section of the reactor room pit is 84 inches in diameter and 120 inches long. A covered man hole and several vent pipes are provided on the uppermost surface of the tank in addition to the feed and dump line ports. Connections to the tank are by flanged and welded fittings. The tank capacity is about 3500 gallons.

Figure 6 describes the piping and valving arrangement connecting the sump and reactor tanks to facility lines. The reactor tank may be dumped via a direct 6 inch line to the sump tank through a 6 inch butterfly-type gate valve.

Figure 5 - Reactor Tank Structure

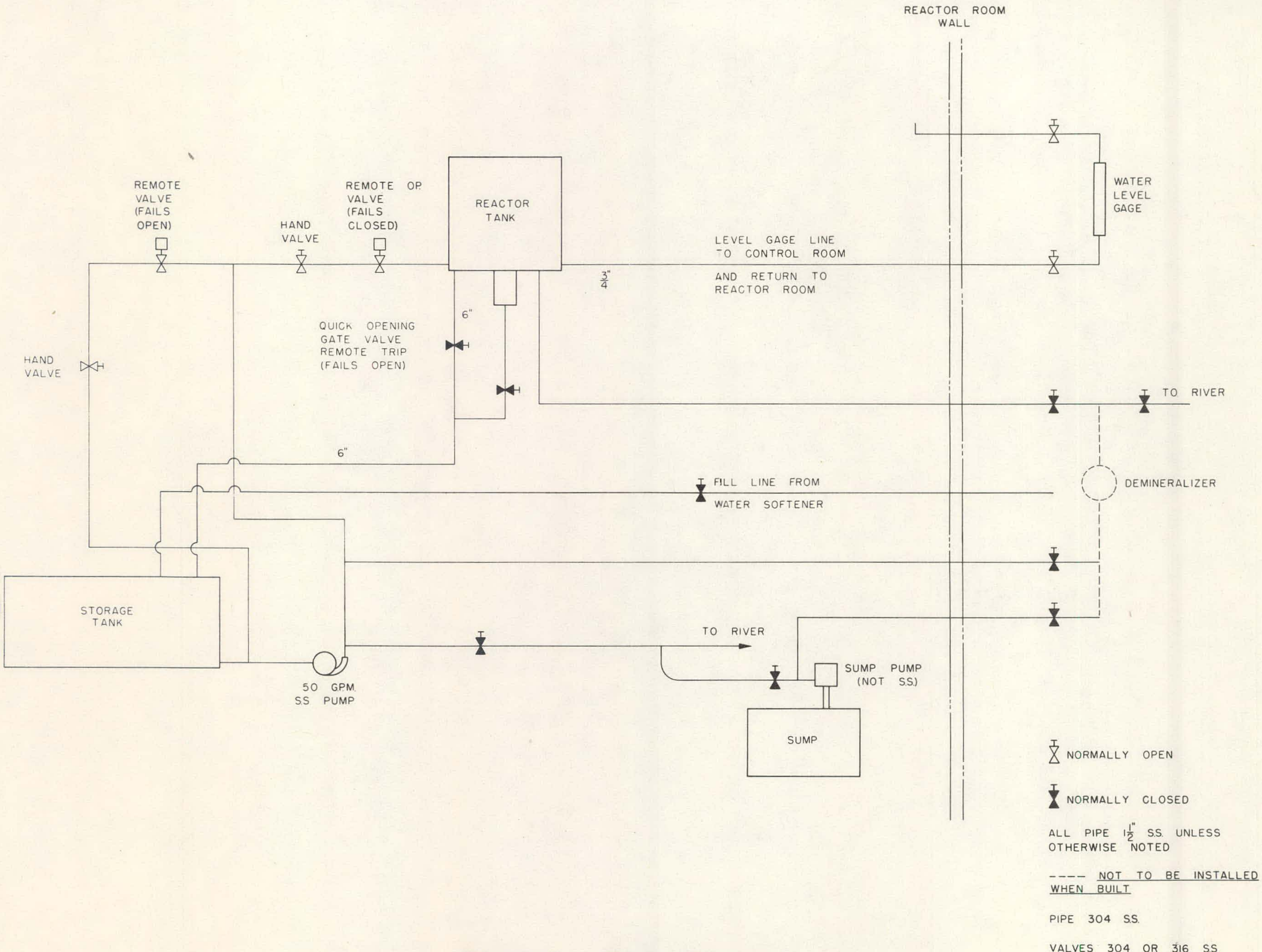

Figure 6 - Piping Diagram

The valve is held closed by compressed air fed through a three way Asco solenoid valve. Weights are provided to insure quick opening of this valve in the event that either air pressure or power to the solenoid fail. A 1-1/2 inch feed line from a 50 gpm pump supplies moderator to the reactor tank through a normally open manual gate valve in series with a pneumatic and solenoid operated valve which fails closed. A 1-1/2 inch pump by pass line is provided feeding through a normally open manually operated gate valve in series with a normally open pneumatic and solenoid operated valve which fails open. The normal feed rate of 50 gpm may be reduced, with optimum head conditions in the reactor tank, to 10 gpm by feeding with the by pass line open.

Several combinations of lines to the river are available and can be clearly observed in Fig. 6. The dotted lines denote future connections to a demineralizer if the need arises. The sight glass line to the control room is return vented to the reactor room. All lines leading to the river are locked to prevent inadvertant dumping to the river. A sump pump and valving arrangement is available in the event of minor flooding.

C. Control Rod Drives

The overhead control rod drives, seven in number, used at the facility are shown in Fig. 5, as mounted on the tank, and in detail in Fig. 7. The drives are supported by rigid cantilevers with three degrees of freedom to allow positioning of the rods at any point in the tank. Structurally, the drives are modelled after the APPR-1 drives and consist of a 1/20 H. P. motor, gear box, magnetic clutch, drive shaft, pinion gear, and control rod rack. A worm gear and travelling nut actuate upper and lower limit switches. Control rod position is determined by a pair of geared anti backlash synchomotors. The rod zero position is determined under tension to compensate for flexing of the supports. Several ball and socket joints connect the rack to the control rod proper to eliminate binding frictions due to minor misalignments. A dash pot assembly, not shown in Fig. 7, may be attached for use with light blade type rods. Heavy rods, such as those used in the APPR-1 reactor series, are provided with dash pot arrangements beneath the core proper and in line with the guide shaft and bearing assemblies.

Electrically the control rods operate on demand from the control room with power supplied to the magnetic clutches from the safety amplifiers. A minimum holding current is adjusted for each drive individually to minimize magnet decay time and therefore the rod droptime. This current is interrupted on receipt of any scram signal or on power failure.

D. Source and Source Drive

A neutron source of encapsulated Po-Be is used during reactor operation. Sources are purchased with emission rates of approximately 1×10^7 neutrons/second and are allowed to decay to about 5×10^4 neutrons/second before being replaced. The source is inserted into and withdrawn from the reactor via an attached 1/4 inch rod by means of a friction drive. In the withdrawn position the source is enclosed

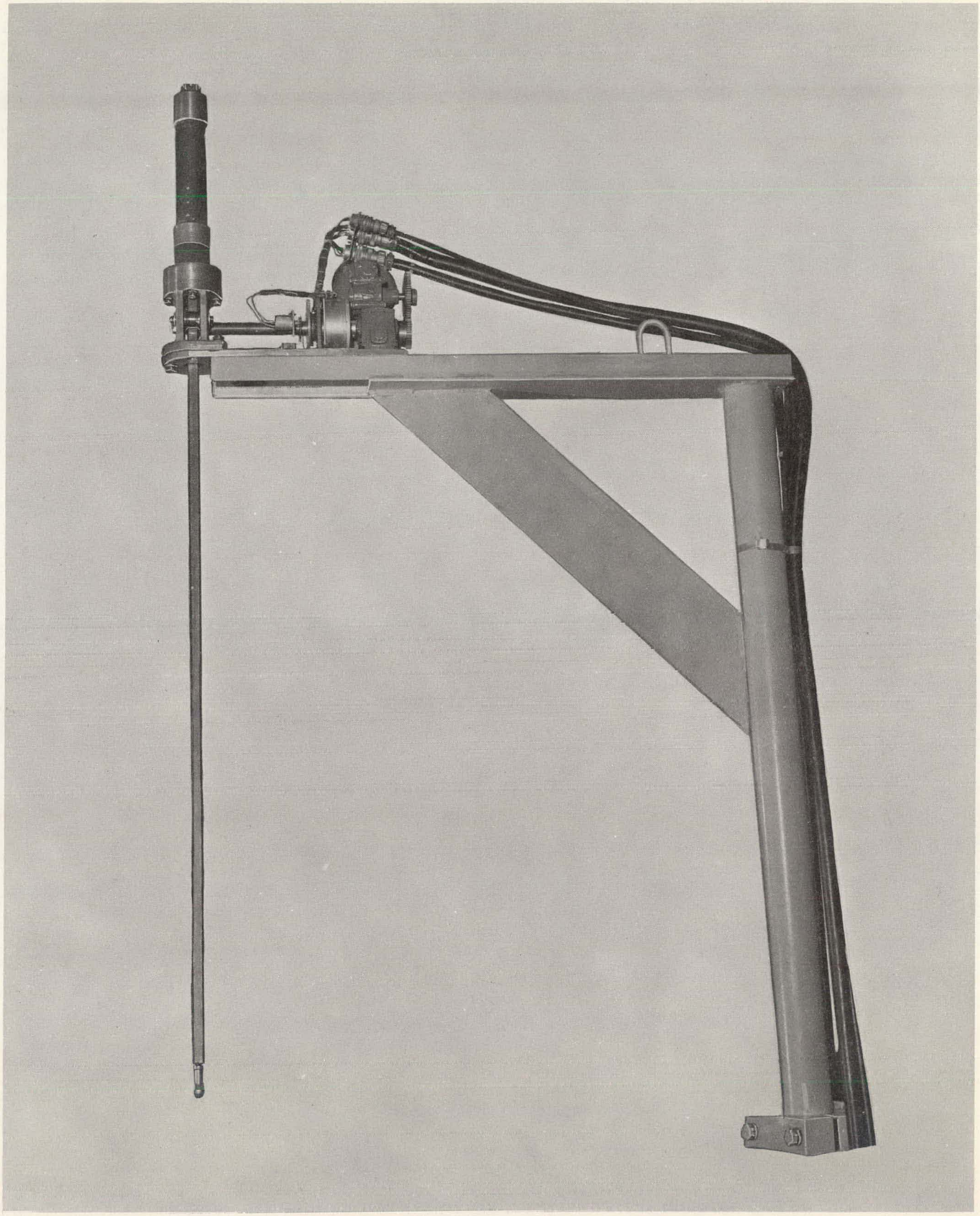

Figure 7 - Control Rod Drive

in a 6 inch x 8 inch paraffin block for shielding purposes. Limit switches and motor controls indicate the full in and full out positions of the source and conditions of motion. The entire source drive unit is mounted in a desirable location by means of unistrut structures mounted securely on the reactor tank rim.

E. Control Instrumentation

The facility control instrumentation is based upon a fail safe philosophy and multiple channel scram triggers. In this approach, the probability of a neutron level increase failing to cause scram is insignificantly small. Figure 8 presents a block diagram of the key control circuits.

Neutron Chambers

The neutron chambers are positioned within about one foot of the core face in water tight stainless steel tubes. These tubes are secured to the unistrut mounted on the reactor tank rim. Cables run directly from the chambers to amplifiers in the control room or, in the case of the BF_3 counters, to A1A preamplifiers on the reactor tank structure. Any given experiment is conducted with the following chambers in place:

1. One Westinghouse Fission Counter - WL6376.
2. One Nancy Wood triple BF_3 counter or one Westinghouse BF_3 counter - WL6307.
3. Four Westinghouse Compensated Ionization Chambers - WL6377.

The circuits fed by these chambers are described below.

Control Console

The control console located in the control room is the center for all nuclear control of the reactor.

1. Start up Channels - During all normal operations, in addition to initial multiplication approaches to criticality, the fission and BF_3 counters described above supply input signals to AID linear amplifiers. Power supplies, scalers, and log count rate meters complete the two channels. A signal is taken from one of these channels to provide an audible indication of the change in count rate in the control and reactor rooms.

2. Linear Control Circuits - Three Beckman V micromicroammeters receive their input signals from three WL-6377 chambers. These instruments are linear in nature with scale changes provided to cover a range of from 3×10^{-13} to 3×10^{-7} amps. Output currents proportional to the input signals to these instruments pass through dual transistor amplifiers. These intermediate amplifiers have in

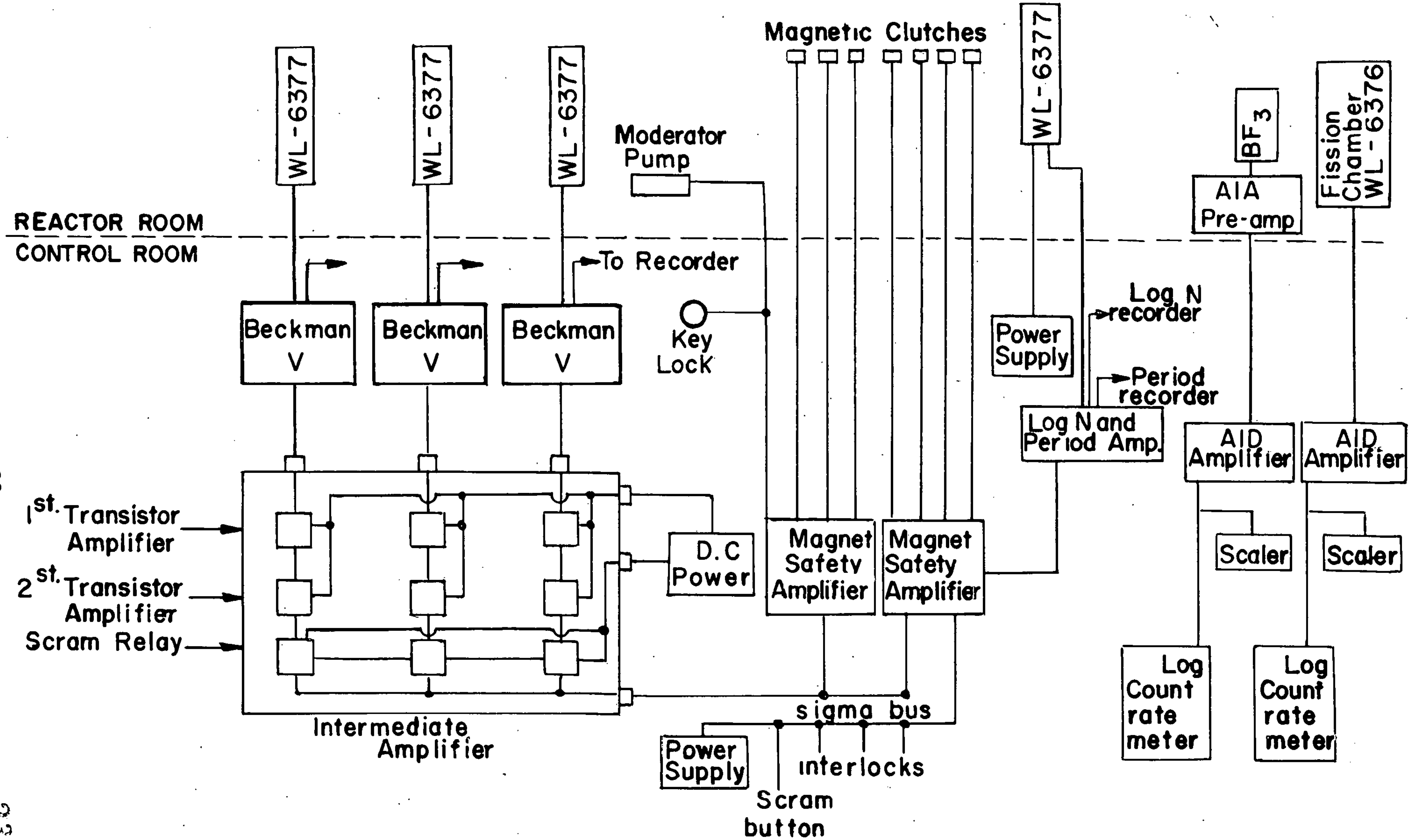

Figure 8 - Control Instrumentation

their output a hermetically sealed relay coil which is held closed during operation. The scram level is preset for any desireable percentage of full range effective for all of the twelve scales available on the Beckman V. When this scram point is reached the current level in the amplifier decreases and the scram relay opens causing the contacts of the relay to short circuit the input to the magnet safety amplifiers. The relays are operated in a sigma bus fashion whereby any one of the three can initiate a scram. On each relay double contacts are used to insure that there will be no failure due to frozen contacts. Fail safe relay operation and multiplicity of components minimizes the probability of scram failures.

The presence of an inherent transient while changing scales on the Beckman V instrument necessitates the depression of a momentary button by-passing the scram circuit. Each channel is independent in this regard also and the likelyhood of multiple failures at this point is therefore remote. Lights on each amplifier indicate a scram condition and also closed contacts on the by-pass button. A reset is also provided. All circuits are fail safe.

The Beckman V output is recorded on individual Brown Recorders.

3. Log N Control Circuit - One of the four WL-6377 chambers feeds a log N and period amplifier. Separate Brown Recorders and meters are provided for both functions. The range of this amplifier is 3 x 10^6 units of power. The WL-6377 chamber receives its power from a separate power supply.

A signal from the differentiating period circuit is fed directly to the magnet safety amplifiers and any period 5 seconds or shorter causes scram. Periods shorter than 15 seconds interrupt rod motions introducing reactivity by means of a back set switch built into the period recorder.

4. Magnet Safety Amplifier - The safety amplifier receives signals in the form of small currents from the linear intermediate and period amplifiers and supplies controlled currents to the magnetic clutch releases for the control rods.

The signal current passes through appropriate resistors and the voltage appears on the grid of a 5691 tube. Increasing signal causes the plate current of this tube to decrease. Under conditions of no signal, this plate current is approximately 3 milliamperes and energizes a drop-out relay. As the plate current is reduced to about 1 milliampere, the relay drops out. This relay drop-out, selected for its fail safe characteristic, initiates the "fast" scram action, so called because it can take place in less than five milliseconds.

The current for each magnetic clutch is controlled by a 6CD6GA tube. This is a simple pentode with the magnet as a plate load. The grid of the tube is controlled by the drop out relay, and when the relay opens, the grid is driven negative by about 60 volts, enough to cut off the magnet current completely.

For the utmost in safety, the circuits described above are not completely relied upon for scram. The second method or "slow" scram action consists of turning off the magnet power supply, and this method is used for manual scram. The slow scram is also actuated whenever a fast scram occurs, by interruption of the magnet power by a "slave" relay, which is opened by the drop-out relay.

The above paragraphs outline the essentials of operation of the safety amplifier. Actually, the 5691 tube is a double tube within the same envelope. The current from the sigma bus then drives two parallel amplifier stages, each of which controls a drop-out relay, and each drop-out relay in turn controls a slave relay for interrupting the magnet current. There are three linear channels and the period amplifier, any one of which can initiate a scram signal. If any one of the "drop-out" relays or any one of the "slave" relays is opened, current to all seven of the magnetic clutches is interrupted.

5. Other Console Control Features - Other operational features of the facility control console include coarse and fine control rod position indicators (sensitive to 0.002 inches), telephone spring type switches for individual rods and a single gang switch for control of a maximum of 5 rods, limit switches, scram and reset buttons, key locked reactor "on" and power switches, miscellaneous power supplies and a multi-point Jordan radiation monitor.

Auxiliary Control Panel

Mounted against the reactor room wall of the control room a control panel is provided for remote control of the following equipment:

1. Fast and slow fill and drain controls and lights for moderator control.

2. Key locked switch for optional automatic dumping of the moderator on any scram signal. This feature is always used when approaching criticality with the moderator controls.

3. Moderator dump and reset buttons.

4. Power circuit breakers.

5. 400 cycle MG set voltage, current, and frequency meters and push button control.

6. Source drive controls and limit switch lights.

7. Sump pump, agitator (used for maintaining uniform tank temperature during temperature coefficient runs), two 15KVA immersion heater, air compressor and unit heater fan controls.

F. Scram Provisions

All of the scram provisions provided control by means of rod drop and optional dumping of moderator via the 6 inch line previously described. Calibrations to date indicate a moderator dump rate of approximately one inch of moderator height every three seconds. Since normal operations involve approximately 8 inches of moderator above the active core, appreciable reductions in reactivity by this means commence about 25 seconds after scram. When approaching critical by moderator control, reactivity reduction is appreciated within two seconds after scram. Experimentally determined rod drop times for the APPR-1 type rods at the facility from the receipt of an increase in input signal, to the safety amplifiers, to drops of various distances are as follows:

Distance Dropped-inches	Time - seconds
1.0	$0.33 ^{+0}_{-0.1}$
3.0	$0.45 ^{+0}_{-0.1}$
11.0	$0.62 ^{+0}_{-0.1}$

1. Period Scram - scram is induced by any reactor periods of 5 seconds or shorter.

2. Linear Scram - scram is induced by power levels exceeding at most 95% of full scale on each scale of all three linear channels. On the basis of power level calibrations the chambers are positioned around the reactor such that 95% of the highest scale on each channel is less than 100 watts.

3. Scram Bus - scram is induced manually by push button control of either rods or moderator or both simultaneously. Interlocks provided that will induce scram if interrupted are:

   (a) Opening of either truck or personnel access doors to the reactor room.

   (b) Others as required.

G. Radiation Monitoring

A multi-point area monitoring system provides continuous indication of gamma radiation levels in and about the facility. Flashing light alarms indicate radiation levels in excess of from 10 to 100 mr per hour. Chambers are located in the reactor room pit, on both sides of the three foot wall separating the control and reactor rooms, and opposite the viewing window in the equipment area. Other chambers can be added as required.

Air in the reactor room is monitored routinely. In the event of an accident during reactor operation while the room is closed, the air will be decontaminated of particulate activity by recirculating it through an absolute filter of the C. W. S. type within the room. The room will remain closed until sampling indicates the particulate and gaseous activity has been removed or has decayed to tolerable concentrations. A minor amount of fission products could reach the atmosphere through the stack, but since the stack also contains a C. W. S. filter, the activity released is negligible.

Water accumulated in the storage tank is monitored for alpha and beta-gamma activity prior to release to the Mohawk River. No significant quantities of radioactive liquid wastes are anticipated under normal operating conditions. In the event a fuel element rupture is encountered, or the water otherwise becomes contaminated, it will be recirculated through a demineralizer until the concentration is reduced to accepted limits for discharge to the river. The resulting radioactive solid waste will either be stored safely until it has decayed to acceptable disposal levels (short-lived activity) or arrangements will be made to have the waste shipped according to applicable regulations to an acceptable burial ground (long-lived activity). Since the average power of operations is on the order of one watt, no significant buildup of long-lived activity is anticipated.

Beta-gamma monitoring of the facility stack with the mobile air monitor is routine. Portable alpha, beta, and gamma radiation instruments are available for survey purposes. Personnel radiation pencils and film badges and fixed film badges around the facility, fencing, and Maxon Road plant limits provide continuous information of area dose rates.

A high level gamma recorder is operating in the control room during all operations to record radiation excursions.

H. Accident Safeguards

The following serves as summary of all accident safeguards presently instituted at the facility.

1. Scram Provisions - Scram occurs on power level, short periods, loss of power, opening of reactor room doors, or component failure.

2. Interlocks - (a) Control Rod motion tending to increase reactivity is overridden by the switch positions demanding a decrease in reactivity. (b) Reactor "on" light is interlocked with the key

operated console power switch. (c) Failure of 400 cycle control rod syncho power prevents rod motion resulting in reactivity increases. (d) Others as required.

3. Radiation Monitoring - Portable survey meters, mobile air monitor, portable air monitor, high range gamma monitor, multipoint area monitor, film badges for personnel and area monitoring are provided and used routinely.

4. Control Philosophy - The basic philosophy of accident prevention centers about the employment of well trained, qualified, and careful operators; sound normal and emergency operation procedures (Chapters V and VI); maintained equipment; and careful "housekeeping".

5. Meteorological Data - Continual records of wind direction and velocity are provided by an Aerovane anemometer. Barometric pressure, temperature and humidity readings are also taken.

6. Fire Control - The location of several CO_2 and Met-L-X fire extinguishers throughout the facility and a fire alarm in series with the ultrasonic alarm protection provide adequate coverage.

7. Anti-Sabotage - Guard service at the facility during operation and ultrasonic alarming controlled from guard headquarters provides twenty four hour coverage. Several 1000 watt spot lights illuminate the facility grounds at night.

8. Waste Disposal - Moderator effluent to the Mohawk River is via locked valves keys to which are available to the facility supervisor or his designate only. All outgoing shipments of any kind are subject to plant health physics procedures.

9. Siren - A loud siren mounted atop the facility and controlled by a red switch in the control room provides audible warning of an incident.

CHAPTER IV - SITE CONSIDERATIONS

A. Location

The ALCO criticality facility was built at Schenectady, N. Y. within the boundries of the main Alco Products plant and bordering on the Mohawk River. The relationship of this location to the city of Schenectady and surrounding area is shown in Fig. 9.

The city of Schenectady is geographically situated in the eastern section of Schenectady County which has an area of 209 square miles. The Schenectady area is more generally considered to be the western boundry of a larger metropolitan area - the so-called Capitol District - composed chiefly of the cities of Albany, Troy, Watervliet, Rensselaer, Cohoes, and Schenectady. The center of this area is in the vicinity of the Albany Airport which is about 7 miles to the southeast of the proposed facility. The combined population of this metropolitan area is 415, 170 according to the 1950 U. S. Census.

Although small in area the city of Schenectady ranks high as a manufacturing center with many products used by the Government for defense purposes. Two industries, the General Electric Company and Alco Products, Inc. account for nearly all the manufacturing in the County. As an index of their importance to the economy and defense of the United States, it is reported that from June 1940 to December 1944 more than 2 billion dollars in war-supply contracts were awarded to concerns in Schenectady County.

Vital military installations in the immediate Schenectady area include the Air National Guard located at the Schenectady County Airport (2 miles to the north), the Scotia Naval Supply Depot, and the Voorheesville Army Supply Depot. The geographical relationship of these installations to the proposed facility site is indicated in Fig. 9. The Government owned Knolls Atomic Power Laboratory operated by the General Electric Company for the Atomic Energy Commission is also indicated. This installation is 3-1/2 miles east and 5-1/2 miles downstream of the proposed Alco facility.

Other points of interest indicated in Fig. 9 include the facts that the proposed site is one mile north-northeast of the commercial center of the city and about 3 miles downstream from the public Schenectady water supply. This supply is taken from drilled wells 56 - 70 feet deep near the Mohawk River in the vicinity of Lock 8.

The Schenectady urban area as defined by the U. S. Census Bureau includes the city, the village of Scotia, and parts of the towns of Colonie, Glenville, Niskayuna and Rotterdam. The total population of this area was 123, 273 in 1950. The average growth rate of the area over the past 10 years is approximately 1% per year. The distribution of this population around the proposed facility site is indicated in Fig. 10. The estimated total resident population within various distances of the proposed site is indicated in the following table.

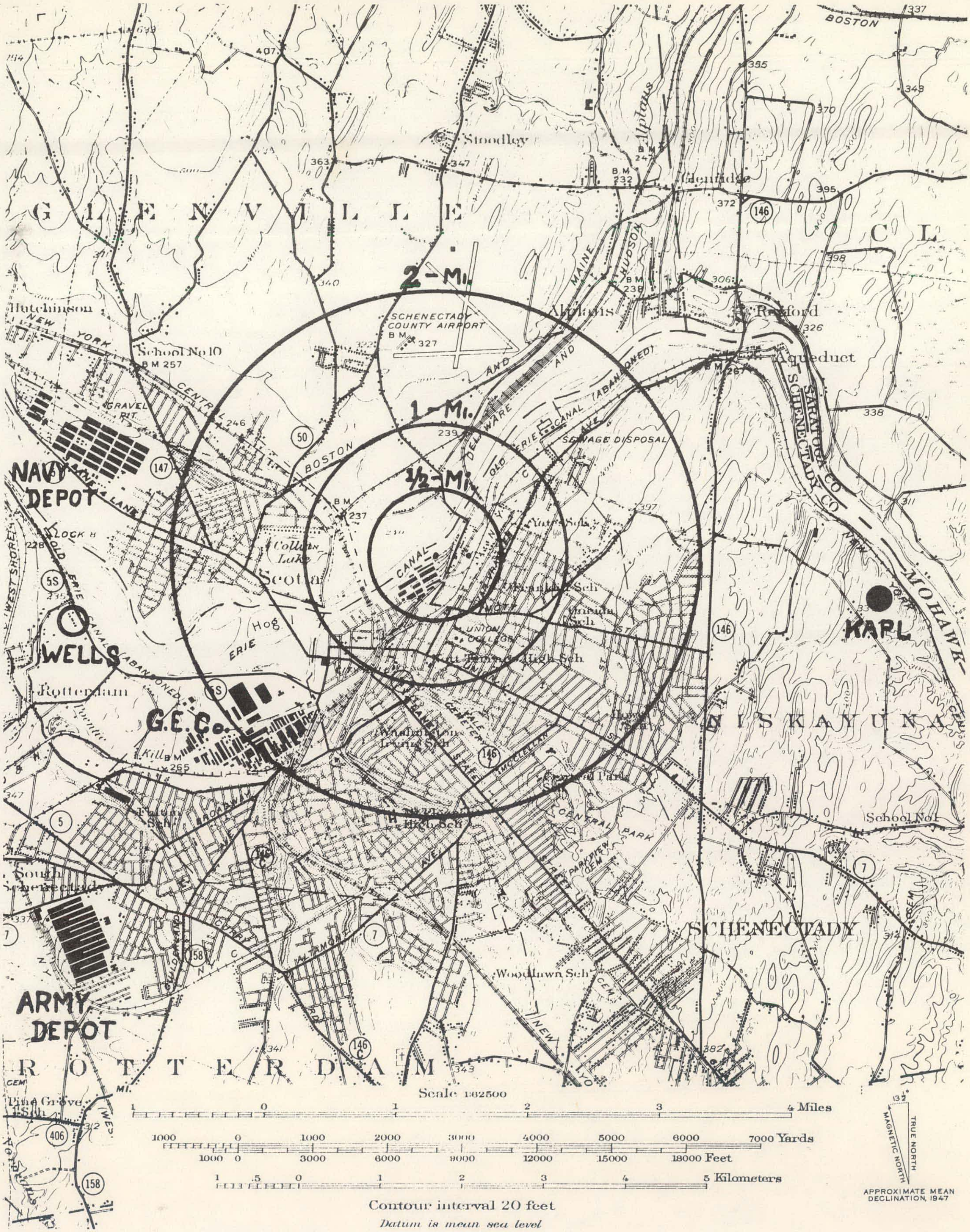

Figure 9 - Map of Schenectady Area

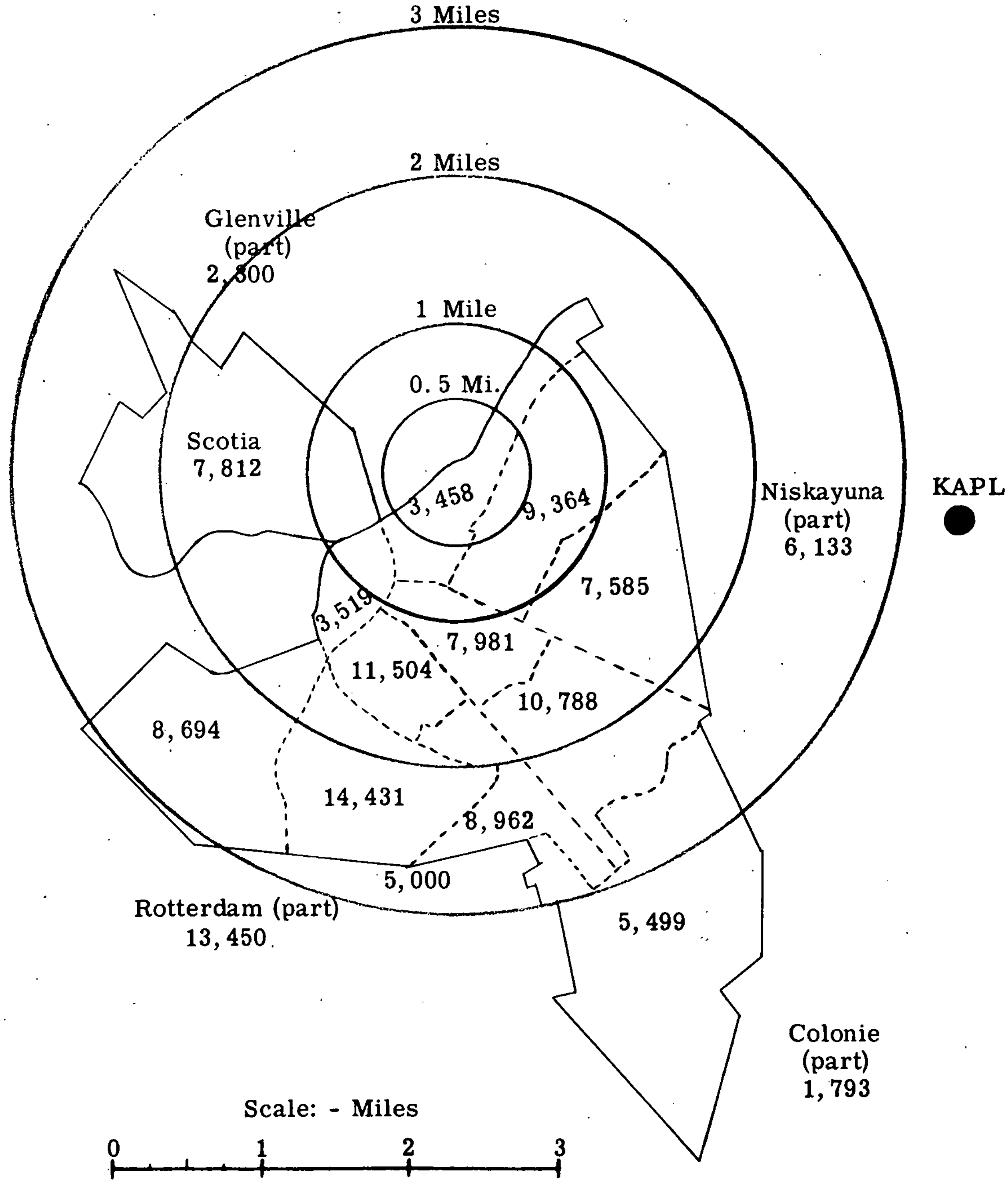

Figure 10 - Population Distribution of Schenectady Urban Area

Table 1
Population Density in the Vicinity of Proposed Site

Miles from Site	Estimated Total Population	Direction from Site
0.5	3,500	E - SE - S
1.0	18,476	E - S - SW
2.0	61,807	E - S - WNW
3.0	104,026	E - S - WNW
4.0	121,480	E - S - WNW

Orientation of the proposed facility within the Alco Products Plant and its relationship to the immediate vicinity is indicated in Fig. 11. The area to the north and west, across the river not shown in the figure, is unpopulated marshy lowlands of no current use. The nearest building and residence in this direction is about 1/2 mile away on higher ground. The nearest shop building within the Alco plant, the Carpenter Shop, is about 300 feet southeast of the proposed site. The closest distance between the site and Maxon Road to the east is approximately 600 feet. The nearest commercial establishment on the east side of Maxon Road, Kellam and Shaffer, is 700 feet distant. Although Alco will have no control over the future use of commercial property along the east side of Maxon Road, it is improbable that residences will be built in this area. From a hazards standpoint this places people not under control of Alco within 700 feet for a normal work day only. The nearest residence is 1150 feet to the southeast which represents the nearest point at which a person not under Alco control would be exposed to an incident continuously.

The employee population within the Alco Plant ranged from 3500 to 8500 over the past ten years.

B. Geology and Hydrology

Topography and Drainage

Schenectady County lies almost entirely within the lowland area bounded by the Adirondack Mountains on the north and by the Helderberg escarpment of the Allegheny Plateau province on the south. The lowland has been deeply eroded and has considerable relief. The altitude of the County ranges from about 200 feet above sea level in the flood plain of the Mohawk River to about 1100 feet at Glenville Hill on the north side of the Mohawk, and to more than 1400 feet in the hills near the center of the County on the south side of the Mohawk.

The Mohawk River enters the County at the village of Hoffmans and flows south-easterly for about 9 miles on a flood plain about a mile wide, until it reaches the city of Schenectady. There the flood plain flares out to a width of more than 2 miles and the river changes its direction of flow to the northeast. About 4 miles

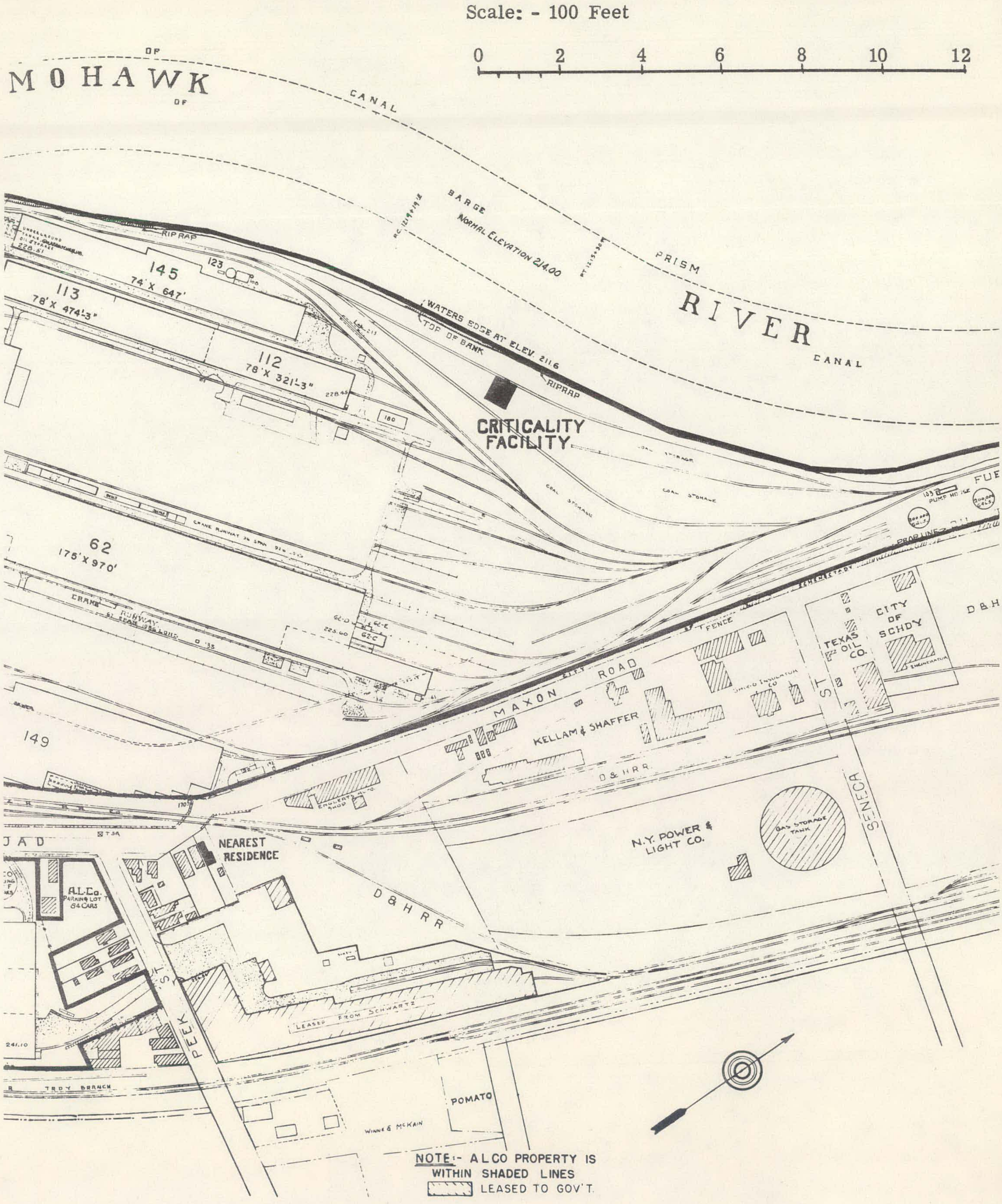

Figure 11 - Map of Alco Plant Showing Site

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farther downstream the river bends again to the southeast and continues in that direction through a narrow rock channel, about 100 feet deep, almost until it leaves the county near the village of Niskayuna. All drainage in the County is to the Hudson River, mostly via the Mohawk River.

At the southern edge of the flood plain of the Mohawk River, in the area of the facility site, the land surface rises rather abruptly within 1/2 mile from an altitude of about 230 feet to 350 feet above sea level. The higher level is a sand plain, in a youthful stage of dissection, which extends from Schenectady southeastward toward Albany. Most of the residences in the County are built on this sand plain.

Figure 12 indicates the waterways and potable water sources in the Schenectady area.

Stratiography Summary

Rocks underlying Schenectady County were deposited in two widely separated eras; in early Paleozoic time and in late Cenozoic time. The Paleozoic rocks consist mostly of alternate layers of shale and sandstone deposited in shallow Ordovician seas as clay, silt, and sand. These sediments were buried by younger sediments, consolidated, raised above sea level, and subjected to erosion and weathering (after removal of younger sediments) during succeeding geologic time. The rocks in the eastern part of the County are folded and faulted, having been affected by crustal deformation originating near what is now New England.

The Paleozoic rocks are mantled almost everywhere by unconsolidated glacial drift deposited during Pleistocene time. During this period a continental ice sheet that originated in Labrador repeatedly advanced and retreated across the entire State. In some areas the glacier eroded the rocks deeply and in other areas it laid down thick deposits of unconsolidated material. It is believed that during the final stage of ice advance, called the Wisconsin stage, the glacier was thick enough to submerge completely the highest peaks in the Adirondack and Catskill areas. The Wisconsin ice advance, within Schenectady County, seems to have removed or reworked all or almost all the material that had been deposited during previous advances of the ice sheet. Wisconsin deposits in Schenectady consist mainly of glacial till containing a high percentage of clay, and of fluvioglacial deposits of gravel, sand, and clay. In addition, smaller deposits of clay, silt, and sand have been deposited on the flood plains of the larger streams of the County during Recent time.

Structural Geology

The structure of most of the consolidated rocks in Schenectady County is relatively simple. Almost the entire County is underlain by the Schenectady formation, a series of alternating beds of shale, sandstone, and grit about 2,000 feet thick which dip gently west and southwest. In most places the dip ranges from 1° to 2°, but in places it is as much as 5°. Although the Schenectady

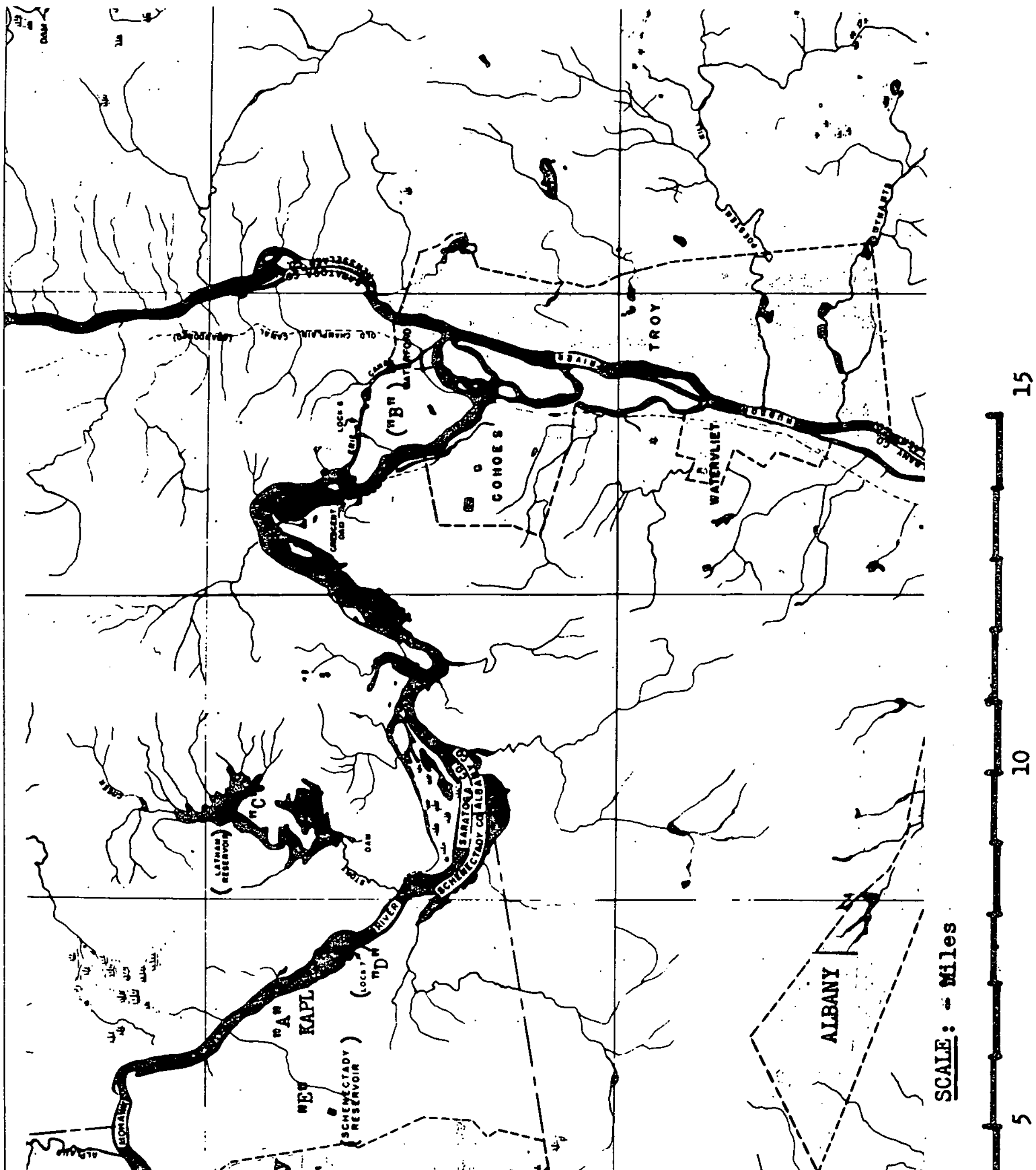

Figure 12 - Waterways in the Schenectady Area

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formation has never been subjected to stresses sufficient to produce folding, its continuity near the surface is broken by sets of intersecting nearly vertical joints.

Summary of Ground-Water Conditions

An average of more than 25 million gallons of ground water is pumped daily in Schenectady County. Ground water is the source of every municipal supply and water district in the County, with the small exception of the village of Delanson. In addition, several thousand wells have been drilled, driven, or dug to supply ground water to surburban and rural homes and to farms. Municipal supplies serve approximately 100,000 people, or about 80 percent of the area population, and several large industries including the General Electric Company, the Alco Products, Inc. and the Knolls Atomic Power Lab. The principal pumpage is from an unconsolidated gravel deposit underlying the Mohawk River between the city of Schenectady and the village of Scotia. This deposit is relatively small in size but has produced large volumes of water continuously for more than half a century with no sign of depletion, undoubtedly because of recharge to the gravel from the Mohawk River.

Except for ground water derived from river recharge, essentially all potable ground water in the County originates from precipitation that falls on the surface of the County and its immediate vicinity. At any given spot the direction of ground water movement ordinarily is toward the nearest stream channel. The movement is usually under water-table conditions, and although artesian horizons are found locally, flowing wells are scarce.

Underlying more than 90% of the County, the Schenectady formation is its most widespread consolidated-rock aquifer, consisting of an alternating series of shale and sandstone beds as much as 2,000 feet thick. This formation and the other bedrock formations of the County are essentially impervious to the flow of ground water except insofar as they contain joint openings and bedding planes. Such openings are difficult to anticipate and generally tend to pinch out with depth. Yields from the rock wells show a considerable range and depend in large part on the thickness and nature of the overburden. In general, the yield is greatest (up to 150 gallons per minute) where the overburden consists of gravel or sand, and least (as low as 1 gallon per minute or less) where the overburden consists of clay or till. In most places, however, the consolidated rock will yield to drilled wells, ranging from about 50 feet to about 250 feet deep, enough water of satisfactory quality for domestic or farm needs. The mineral content of water from rock wells ranges over wide limits, both in hardness and in dissolved solids. The hardness may range from very low to very high but the dissolved solids are rarely low. The water from some wells is so highly mineralized as to be undesirable for most uses. Hydrogen sulfide gas in small amounts is not uncommon; traces of natural gas are occasionally found; carbonated mineral water of the Saratoga Springs type was found in one well.

Unconsolidated deposits of glacial origin, consisting of till, clay, sand, and gravel, mantle the consolidated racks almost everywhere. Glacial till is the most widespread of the unconsolidated deposits and, in Schenectady County, is dense and almost impervious, yielding only a few hundred gallons of water per day to large diameter dug wells. Deposits of till up to about 300 feet thick are found, but ordinarily the deposits are less than 50 feet thick. Clay of alluvial or lacustrine origin, which is much less common than till, will yield about the same quantity of water to large diameter dug wells.

By far the largest quantity of water is pumped from deposits of sand and gravel of relatively limited size. Most of these deposits occur along the principal stream channels. A deposit of sand occurs over a wide area in the section south of the city of Schenectady and in scattered places elsewhere in the County. Hundreds of shallow wells have been driven into the sand, usually yielding ample water for all domestic needs. The most productive aquifers in the County are part of a series of more or less interconnected deposits of sand and gravel that underlie the Mohawk River flood plain from the city of Schenectady upstream approximately 8 miles to Hoffmans. This series is the source of all the ground water pumped for municipal use in the County. The individual wells yield as much as 3,000 gallons per minute with relatively small drawdowns.

The water from the unconsolidated deposits is generally acceptable for industrial or municipal use, usually without treatment. So far, no public or industrial ground-water supply is treated in any way, except for stand-by chlorination. Small portions of water, however, are treated for particular industrial uses. Dissolved solids rarely exceed 500 ppm and hardness usually is less than 300 ppm. Iron or manganese occasionally is found in high-enough concentration to be troublesome.

Test borings were taken at the proposed site about 100 feet from the southeast bank of the Mohawk River. Three holes were drilled; two to a depth of 25 feet, and one to a depth of 70 feet. The character of natural soil from 15 to 70 feet below the surface is classified as a fine, relatively uniform silt or silty sand with considerable evidence that much of the material is organic. The particle sizes range from 0.4 to less than 0.001 mm in diameter with the "50% finer than" point at 0.05 mm.

Artificial fill consisting of cinders, sand and brick in varying degrees of compactness was experienced to a depth of 15 feet below the surface. The apparent ground water level was reached at a depth of 12 feet which compares closely to the elevation of the Mohawk River.

Because of the character of this unconsolidated material, the Critical Facility building was supported by a reinforced concrete foundation resting on 104 treated wooden piles driven to a depth of 50 feet. Each pile is rated for a 20 ton bearing pressure.

Seismology

N.H. Heck's "Earthquake History of the United States", which reports on all recorded disturbances to 1927, indicates there have been two tremors in the immediate Schenectady area. These occured on January 24, 1907 and February 2, 1916. The former had an intensity of 5; and the latter, 4 to 5 on the Rossi-Forel scale of intensity. A quake with this intensity is described as a moderate shock, generally felt by everyone, and with some distrubance of furniture and ringing of bells. No damage results to a structurally sound building at this intensity level.

C. Meteorology and Climatology

In addition to the meteorological data taken during 1956-57 at the facility very complete records covering many years were available from the U.S. Weather Bureau in Albany. The Meteorology station at the Albany Airport is approximately 7 miles to the southeast and on a relatively level plain with an elevation approximately 120 feet above the proposed site. General land contours toward the southeast rather abruptly rise from an elevation of 230 feet at the site on the bank of the Mohawk river to the elevation of the Albany Airport within 1/2 mile from the site. The differences in the data taken at the Facility and the Albany Airport are no doubt influenced by the difference in location and the relatively poor statistics of facility data collected during a period of just 18 months.

Climatological Summary

The climate at Schenectady is primarily continental in character but is subjected to some modification from the maritime climate which prevails in the extreme southeastern portion of New York State. The moderating effect on temperatures is more pronounced during the warmer months than in the cold winter season when outbursts of cold air sweep down from Canada with greater vigor than at other times of the year. In the warmer portion of the year temperatures rise rapidly during the daytime to moderate levels. On the average, there are only 9 days per year with maximum temperatures of 90 degrees or above at Schenectady. The highest temperature of record is 104 degrees. As a rule, temperatures fall rapidly after sunset so that the nights are relatively cool and comfortable.

Winters are usually cold but no commonly severe. Daytime maximum temperatures in the months of December, January and February average around 37 or 38 degrees; the minimum during the night is about 20 degrees. On the average, there is an expectancy of 9 days during the year with sub-zero temperatures and the minimum temperature of record is 26 degrees below zero. Snowfall averages about 50 inches annually and the number of days in which one inch or more of snow covers the ground is approximately 50.

The precipitation at Schenectady is derived from moisture-laden air that is transported from the Gulf of Mexico and the Atlantic Ocean. Instrumental in the importation of this air are cyclonic systems which progress from the interior of the country northeastward over the St. Lawrence Valley, and also similar systems which move northward along the Atlantic Coast. It is only occasionally that the centers of these storms pass directly over Schenectady. Nevertheless, the area enjoys sufficient precipitation in most years to adequately serve the requirements of water supplies, agriculture and power production. Only occasionally do periods of drought conditions become a threat. The months of heaviest rainfall are from May through October when the average monthly totals range between three and four inches per month. The greatest fall to occur in any individual month is 13.48 inches while the least amount is 0.08 of an inch. Thundershowers are infrequent during the winter although they have been recorded for each month in the year. The mean number for the period of record is 22 annually. A considerable portion of the rainfall in the warmer months is supplied by storms of this type, but they are not usually attended by hail of any consequence.

On the whole, wind velocities are moderate. The prevailing wind direction from May through November is from the south, from the north in January, and from the west in the remaining months of the year.

Generally speaking, November, December and January are cloudy months but the remainder of the year is comparatively sunny with abundant sunshine to be expected in June, July and August. In fact, the average of cloudy days for the three summer months is only 7 or 8. Usually there are only a few days in the year when the relative humidity of the air causes personal discomfort to a great degree.

The extremes of atmospheric pressure over the 75 year period of record range from 28.46 to 31.10 inches of mercury.

With only those differences which are the result of differing latitudes, and topographical effects, the climate of Schenectady is representative of the humid area of the Northeastern United States.

Surface Wind Directions and Velocities

Hourly wind observations for an 8 year period (1938 - 1946) taken at the Albany Airport, on a plain about 7 miles southeast of the proposed site, are presented in Fig. 13 in terms of the average annual percentage frequency of surface wind direction and associated velocity. Figure 14 presents similar data taken at the Facility for the period September 1956 thru December 1957. It will be noted in Fig. 14 that 8.8% of the time prevailing winds occur from the south with an average velocity of 7.5 miles per hour (3.4 meters per sec.). On the other hand, winds from the northwest quadrant occur a total of 28.9% of the time with an average velocity of 8.9 miles per hour (4.0 meters per second). For purposes of this report, therefore, prevailing winds can be considered as originating in the northwestern quadrant and affecting the populated Schenectady area about 29% of the time. The relationship between wind direction and velocity and potential hazards to the surrounding population will be discussed in Supplements to this Application.

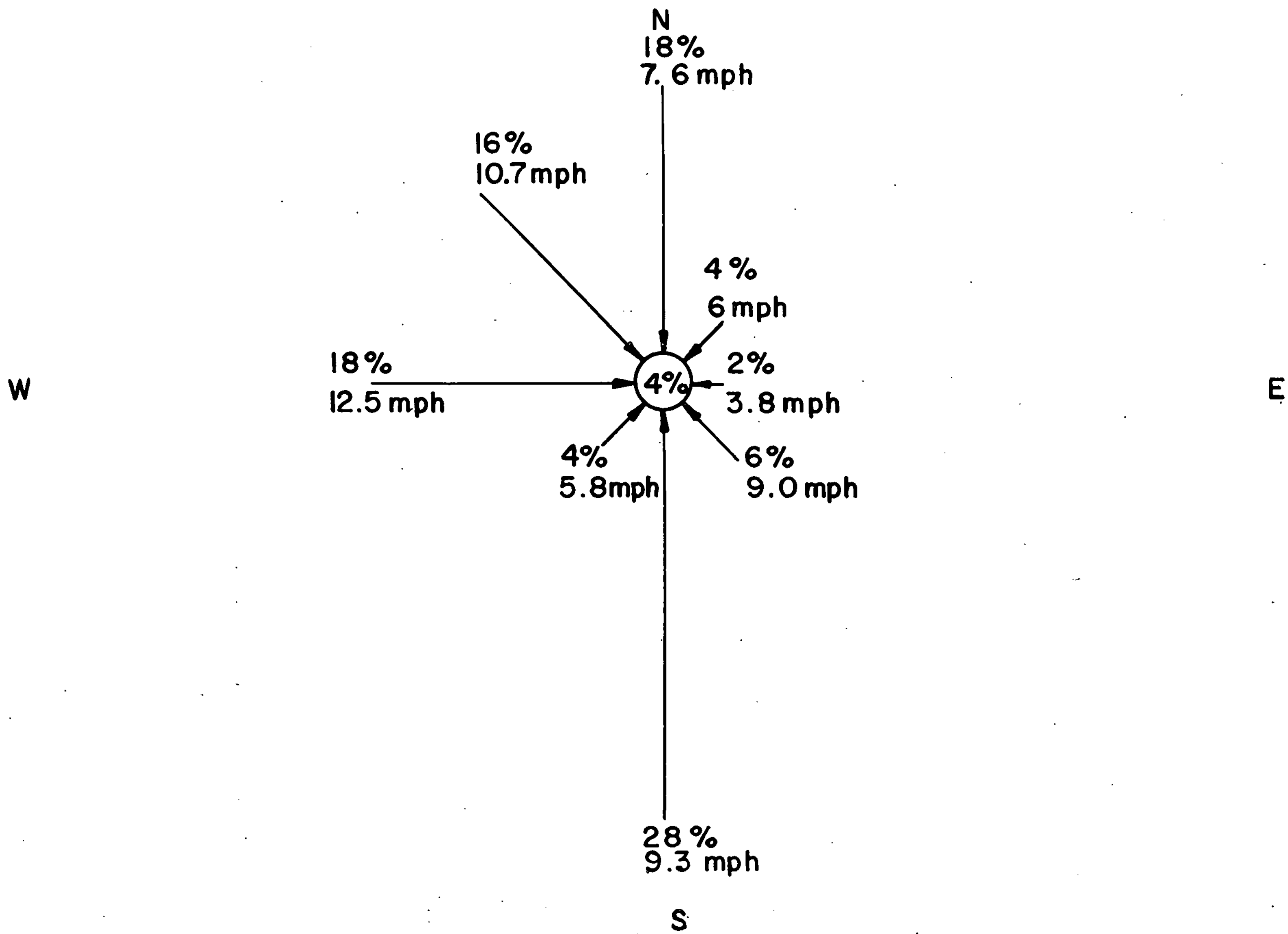

Figure 13 - Average Annual Frequency of Surface Wind Direction (Albany Airport)

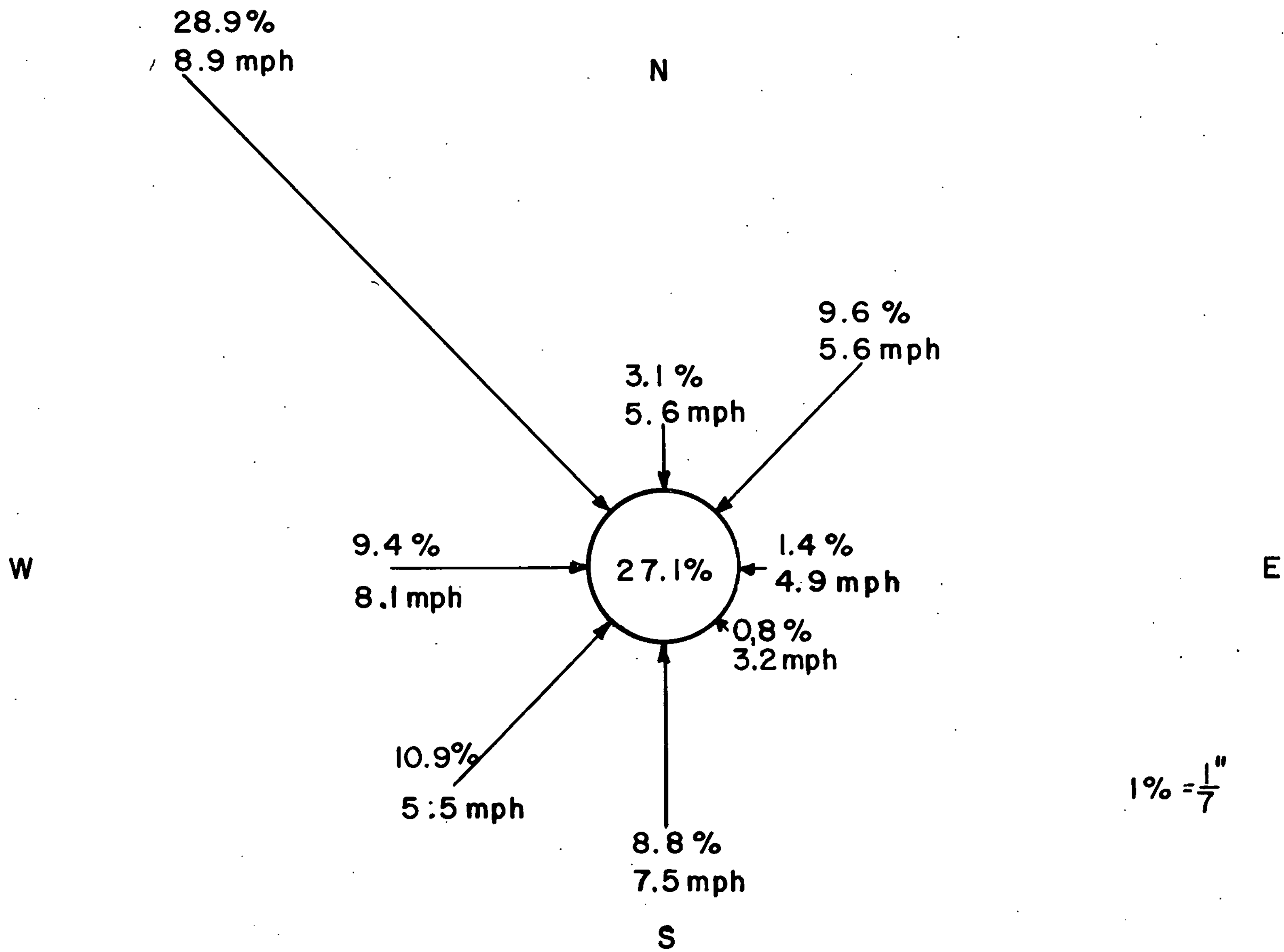

Figure 14 - Average Annual Frequency of Surface Wind Direction (Alco Criticality Facility)

Flood History

Records kept by Alco Products since 1914 are summarized in Table 2. This indicates a general flooding of the plant on several occasions with some flooding in buildings. No structural damage of significance has been experienced. From the last recorded high water in February 1939 to January 1956 there have been no floods exceeding an elevation of 227 feet. The floor level of the facility is at 230 feet, so no serious threat is anticipated in this respect. Precautions, however, will be taken to minimize or prevent damage which could result in the uncontrolled release of activity in a severe flood. For example, valves will be provided on sewer drains and the waste storage tank will be filled or securely anchored to prevent it from breaking loose during a flood although it is expected no significant amounts of activity will be stored in it.

Table 2
Maxima Recorded High Water at Alco Products, Plant #1

Date	Elevation (ft.)
March 28, 1914	232.0
April 2, 1916	229
February 20, 1918	227.3
February 12, 1925	227.0
March 15, 1929	227.1
March 19, 1936	228.0
February 21, 1939	227.5

From 1939 to January 1956 there have been no water levels exceeding an elevation of 227 feet.

Evaluation of the Facility Site

It is believed the facility site as considered in this chapter is a satisfactory one for the construction and operation of a zero power critical assembly or critical experiment.

The static and southwestern quadrant wind conditions 38% of the time and the sparsely populated area beyond 1/2 mile to the north of the proposed site are highly favorable. On the other hand, winds from the northwest quadrant 29% of the time could potentially affect the heavily populated Schenectady area which makes the site less favorable.

The location of the facility on the bank of the Mohawk River three river miles downstream of the Schenectady public water supply is of no apparent hazard to this water source. The relation of the site to other potable water supplies downstream and downwind introduces no real hazard.

From all other considerations of the meteorology, geology, hydrology and seismology, the facility site in the Alco plant appears to be as satisfactory a site as could be selected within the Alco plant or the immediate area.

CHAPTER V - NORMAL OPERATION PROCEDURES

The typical routine procedures for maintaining and operating the Alco Products Criticality Facility and the associated experimental programs are described in detail in this chapter to afford comprehensive understanding of the implications of such procedures in minimizing the probability of operational failures and radiation hazards.

A. Facility Operation

The principles of safe facility operations are based upon 1) personnel safety, 2) security, and 3) equipment reliability. The following paragraphs define the major procedures instituted to insure compliance with these principles.

Personnel Safety

In order to provide assurance that the requirements of Title 10-CFR-Part 20, "Standards for Protection Against Radiation", of the Act are complied with in fact and spirit, the following health physics routines and limits are practiced:

1. All personnel regularly employed at the facility are required to have complete company physical examinations annually.

2. All personnel regularly employed at the facility are required to wear personnel monitors in the form of gamma-beta and neutron sensitive film badges, changed bi-monthly, and gamma and neutron sensitive pocket ionization chambers.

3. Visitors to the facility are provided with either pocket chambers or film badges depending on the operation.

4. All personnel entering the reactor room are required to carry and use appropriate portable radiation monitors.

5. A weekly surface and wipe survey is performed to assure the following requirements: Wipe counts - zero d/m
   Surface counts - less than 1 mrad/hr
   Any deviation from these requirements is interpreted as to cause and remedial measures are taken to contain the source of contamination and to clean contaminated surfaces.

6. Reactor system water is dumped to the Mohawk River several times a year and then only after the effluent is known by analysis to meet the NBS-52 standards. The facility supervisor is the sole possessor of the keys to the locked valves leading to the river.

7. General facility cleanliness is insisted upon to encourage interested care in all operations.

8. All routines are followed as per the "Health Physics Manual for the Alco Criticality Facility", APAE Memo 26, Rev. 1.

Security

In order to provide internal administrative control as well as to comply with the usual security regulations, the following measures are practiced:

1. The facility ultrasonic alarm is checked for proper functioning on a daily basis.

2. Guard service at the facility is continuous through all facility operations.

3. Periodic guard tours and clock-in station are provided during off hours.

4. No persons are normally allowed to enter the facility without the expressed approval of the facility supervisor or his duly appointed representative.

5. During operation admittance to the facility is at the option of the operator.

6. All classified materials are secured in proper vaults during off hours.

Equipment Reliability

The proper functioning of all critical equipment is a prime corollary to safe facility operation, for, only with this assurance will the probability of radiation accidents be reduced to a satisfactory minimum. The following equipment checks are routine with a frequency as demanded by their influence on safe operation.

1. Control Console and Auxiliary Panel - Wiring and tube checks are conducted annually in addition to the daily routine operation tests described below.

2. Control Rod Drives - Monthly mechanical checks and annual oil changes are made in addition to daily operational tests.

3. Health Physics Instrumentation - All instruments are maintained in working order and checked on a daily basis. Instruments are calibrated at least twice a year.

4. Experimental Rig - The core support and related experimental rigs

are checked for mechanical soundness on a daily basis. The degree of this check is largely dependent on the complexity of designs peculiar to a given set of experiments.

5. Main Pump - The main pump is oiled and repacked annually.

6. Fire Extinguishers, etc. - All safety equipment is checked at least semi-annually.

7. Miscellaneous - Air conditioners, overhead crane, water softener, air compressors, all other electrical and mechanical parts, and technical equipment are serviced at least annually.

B. Approach to Criticality

Approaches to criticality are principally of two types: 1) initial approach to an unknown system, and 2) the routine approach to known systems. Both approaches to criticality are subject to essentially the same procedures, but with variations in emphasis. The following description delineate the procedures for normal start-up operations:

System Check-Out

Each new reactor experiment will be subject to basic tests to insure the proper mechanical and electrical functioning of all equipments prior to start-up. These tests include the following:

1. Mechanical Structure - the soundness of the core support and other experimental equipment, structurally, is determined at the time of of its design by the facility supervisor and the designer and again during installation. In general equipment is over designed to insure safe loading margins.

2. Main Pump and Valves - Prior to initial operation the water feed rates and dump rate are carefully determined and checked against previous operations.

3. Control Rod Drives - The control rod drive mechanism and the control rods are individually checked for proper mechanical functioning to insure freedom from binding frictions due to burrs, misalignment, improper loading, etc. The position indicators are checked against actual rod motion and the zero points are established. The control rod actuator and magnet currents are checked for proper functioning and are set to minimize magnet decay time or scramming. These tests are performed whenever changes are made in the position of the control rod drive supports in addition to the daily checks indicated below.

4. Electronics - All electronic circuits are checked for proper functioning prior to operation.

5. River Valves - All valves to the river are locked following dumping and recharging the sump tank.

Start-Up Procedures

Prior to start-up the following daily procedures are observed to guard against system failures occurring since the previous operation:

1. Daily Check List - The results of the daily check list are recorded in the log book and signed by a responsible operator. The check list includes:

    a. Building "Reactor ON" lights are actuated when power is turned on by means of a key operated switch.

    b. Linear instruments must record source level with the source inserted in the system.

    c. Scram check on control rods and dump valve must be satisfactory.

    d. Instrument calibration must result in proper zeros and minimum holding magnet current.

    e. Information concerning: Experiment No., Run No., Crew Chief, Operator, date, hour.

    f. Reactor room doors closed by interlocking with scram circuit.

2. Start-Up Operation

    Safety in the form of available negative K necessary to override the remote addition of positive K is provided by control rod settings and the moderator dump. With the system loaded (by manual fuel additions to be described below) moderator is introduced at approximately 50 gallons per minute until the level exceeds the top of the active core by no more than six inches or until the sub-critical multiplication has increased so as to warrant a reduction in the rate of moderator addition by a manual rate change to approximately 10 gallons per minute.

    Final reactivity additions are provided by control rod motion or in some cases moderator control. Criticality is achieved when the source has been removed and the neutron level remains constant. Since criticality is unique by definition, one understands that the described approach to criticality usually results in a slightly supercritical condition as the delayed neutrons become effective.

Loading Changes

Manual changes in the material content of a reactor system may be grouped as either major or minor in nature. Reactivity additions greater than the equivalent of 10% U_{235} critical mass are classed as major changes and necessitate the usually inverse multiplication approach to criticality, for example, the initial fuel loading. Minor reactivity additions involving fuel additions and poison removals require the usual start-up procedures described in item 2 above.

In all cases loading changes are made in the absence of a moderator and then only after careful evaluation by the Crew Chief and the Facility Supervisor. All changes in the reactor system are noted in the log book and by direct check against a loading chart and the S. S. accountability records. Only one man at any given time will manually add reactivity to the system. Nuclear instrumentation will be active during all loading changes and a member of the crew will constantly monitor such changes by these instruments. An intercom system is available to provide warning of incorrect changes.

After each manual addition of reactivity during major system loading changes, multiplication measurements will be made to predict the critical condition. Further additions of reactivity will not exceed one-half the difference between the extrapolated critical mass and the current loading or their equivalents. Additions will be limited to 2 kg U_{235} or its equivalent. Known systems may be loaded to previous configurations directly in the absence of a moderator.

C. Operation of Critical Systems

1. Introduction of reactivity to a critical or slightly sub-critical system will be limited to approximately 0.01% K per second. A period of from 100 to 30 seconds will be considered routine. Since rod motion tending to increase reactivity ceases by interlock in response to a 15 second period, this condition will be considered unsafe and the system reactivity will be decreased without "scram". Periods less than 10 seconds will demand an operator "scram" and periods of 5 seconds or less will automatically "scram".

2. The average operating level will be one watt, or less, and the maximum operating level will be 100 watts.

3. Control rods and moderator level will be calibrated by period or "rod drop" techniques as soon as possible after the initial critical to provide reactivity rate estimates for ensuing experiments.

4. Nuclear instrumentation will be under constant surveillance and major instrument inconsistencies will be deemed cause for shut-down.

Shut-Down Procedures

1. Reactivity will be reduced by moderator and/or fuel removal and poison additions.

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2. Radiation levels will be checked.

3. Moderator control valves will be returned to their normal safe positions.

4. The power supplies and console will be properly locked to prevent acts of sabotage.

Scram, Power Failure, and Instrument Failure

1. Scram, manual or automatic, will return the system to a safe condition as described in the section on instrumentation and controls.

2. Power and instrument failures, though remote, will result in a scram. Proper instrument checks and resets will follow all scrams due to component failures. Start-up procedures will be instituted before any ensuing criticals. Scram resulting from an accident will be followed immediately by power shutdown to all reactor components, locking of the control console, and an evaluation of the accident.

D. Type of Experiments Performed

Two general classes of measurements will be performed on the critical experiments in the Alco Facility, namely, reactivity and flux measurements.

Reactivity measurements include temperature coefficients, U-235 importance functions, reactivity (danger) coefficients, and control rod calibrations. Reactivity coefficients include such studies as: void or poison replacement of fuel or moderator, effect of varying reflector thickness, effect of varying shielding thickness and material, etc. Reactivity measurements involving increases in reactivity will, of course, be subject to the previously described operation procedures.

Flux measurements will include neutron detection by gold and indium foils, aluminum catcher foils, and fission foils. Ionization chambers, movable and fixed, will provide data describing neutron and gamma flux distributions.

E. Personnel

A crew for the operation of critical experiments will consist of one senior personnel and two or three engineers. Senior personnel are those individuals with a minimum of two years operating experience in the critical experiment and power reactor fields. The facility supervisor and other senior personnel will rule on all basic configuration changes involving quantities of reactivity in excess of one dollar.

The engineers assigned to the operating crew will be trained in accordance with all aforementioned procedures. They will be permitted to operate a critical system only after demonstrating a thorough knowledge of the system and the operation procedures.

F. Accountability and S. S. Material Control

For purposes of source and special nuclear material accountability an accountability material balance station has been instituted at the Alco Criticality Facility. The following paragraphs describe the procedures established for this accountability station for the control of materials under AEC and Civilian Applications Division cognizance.

Types of S. S. Material

The S. S. material to be used at this Accountability Station will be in the form of fabricated plates or pin type elements. These elements will consist of clad uranium metal or UO_2 enriched from 5% to top assay U-235.

Clearly, there will be no personnel contact with free U-235 unless an element ruptures. In this case, consideration of solid and liquid wastes becomes important, therefore this description includes the accountability procedures that would be appropriate for such waste material.

Inventory Procedures

Physical inventories shall be taken to verify the quantities of S. S. materials and material balance reports shall be submitted as soon as possible after the end of each month.

Fabricated fuel elements will be inventoried by piece count monthly and by piece count and gross weight checks every six months. Each element shall be identified by a unit number and a letter designating the account.

Solution and solid wastes will be inventoried at the time analytical determinations for S. S. content are conducted and gross weight inventories shall be made of each waste batch at the end of each ensuing month.

Preservation of Material

Precautions will be taken to insure the proper handling of S. S. material in the vault and from the vault to the reactor tank.

1. Handling of Material - Fuel elements will be transferred from the vault to the reactor tank one at a time. The position of a particular fuel element in the reactor tank will be recorded on a loading chart together with the elements identifying symbols. In this way the precise location of all fuel will be known to the operating crew and the supervisor.

2. Storage of S. S. Material - U-235 will be stored in the vault in a lattice of 6-inch by 6-inch cells. This lattice will cover one wall of the vault, 10 feet wide, to a height of 6 feet. Each of the 240

cells will be lined by a minimum of 0.005 inches of cadmium and a maximum of 50 grams of U-235 will be stored in each cell.

Calculations have been performed and show that such a lattice is sub-critical even if of infinite extent and flodded with water.

Records

This Accountatility Station shall maintain permanent double-entry accounting records reflecting the S. S. material receipts, shipments, inventories, and losses for each S. S. material handled. The quantities shown on material balance reports shall agree with the quantities reflected on S. S. material accounting records.

A single system of double entry records will provide information required for both accounting and operating supervision.

The Accountability Station records shall consist of S. S. Transfer Journals, U-235 Material Balance Summaries, and Account Folders.

1. S. S. Transfer Journal - A separate S. S. Transfer Journal shall be used to record the transfer of S. S. material between this Station and each Accountability Station with which such transfer is executed.

   The Shipping Form AEC-101 or AEC-388 shall be the source of the information required, (i. e. Shipper and Receiver Net Weights, and Shipper-Receiver Difference, Shipping Form No., and Material Description).

2. U-235 Material Balance Summary - A Material Balance Summary record shall be maintained for each isotopic assay of U-235 and shall cover the period of one fiscal year.

   Summary record postings shall be compiled from the S. S. Transfer Journals and shall include the date of transfer of material together with the posting reference. All material receipts, removals, the beginning and ending inventories, measured losses, and material unaccounted for shall be recorded.

3. Account Folders - Each "internal account" (material used under a particular contract) and material assay shall have a folder which shall include the monthly inventory sheets. These sheets shall be used, together with the U-235 Material Balance Summaries and the S. S. Transfer Journals, in compiling the Material Balance Station Reports (Forms AEC-577 and 578).

   Each Transfer Account, as posted on an S. S. Transfer Journal, shall have a folder which shall contain the appropriate copy of AEC-101 or 388 covering the transfer of material and any other explanatory records.

Measurements and Statistics

The measurement method for fabricated elements will be by gross weight and neutron multiplication. In general, the measurement method for waste will consist of weighing, sampling and analyzing each unit, batch or container of material and, where appropriate, determining the isotopic composition.

Modern statistical methods shall be used in evaluating sampling plans, determining accuracy and precision, and recognizing possible improvments in sampling and measurement schemes. Statistical analysis of the overall material balance will indicate the relative importance of the several sources of unreliability, enabling efficient allocation of effort to improve reliability.

Uncertainty in measurements shall be subject to confidence limits which are derived from the standard deviation of all measurements and estimates which have been recognized as contributing to the total uncertainty. For purposes of uniformity two sigma (95%) confidence limits shall be used.

Gross weight measurements shall be made on a direct reading balance of appropriate capacity. The sensitivity of the instrument shall be determined and calibrations performed. Waste batch samples will be weighed on calibrated analytical balances. Laboratory facilities will be acquired to perform the appropriate specific gravity and gram uranium per gram total measurements when such measurements are necessary.

Neutron multiplication measurements will be made during the course of the critical experiment program utilizing the material to be measured.

Assay will not be determined at this Accountability Station. The shipper's assay shall be recorded and all shipments segregated on this basis.

CHAPTER VI - EMERGENCY PROCEDURES

The contents of this chapter describe the features pertinent to facility operation at the time of and immediately following a nuclear or radiation accident.

A. Exclusion Area and General Procedures

As previously described in Chapter III, the facility is enclosed by a wire fence on four sides. This fence is approximately 35 feet from the building on the three sides presenting walls of one foot reinforced concrete. The fourth side is boundedby the Mohawk River and presents a three foot reinforced concrete wall. This enclosure is defined as the exclusion area. Signs are posted facing each direction of approach and read esstentially thus:

RESTRICTED AREA

ENTRY BY AUTHORIZED PERSONNEL ONLY

If Alarm sounds, seek -

DISTANCE and SHELTER

A security guard is in attendance at the personnel entrance to the building at all times during operation to assure that all area personnel and official visitors are properly cleared and provided with beta-gamma sensitive film badge dosimeters. Personnel within the area are also provided with gamma and thermal neutron sensitive boron-lined pocket ionization chambers. A "reactor on" or "reactor off" light at the building entrance advises personnel approaching of the operational status of the facility. During normal operations personnel at the exclusion area boundary would be exposed to insignificant amounts of ionizing radiations. The frequency with which personnel approach this boundary is low and the probability that they would remain at the boundary for extended periods of time is remote. Approximately 6-10 people pass to and from the coal yards at various times during the day, both on foot and on railway equipment.

In the event of an excursion or any incident which could create radiation hazards outside the building, the operator will close a switch which actuates a loud warning siren. This device is located on the building roof and is designed to warn any personnel approaching the area to maintain distance and take cover in a nearby building if available. Any personnel near the exclusion area boundary will be directed by the above signs and training to seek distance and shelter in the event the alarm sounds.

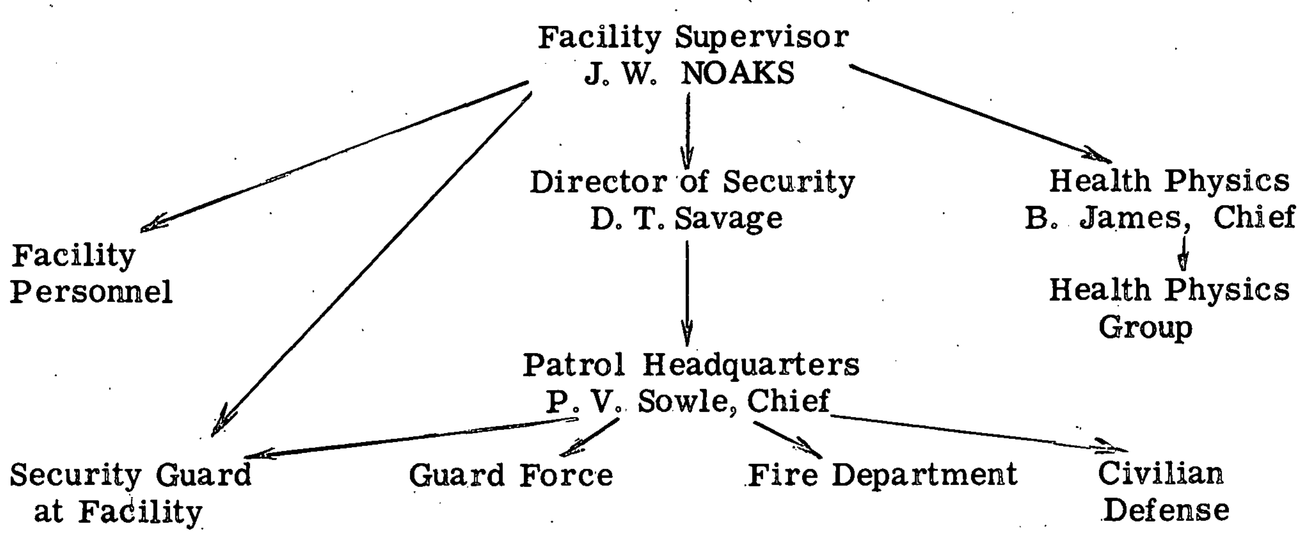
All operating personnel, visitors, and the security guard will assemble in the counting room. This room provides the maximum shielding of five feet of concrete between it and the reactor room and has a one-foot concrete ceiling. From this vantage point the incident will be evaluated and any required emergency procedures inaugurated. Instrumentation available in this area for immediately evaluating the incident includes a continuously recording high range ionization chamber to indicate the magnitude of the incident, a continuous air sampler with multi-station selection to detect the presence of potential airborne hazards, an "Aerovane" anemometer recorder, and other miscellaneous portable survey meters and air samplers. A telephone, protective clothing, respiratory protection and first-aid kit are also available in this area.

In the event the incident involves the escape of significant airborne radioactive materials from the reactor room, as indicated by the constant air monitor sampling the exhaust stack, patrol headquarters will be advised by telephone to shut down ventilating systems and to close windows in plant buildings downwind of the facility. The anemometer recorder in the operating area will indicate this direction and patrol headquarters has been provided with the location of all ventilation control points for each building in the plant. In this manner the inhalation exposure of all plant personnel will be minimized.

Immediately following any incident, radiological conditions in and about the facility will be evaluated to determine when normal operations can be resumed. Fixed area film monitors are available to aid in evaluating the magnitude of the incident.

B. Internal Emergency Organization

The Plant Security Force together with the operating crew of the facility and the Health Physics Group constitute the Internal Emergency Organization. This organization with the names of the key personnel are as follows:



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It will be the duty of the Facility Supervisor to designate an acting Supervisor whenever the reactor is operated in his absence. This will be a senior man with operating experience, who is thoroughly familiar with the emergency procedures.

No experimental work is foreseen that will envolve probable maximum credible accidents warranting an organization external to the Alco Schenectady Plant area.

C. Emergency Plans

1. Plan I - Plan I will be effective in the event of a minor radiation excursion with insignificant fission product production and no release of contamination. The following actions will take place:

   a. The warning siren will be sounded.

   b. The Director of Security, the facility guard and Patrol Headquarters will be notified by the facility supervisor that a "Plan I" incident has occurred. The facility guard will join the facility personnel in the shielded counting room immediately.

   c. All security measures will be observed.

   d. When it has been determined that no fission product release is possible, an "all clear" signal of three ten-second blasts, spaced with ten-second intervals, will be sounded.

   e. Health Physics and Facility personnel will survey the facility and the immediate area and proceed to evaluate the magnitude of the incident.

   f. No other external action will be required.

2. Plan II - Plan II will be effective in the event of a maximum credible incident or fission product release. The facility remains entirely intact. The following actions will take place:

   a. The warning siren will be sounded.

   b. The Director of Security, the facility guard and Patrol Headquarters will be notified by the facility supervisor that a "Plan II" incident has occurred. The facility guard will join the facility personnel in the shielded counting room immediately.

   c. All security measures will be observed.

d. The Director of Security will direct the closing down of all ventilation systems and windows in the affected area. This will be accomplished with the assistance of the guard force and the internal civilian defense organization.

e. Personnel in all affected facilities will remain in the facilities but shall be instructed to congregate in the down wind end of the facilities. The internal civilian defense organization will be responsible for this action.

f. The facility and health physics personnel will evacuate the facility until the contamination is sufficiently low to allow evaluation of the incident. The adjacent railroad yard should be evacuated in accordance with prior instruction shortly after the siren sounds. The siren will be turned off at the time of evacuation without the sounding of an "all clear".

g. Guards will be posted at all approaches to the facility at a safe distance from the contaminated area.

h. Clean-up procedures will follow until the area is deemed safe for occupancy.

The Plan II incident at most will be the maximum credible incident, therefore a general evacuation of the Alco Plant or the surrounding neighborhood will be entirely unnecessary.

D. <u>Health Physics and Clean Up Procedures</u>

A complete description of all health physics procedures is available in Alco document APAE Memo No. 26 Revision 1. Those procedures pertinent to the emergencies described in this chapter are indicated below.

1. Evaluation of radiation hazard produced by the accident will be accomplished initially with the aid of the control instrument records, the high range gamma monitor, the effluent from the facility stack as indicated by the mobile air monitor, readings of personnel pencil ionization chambers, and by portable radiation monitor surveys.

2. All areas of the facility deemed unsafe for occupancy will remain closed off until the radiation decays to suitable levels. The office area air conditioner will remain off until all clean up procedures have been completed.

3. Surface and wipe counts will be taken throughout the effected area around and within the facility at decreasing distances from the

reactor room until entrance to the reactor room is allowable.

4. The final incident will be evaluated on the basis of all the information above and the results of fixed film badge monitors located around the facility to the fence at Maxon Road.

5. Clean up procedures include retaining the water moderator until radiation levels reach the prescribed value or by recirculation thru a demineralizer; (recirculation of reactor room air thru fixed C. W. S. filter to remove particulate matter;) removal and packaging of all contaminated equipment which does not respond to washes with dilute nitric acid or carbonates; removal of flooring and wall paint by suitable means until radiation levels are within permissible limits; shimpent of all contaminated materials by authorized routine to an authorized receiver.

6. Analysis of the moderator and core remains will be made to allow accountability for all fissionable materials.

7. Notification within 24 hours of the accident will be sent to the Manager of the local AEC Operations Office by telephone and telegraph. Written notification of the evaluated accident will be submitted to the Director, Division of Civilian Application, Washington, D. C., with a copy to the Manager of the local AEC Operations Office within 30 days of the accident.

8. Normal facility operations will commence only after complete assurance is given that the resultant radioactive releases have been satisfactorily evaluated and controlled.