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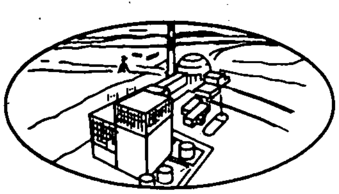
DRESDEN NUCLEAR POWER STATION

UNIT 2

PLANT DESIGN AND ANALYSIS REPORT

VOLUME I



Commonwealth Edison Company

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DRESDEN NUCLEAR POWER STATION

UNIT 2

PLANT DESIGN AND ANALYSIS REPORT

VOLUME I

Commonwealth Edison Company

COMMONWEALTH EDISON COMPANY
DRESDEN STATION UNIT 2

PLANT DESIGN AND ANALYSIS REPORT

I INTRODUCTION AND SUMMARY

I-1 PURPOSE AND SCOPE OF THIS REPORT

1.0 PURPOSE AND SCOPE OF THIS REPORT

The purpose of this Plant Design and Analysis Report is to provide a basis for evaluation of the safety of the second nuclear power plant (Unit 2) to be constructed at the Dresden Station Site of the Commonwealth Edison Company of Chicago, Illinois. A technical description of the facility is included along with an evaluation of the site and environs, a summary of the plant safeguards features, a safety and accident analysis, plant operating procedures, and other pertinent information. Embodied in the report are the design objectives for the safety-related systems and equipment and the bases for the design objectives. In addition, a description of the reactor is given which presents the limits of normal operation and the effects of operation outside the normal limits but still within the design margins. The reactor has many inherent, self-limiting features which are available to restrict and turn around postulated but unlikely excursions. Finally, developing from an understanding of the response of the reactor to normal and abnormal perturbations, the role of the backup safety systems and equipment is presented.

I INTRODUCTION AND SUMMARY

I-2 SITE AND ENVIRONS

2.0 SITE AND ENVIRONS

The information presented in this section summarizes Section III (Volume III), Site and Environs.

2.1 Location of Site

The Dresden Nuclear Power Station consists of a land tract of approximately 953 acres located in the northeast quarter of the Morris 15′ quadrangle (as designated by the U. S. G. S.), County of Grundy, State of Illinois. The tract is situated in portions of Sections 25, 26, 27, 34, 35, and 36 of Aux Sable Township (T.34N., R.8E.).

The principal structures of DNPS Unit 2 will be located approximately on the boundary between Sections 26 and 35, several hundred feet west of the corner point of Sections 25, 26, 35 and 36. This location is approximately at latitude 41°23′20″ North, and longitude 88°16′20″ West. The character and contours of the site and immediate environs are shown in Exhibit III-2-1 (Aerial Photograph) and in Exhibit III-2-2 (Vicinity Map). These exhibits also show the location of Existing Unit 1, while Unit 2 will occupy a similar sized area immediately west of and adjacent to the principal structures of Unit 1. The existing site boundaries generally follow the rivers to the north and east, the railroad on the west, and the road from Divine extended eastward to the Kankakee River on the south as is shown on Exhibit III-5-1.

Paved county roads south of the site connect to state highways within several miles to the east, south, and west. A line of the Elgin, Joliet, and Eastern railroad forms the western boundary of the site, and a siding currently enters the site for service to Unit 1. There are no minor airports within about eight miles of the site, and no major airports within about forty miles.

2.2 Site Ownership and Control

The Commonwealth Edison Company is the sole owner of the entire property. The plant perimeter is fenced in part with agricultural type fencing and is posted at appropriate points. Control of access to the structures of Unit 2 will be by a six-foot chain link type fence surmounted by three-strand barbed wire, with any gates or gatehouses at appropriate locations either secured or attended by plant personnel. This security fencing is expected to be an extension of the existing fencing system for Unit 1.

An access road to the Dresden Island Lock and Dam (U. S. Corps of Engineers) crosses the owned tract from south to north at a distance of about 0.8 mile west of the location of Unit 2. The right of way (easement) for said road was provided to the United States government by the prior owners of the property and was made a condition of the sale to Commonwealth Edison Company.

A narrow strip of land (approximately 17 acres) located on the northeast corner of the property on the Illinois River, is leased by Commonwealth from the State of Illinois. This area is stipulated as a "buffer strip" in the lease which further directs that it remain idle.

2.3 Activities on the Site

New activities on the site will include power generation and associated operations at the proposed Unit 2. Current activities expected to be continued during operation of Unit 2 include power generation and associated operations at the existing Unit 1, some agricultural operations and some limited recreational activities.

Extant lease agreements cover use of a portion of the site for cattle grazing and field crop production. The activities have been performed by one leasee with the number of persons engaged in the work being less than five. Approximately 150 acres are used for grazing, with appropriate fencing provided in the pasture areas to control the approximately 75 head of cattle that may be present during the pasturage growing season. Field crop cultivation generally occupies about 300 acres.

Recreational activity in the form of hunting during the legally prescribed seasons occurs on the site outside the security fenced areas. Entry control of hunters is delegated to the agricultural leasee in recognition of his interest in preventing damage to livestock and crops.

No activities other than those enumerated are currently contemplated for the future.

2.4 Environs Occupancy

Residential occupancy in the immediate vicinity of the Dresden site continues to remain low. Inspection of the aerial photograph (Exhibit III-2-1) shows that within a 1-mile radius there are several residences at the Dresden Dam about 0.8 mile NW of the reactor locations, a few homes at about the same distance on top of the bluffs on the opposite shore of the river to the northeast, and several farm residences at 0.8 to 1.0 miles to the south and southwest. In addition, there is a cluster of about 20 cottages on the west shore of the Kankakee River about 0.7 mile from the reactor location. Most of these are occupied only part-time for recreational purposes. Comparison of the USGS map used in Exhibit III-2-2 which was based on aerial photographs taken in 1952, with the 1964 Aerial Photograph shows that only in this cottage area has there been any increase in the number of roofs visible.

Land usage and population in the environs is summarized in Section III-3. It is noted that no new small village population nucleus has developed near Dresden within the past 15 years; and also that no small village of as many as 100 residents exists within 3 miles of the site. Within 5 miles, the largest center is Channahon (pop. 1,200) 3-1/2 miles to the northeast; within 10 miles, the county seat of Morris (pop. 7,935) 8 miles to the west represents the most heavily occupied octant of the compass. The total 10 mile radius population of about 23,000 has increased less than 10% in the 1950 - 1960 census interval.

There are only two "population centers" within 25 miles of Dresden. Joliet, centered about 14 miles to the northeast, increased from 52,000 to 67,000 in the census interval, but apparently over one-half of this increase was due to annexation. Aurora, 25 miles to the north, increased from 51,000 to 64,000 but with similar significant contribution from annexation.

Within a 10-mile radius, the environs are used principally for agriculture, in abandoned strip mines, and for the large Joliet Arsenal reservation. No significant changes have occurred in 10 years, and none are currently known or foreseen.

2.5 Site Geology

The recent study of the geology of the Dresden site was made by Dames and Moore, Consultants in Applied Earth Sciences, Soil Mechanics, Engineering Geology, Geophysics. Work was performed by their San Francisco and Chicago offices, and some of the core testing was done in their New York laboratory.

The previously available geological and associated data and reports for the Dresden area were reviewed, additional background data were collected, and a field reconnaissance of the area was performed by a geologist. The results of the 69 previous borings on the Dresden site were studied, and two additional test borings to the approximate 100 foot depth were made in March 1965 in the immediate area of the Unit 2 principal structures. Samples of the overburden soils and continuous cores of the underlying rock were obtained. Representative cores of rock were subjected to unconfined compression tests, density tests, and laboratory dynamic tests to evaluate the compressional wave velocity and the shear modulus of the various rock strata encountered. Using small explosive charges, tests were performed in the test borings to measure the in-place compressional wave velocities of the various strata present.

The Dames and Moore report of the currently applicable portions of their work is presented as Section III-2. The results of the Illinois State Geological Survey's analyses in 1957 of the previous records and cores from the previous 69 test borings and from other wells in nearby areas are summarized.

The generalized geologic column for the site consists of an upper layer of Pennsylvanian Pottsville sandstone of variable thickness which in the two new borings showed a thickness of 40 to 50 feet. Next below is a layer of about 15 to 35 feet of Ordovician Maquoketa Divine limestone based on a 65 foot layer of Maquoketa dolomitic shale. The Ordovician system has a total thickness approaching 1000 feet, with the Cambrian system next below. Brecciated rock is found on some cross sections and is indicative of ancient faulting. The geologic evidence indicates that these faults are inactive.

Laboratory tests showed that unconfined ultimate compressive strength on boring samples ranged from 2,000 to 15,000 pounds per square inch on most samples. Laboratory wave velocity propagation tests showed 4,000 to 15,000 feet per second, and the field testing in the two borings was generally consistent with the laboratory findings.

2.6 Hydrology

The Harza Engineering Company, Chicago, Consulting Engineers - River Projects was retained to advise on the characteristics of the river systems of interest. Their report of applicable findings is given in Section III-5.

The Dresden site at the confluence of the Des Plaines and Kankakee Rivers is at the location considered to divide the upper and lower parts of the Illinois River system. The normal pool elevation due to the adjacent Dresden Island Lock and Dam is 505 feet, with a maximum historical elevation of 506.4. Nominal ground elevation is about 516 feet at the location for the principal structures of Unit 2.

River system flow data applicable to the Dresden site for the years 1961-1964 show that river flow exceeded 3,000 cubic feet per second (cfs) on 98% of the days, 3,600 cfs on 93% of the days, 4,000 cfs on 87% of the days, 5,000 cfs on 63% of the days, and 6,000 cfs on 48% of the days.

The principal usages of the water of the Des Plaines River below Lockport and of the Illinois River are for navigation, sewage disposal and dilution, and condenser cooling water for power plants. At and below Peoria, the Illinois River is also used for domestic water supply. The Kankakee River is not navigable and is used for domestic supply. Corps of Engineers future planning envisions a second lock at the Dresden Dam.

River system water temperatures fluctuate principally due to the seasons. The U. S. P. H. S. in a 1963 report said that due to river usage, the net rise in temperature in the upper portion of the waterway system was about 9°C. The chemical composition of the river waters was studied in detail during 1961 - 1962, as were the biological and bacteriological conditions. The over-all effect is that the lower river system is biologically degraded, and that most sampling stations on the upper and lower system showed evidence of excessive pollution.

2.7 Regional and Site Area Meteorology

Murray and Trettel, Certified Consulting Meteorologists, Northfield, Illinois, have been retained to advise on regional meteorology characteristics, and the summary of their recent studies is given in Section III-6. Additional studies of site atmospheric diffusion characteristics by Nuclear Safety Engineering, General Electric Company are reported in Section III-7.

The site is located in typical "rolling prairie" Illinois terrain. The only major topographic influence, meteorologically speaking, in the area is Lake Michigan, but this is 45 miles to the northeast and is considered to have an insignificant effect on the site climatology.

Maximum temperature in the area, based on the July, 1949 - June, 1955 Argonne National Laboratory data, is 97°F, and the minimum is -19°F.

Normal annual precipitation in the area is 33.18 inches. Within a 24 hour period a maximum of 6.24 inches has been recorded. Average yearly snowfall is 37.1 inches, with a maximum of 66.4 inches recorded in the 1929-30 winter season.

In the 50-year period, 1913-1963, four tornadoes have been reported in Grundy County. Of 140 tornadoes reported in the state as a whole, 52 are considered "destructive," i.e., caused $50,000 damage or more and/or at least one death. Average area covered by reported tornadoes is about 8 square miles. The shortest path is 1 mile, the longest 163 miles. Width of paths range from a minimum of 34 yards to 4 miles maximum. No tornado wind velocity information is available.

Annual wind frequencies show a rather uniform distribution of wind direction. The most frequent wind directions are from the west and south sectors (22-1/2 degrees). Average wind speed at the site at the 15-foot level is about 8 mph. Maximum wind velocity reported in the area of the site is 109 mph unofficially reported at Joliet on April 3, 1956, and on April 30, 1962 (the official Weather Bureau station closed in 1952). This is a fastest gust reported during heavy thunderstorms and scattered tornadic activity. The fastest mile of wind reported at various locations in the site area is 87 mph at Chicago and 75 mph at Peoria.

Hourly wind direction variability at the site shows that an average direction range (angular change in direction) is 120 degrees in a 1-hour period, for all wind speed conditions combined. During 0 - 3 mph wind speeds, the average range in direction is 100 degrees. Approximately 87% of the time when the wind speed is 0 - 3 mph (or 98.3% of all wind speeds) the wind direction range is 60 degrees or more, which corresponds to a value of the diffusion parameter $\sigma_\theta \bar{u}$ of 20 degree-mph or 0.16 radian-meters/second.

2.8 Seismology

The Dresden site area is placed in Zone 1 (zone of minor damage) on the seismic probability map of the 1958 Uniform Building Code. The August 1958 Seismic Regionalization map by Richter gives general predictions of probable maximum intensity, and, recognizing that lines between the areas of differing intensity are approximations only, shows the Dresden region as Modified Mercalli 7 to 8.

Only several earthquakes of significant intensity in northern Illinois have been reported since 1800, and none has been accompanied by clear-cut surface faulting. A quake on May 26, 1909, caused moderate damage in Aurora, Bloomington, Chicago, and Joliet, and may have been of intensity MM7 in the Dresden area. A quake on January 2, 1912, had a reported intensity of MM6 at Aurora, Yorkville, and Morris, and probably was of similar intensity at Dresden. Consideration of an intensity of MM7 for the Dresden region appears appropriate.

The engineering consulting firm of John A. Blume and Associates, San Francisco, has been retained for advice on seismology, and they have consulted Dr. Perry Byerly, Oakland, California, on the seismicity of the site region. The consultant's findings are reported in Section III-4.

2.9 Environs Radioactivity Monitoring

The natural-and-man-made radioactivity of the environs of the Dresden site is surveyed by several monitoring programs. The long-established and continuing program of the Argonne National Laboratory monitors a radius of the order of 100 miles, thus encompassing the Dresden area, and includes one monitoring point 3 miles north of Dresden. An initial series of river samples was analyzed in 1956-7 by the National Aluminate Company under contract to the General Electric Company. The monitoring program of the State of Illinois Department of Health includes sampling of air and water near the Dresden site starting in November 1959. The continuing program sponsored by the Commonwealth Edison Company was started in September 1958, and typically includes some 3000 to 4000 radioactivity analyses and survey instrument readings each year.

Particulate radioactive material in the air is dominated by fallout from weapons testing, reaching a beta emitter peak of 1.3×10^{-11} $\mu c/cc$ in June of 1963 compared to about 10^{-12} $\mu c/cc$ in late 1964.

External gamma radiation of 2 to 3 milliroentgens per week is from natural background cosmic and ground sources, and is not significantly altered by weapons testing.

River water concentrations show a natural background of 1 to 5×10^{-8} $\mu c/cc$ due to natural radium, uranium, and radio-potassium, and have shown an order of magnitude increase during the 1963 peak weapons testing fallout.

Biological samples from the river, and vegetation and milk samples also reflect trends ascribable to weapons testing.

The over-all findings have been in general agreement with other local programs and with the national fallout surveillance network results.

I INTRODUCTION AND SUMMARY

I-3 PLANT DESIGN BASES DEPENDENT UPON THE PLANT SITE AND ENVIRONS CHARACTERISTICS

3.0 PLANT DESIGN BASES DEPENDENT UPON THE PLANT SITE AND ENVIRONS CHARACTERISTICS

Information relating to the Dresden site and environs is included in Section III (Volume III) of this report and summarized in Section I-2.0. It is intended to use this information as applicable to the design of Dresden Unit 2. Several design bases are presented in this section.

3.1 Off-Gas System

Dresden Unit 2 is designed to use the same stack as Dresden Unit 1. Consequently, the current stack release limits will continue to apply. At present these release rates are as set forth in the Dresden 1 Operating License DPR-2, as amended, and are in compliance with 10CFR20.

3.2 Liquid Waste Effluent

Dresden Unit 2 will use the same discharge canal as Unit 1. Therefore, current license liquid release rate concentration limits will continue to apply. The release rate concentration are those described in the Dresden 1 Technical Specifications and are in compliance with 10CFR20.

3.3 Wind Loading Design

All structures will be designed to withstand the maximum potential loadings resulting from a wind velocity of 110 mph. The design will be in accordance with standard codes and normal engineering practice.

Structures, where failure could affect the operation and functions of the primary containment and process systems, will be designed to assure that safe shutdown of the reactor can be achieved considering the effects of possible damage to these structures when subjected to the forces of short term tornado loadings up to 300 mph.

3.4 Geology

The geology of the area indicates that bedrock loading capability ranges from 2000 to 15,000 psi. These values are well above normal high load footing design values. Consequently, no problems or restrictions beyond normal design practice are anticipated.

3.5 Seismic Design

The seismic design for critical structures and equipment for this station will be based on dynamic analyses using acceleration or velocity response spectrum curves which are based on a ground motion of 0.1g.

The natural periods of vibration will be calculated for buildings and equipment which are vital to the safety of the plant. Damping factors will be based upon the materials and methods of construction used.

Earthquake design will be based on ordinary allowable stress as set forth in the applicable codes, but more conservative because the usual one-third increase in allowable working stresses due to earthquake loadings will not be used. As an additional requirement, the design will be such that a safe shutdown can be made during a ground motion of 0.2g.

The foregoing design criteria are for critical items only, that is, for Class I items. Class I items are defined as structures (buildings and equipment) which are vital to the safe shutdown of the plant and the removal of decay heat.

Class II items will be designed following the normal practice for the design of power plants in the state of Illinois. Class II items are those structures (buildings and equipment) which may or may not be required for operation of the power plant, but which are not required for safe shutdown.

I. INTRODUCTION AND SUMMARY

I-4 SUMMARY DESCRIPTION OF THE FACILITY

4.0 SUMMARY DESCRIPTION OF THE FACILITY

The addition of Unit 2 at Commonwealth's Dresden Nuclear Power Station is consonant with the original plans for development of this 953-acre site which began with the construction of the original Dresden Nuclear Power Plant which hereafter must be referred to as Dresden Unit 1. Construction of Unit 2 for net electrical power output of 715,000 kW is scheduled for completion in early 1969 in order to meet anticipated demands for power in Commonwealth's service area of Chicago and Northern Illinois.

To meet this requirement, General Electric has undertaken to furnish a complete nuclear power plant to be licensed for operation initially at power levels up to approximately 2,300 MWt. To provide assurance that this objective can be safely met and to achieve maximum economic benefit in reduced construction and operating costs, the plant will be designed for ultimate operation at power levels of about 2,600 MWt. However, authority to operate at power levels in excess of 2,300 MWt will not be sought until such time as operating experience and requisite tests shall have demonstrated that an increase in power level is feasible.

4.1 General

Unit 2 will be a single cycle, forced circulation, boiling water reactor substantially similar, except for a modest increase in size and capability, to the reactors recently authorized for construction at the Oyster Creek Nuclear Power Plant of Jersey Central Power and Light Company (AEC Docket 50-219) and the Nine Mile Point Nuclear Power Plant of Niagara Mohawk Power Corporation (AEC Docket 50-220), each of which is scheduled for operation in 1967. The plant will incorporate numerous technological developments in reactor engineering which have been successfully demonstrated in the operation of the following domestic and foreign nuclear power plants built by General Electric:

The 210,000 kWe dual cycle BWR Dresden Nuclear Power Station for Commonwealth Edison Company and the Nuclear Power Group, in operation since 1960.

The 160,000/240,000 kWe dual cycle BWR Garigliano Nuclear Power Station for Societa Elettronucleare Nazionale (SENN) in Italy. Criticality was achieved on June 5, 1963; first electricity in January 1964, and full power output on May 24, 1964.

The 15,000 kWe natural circulation BWR Kahl Nuclear Power Plant for Rheinisch Westfalisches Elektrizitatswerk (RWE) in Germany, in operation since early 1961.

The 50,000/75,000 kWe single cycle BWR Big Rock Point plant for Consumers Power Company. Criticality was achieved on September 27, 1962; first electricity on December 8, 1962, and full power output on March 21, 1963.

The 50,000/60,000 kWe natural circulation BWR Humboldt Bay plant nuclear unit for Pacific Gas and Electric Company. Criticality was achieved on February 16, 1963; first electricity on April 18, 1963, and full power output on May 4, 1963.

The 12,500 kWe single cycle BWR Japan Power Demonstration Reactor power plant for the Japan Atomic Energy Research Institute. Criticality was achieved on August 22, 1963; first electricity on October 26, 1963, and full power output in November 1963.

The 5,000 kWe Vallecitos Boiling Water Reactor (VBWR) power plant, operated in conjunction with Pacific Gas and Electric Company from 1957 to 1963.

The only significant development to be incorporated in Unit 2 which has not already been demonstrated by reactors now in operation or will not have been demonstrated by reactors now under construction will be the use of jet pumps in the forced recirculation system. Jet pumps have been used for many years in a variety of applications where simplicity, ruggedness, and lack of moving parts are prime factors. A program has been established to demonstrate the feasibility of their application in boiling water reactors such as Unit 2.

4.2 Reactor and Controls

The reactor will consist of a core comprised of approximately 724 fuel assemblies containing a total of approximately 356,000 pounds of slightly enriched (an average of about 2.0%) uranium dioxide. The core will be assembled in modules, which have been used in all General Electric reactors, of four fuel assemblies clustered in the interstices of a cruciform control rod. The fuel cladding will be Zircaloy-2 which has been proven to be highly satisfactory in Dresden Unit 1 for exposures in the range of 14,000 MWD/short ton. The initial core of Unit 2 will be designed for an average exposure of 15,000 MWD/short ton.

Reactivity control of the nuclear core will be achieved by 177 cruciform control rods of the same type as have been used in Dresden Unit 1 since 1961, i.e., an assembly of sealed stainless steel tubes, 3/16 inch in diameter and 12 feet long, filled with compacted boron carbide powder and held in the cruciform array by a stainless steel sheath. The control rods, located in the reactor core, are positioned by the hydraulically operated drive mechanisms which enter through the bottom of the vessel. The control drive mechanisms will be individually activated with a capability of fully inserting a completely withdrawn rod in 3-1/2 seconds. Only a single rod may be withdrawn at any time at a maximum rate of 3 inches per second. The reliability of such control rods and drive mechanism has been demonstrated by their use in Dresden Unit 1 and subsequently-built General Electric reactors. None of such control drives has ever failed to scram when called upon. Use of the bottom-entry control rods provides improved fuel cycle performance through the concentration of control in the most reactive (lower) regions of the core, adequate control of equilibrium cores at exposures of 20,000 MWD/T, or more, without use of liquid poison control systems, and simplified access to the core for refueling and to the drive mechanisms for servicing.

A control rod reactivity value limiting device, called a rod worth minimizer, will be used with the Dresden Unit 2 reactor. The rod worth minimizer is coupled to an interlock system which assures that the maximum control reactivity associated with any single rod under all operating conditions is less than 2.5 percent $\Delta k/k$.

In addition to the control rods, reactivity control during the early life of the initial core will be aided by use of temporary poison curtains made of boron stainless steel hung from the upper core grid and extending downward between the fuel assemblies. These temporary poison curtains will be removed subsequent to the initial operation of the plant. The need for the curtains is obviated as core reactivity is reduced and all curtains will be removed prior to reaching core equilibrium.

In order to provide a continuous and immediate indication of flux and power conditions in the reactor during operation, in-core neutron monitors will be provided in a uniform pattern throughout the core. The successful development and operation of in-core monitors for Dresden Unit 1 and subsequent plants has demonstrated the reliability of this system to provide for safe operation and economic fuel burnup. In addition to this monitoring system, other proven neutron monitoring systems inside the reactor will be available for use during source-to-criticality and criticality-to-rated-power phases.

The reactor will be designed so that the critical heat flux ratio will not be less than 1.5 at the peak. Extensive experimental programs have been carried out by General Electric to establish critical heat flux design limits. The design limit will be established at levels below those confirmed as safe by all experimental results to provide additional conservatism. Experience with other reactor designs and calculations performed for these designs together with experimental data show that with the selected steam quality and corresponding channel flow, power and steam volume fractions will be well within the limits of the critical heat flux and hydraulic stability.

4.3 Reactor Vessel

The reactor core, control rods, and in-core instrumentation will be contained in a pressure vessel which will be designed, fabricated, and tested in accordance with the ASME Boiler and Pressure Vessel Code, Section III, and all applicable State regulations. The base material will be low-alloy steel clad on the interior with stainless steel. Fine-grained steels and advanced fabrication techniques will be used to minimize radiation effects. The design will be such that vessel material neutron exposure of energy levels greater than 1.0 MeV will be limited to less than 1×10^{19} nvt within a 40-year operating life. Vessel material surveillance samples will be located within the core region to enable periodic monitoring of exposure and material properties.

The vessel top head closure seal will utilize two concentric metal O-rings, and the region between the rings will be monitored for leakage.

The vessel will be mounted on a supporting skirt resting on a concrete-and-steel structure which will be integral with the reactor building foundation. Lateral stability for the top of the vessel will be provided by matched sets of guides attached to the vessel and the surrounding drywell structure. These guides allow axial and radial vessel expansions and provide ample support even under earthquake conditions.

Steam outlet lines will be attached to the vessel body rather than the vessel head, thus eliminating the need to break flanged joints in the steam lines when removing the vessel head for refueling. Safety valves will be mounted on nozzles in the reactor steam lines. Another design feature that facilitates refueling will be the removable seal between the vessel and the surrounding drywell structure, which permits flooding of the space above the vessel.

The major internal reactor components, other than the core and other elements previously discussed, will include the core shroud, the steam separator assembly, the steam dryer assembly, and the jet pump system. All will be made of stainless steel or other corrosion-resistant alloy. Location of the steam separation within the reactor vessel permits the elimination of the external steam drum and associated riser and downcomer piping used in earlier plants, and results in an unusually compact plant design. The same system is incorporated in the design of the KRB, Tarapur, Oyster Creek, and Nine Mile Point reactors.

4.4 Recirculation System

The jet pump recirculation system employs water jet pumps and centrifugal pumps in combination to provide forced recirculation coolant flow for the boiling water reactor. With the jet pumps located within the reactor vessel, in the peripheral annulus around the reactor core, only a portion of the coolant will be extracted from the vessel and returned by the centrifugal pumps at a pressure sufficient to provide the jet pump nozzle or "driving" flow. The high-energy driving flow imparts momentum to the "driven" flow and the combined flow provides the total reactor core recirculation flow required. The application of jet pumps permits the use of a basic two-loop system. This simplification of the layout and design of the drywell and reactor external loops results in compactness of the drywell. Maintenance will be reduced also since there will be only two loops rather than the six loops that would otherwise be required. The natural circulation flow rate in a jet pump reactor will be substantially higher than for previous centrifugal pump designs and, consequently, safety aspects will be improved in case of loss-of-power to the recirculation pumps. It is for these reasons that jet pumps will be used in Unit 2.

Plant load-following characteristics of the single cycle boiling water reactor in combination with the turbine assure performance comparable to modern fossil-fueled plants. By controlling recirculation flow and without requiring changes in control rod settings, the plant will respond to ramp changes at a rate of approximately 30 percent per minute.

4.5 Containment

The reactor vessel and the recirculation system will be contained within a sealed steel pressure vessel, the drywell. The drywell together with the suppression chamber, also a sealed steel pressure vessel, comprise the pressure suppression containment system which provides the primary containment. Normally the drywell will be filled with air at near atmospheric pressure. Vents will lead from the drywell into a pool of water in the suppression chamber. In the very unlikely event of a break in the reactor primary system, water and steam would escape causing a rise in drywell pressure. Air, steam, and water would then flow from the drywell through the vents to the water pool, where the steam would be condensed.

The arrangement and design conditions of the pressure suppression system for this plant have been substantiated by the extensive testing and development programs conducted by Pacific Gas and Electric Company and General Electric Company, sometimes referred to as the "Moss Landing Tests." This type of primary containment has been approved for use in the Oyster Creek and Nine Mile Point reactor plants.

The drywell vessel, the vent system, and the suppression chamber will be carbon steel pressure vessels designed, fabricated, erected, and tested to the provisions of Section III of the ASME Boiler and Pressure Vessel Code for Class B vessels (containment).

The pressure suppression system will be the primary barrier in a multi-barrier containment system. The primary barrier will be sealed during operation and the temperatures will be maintained at a reasonable level (135 to 150°F maximum) by recirculating the drywell air across forced draft air cooling units which, in turn will be cooled by a closed loop cooling water system. A slight vacuum will be established and maintained within the primary barrier to provide for eventual continuous leakage monitoring.

Piping penetrating the primary barrier will be furnished with isolation valves which close automatically on appropriate signals of abnormal conditions. All influent and effluent pipes which connect to the nuclear boiler or will be open to the drywell free air space have two isolation valves in series, while lines which will neither connect to the nuclear boiler nor open into the drywell, but which, in the case of pipe failure inside the drywell, might discharge radioactive materials outside, will be equipped with at least one shutoff valve.

Auxiliary and standby cooling systems will include a shutdown cooling system, an isolation condenser system, a core spray system, a core flooding system, a primary containment spray system, and a suppression pool cooling system. The shutdown cooling system removes reactor decay heat during normal shutdown operations. The isolation condenser system will be a high-pressure system for removing reactor decay heat in the event that the main condenser is not available for the purpose or containment isolation has taken place. The core spray system removes fission product decay heat in the event of a loss-of-coolant accident. The core flooding system will be provided to refill the inner reactor vessel rapidly in the event of a loss-of-coolant accident. The primary containment spray system and the suppression pool cooling system will be used to reduce containment pressures subsequent to an accident.

The piping penetrations in which movement provisions will be made are generally the thermally hot lines such as steam pipes and other reactor system lines. For these penetrations the design includes a seal bellows and a guard pipe to protect the bellows. Provisions will be made to make the penetration readily adaptable to periodic leakage testing during the life of the containment vessel.

The cold piping penetrations normally will be welded directly to nozzles in the containment shell. No specific provisions will be made for periodic leakage testing.

Electrical penetrations will be of the double bulkhead type sealed at each bulkhead and with provisions for periodic testing.

Hatches and other removable covers on openings will be provided with double gaskets. This feature permits pressurizing between the gaskets to check leak tightness whenever such covers are replaced.

Vents from the primary suppression system, such as the purge lines, will be routed to the stack via the emergency gas treatment system. These vents will normally be closed.

The secondary barrier will be the reactor building, a rectangular-walled structure designed to enclose the pressure suppression system completely. The reactor building structure will be reinforced concrete up to the refueling floor and above this floor will be steel frame with insulating metal siding; the siding will be installed with sealed joints.

The reactor building provides containment for possible incidents originating outside the drywell. The leak rate design of this building provides for a maximum of 100 percent of the building volume inleakage per day at one-fourth inch of water vacuum in the building. An emergency gas treatment system will be provided consisting of exhaust fans discharging infiltrating air to the stack via high efficiency particulate and charcoal filters for fission product decontamination. On high radiation signals in the reactor building the appropriate building penetrations, including the main ventilation system ducts, will be closed and the emergency gas treatment system will automatically be placed in operation.

Contained within the reactor building will be the systems and support facilities for the reactor. Included will be the reactor cleanup system, the reactor shutdown system, the reactor isolation condenser system, and the reactor control rod drive hydraulic system. In addition all refueling functions will be provided inside the building. The new-fuel storage vault and the spent fuel storage pool will be located in the reactor building.

The equipment and procedures used in handling and storage of fuel will be designed to permit safe refueling of the reactor with a minimum of outage. The equipment provided to handle the fuel safely from its arrival at the plant until shipped for reprocessing will include a new (dry) storage vault located on the reactor operating floor, fuel storage pool, and the fuel and component handling system (tools, grapples, and hoists).

4.6 Turbine-Generator System

Saturated steam generated in the Unit 2 reactor at 1015 psia passes directly to the turbine where the pressure at the throttle is 965 psia. Steam exhausts at a pressure of 1.5 inches of mercury absolute to the condenser. After passing through the air ejector and gland seal condensers the condensate will be processed through a full flow demineralizer to remove corrosion products and such minor amounts of radioactive materials as may be present. After four stages of feedwater heating, water will be returned to the reactor at 334°F.

The turbine, generator, feedwater heaters, condensate pumps, and condensate demineralizers will be situated in the turbine building to the west of and adjacent to the turbine building for Dresden Unit 1. The turbine building will be a reinforced-concrete structure up to the turbine deck with walls of the of the thicknesses necessary to provide required radiation shielding. The floors over areas requiring shields will be of suitable thickness. All floors except the few cases where grating is used will be of reinforced concrete. Above the deck, the structure will be steel frame with insulated, protected metal siding. A lightweight, precast concrete slab deck roof will be supported on girders and fill-in beams and will be covered with built-up roofing. The walls up to the operating floor are of the thicknesses necessary to provide required radiation shielding.

4.7 Radioactive Wastes

Radioactive wastes are classified, in general, as gaseous, liquid, and solid wastes. Disposal systems will be provided to safely and efficiently process these wastes. The over-all system designs will be directed toward discharge of radioactive waste products well within the limits established by the United States Atomic Energy Commission set forth in 10CFR20 and other applicable regulations. The plant will be operated within the limits of 10CFR20. Radioactive gases entering the off-gas system will be held up for short-term decay of short-lived isotopes, then routed to the existing Dresden stack for dispersion to the atmosphere. The radioactive liquid waste system will be capable of processing and disposing of all liquid wastes resulting from operation of Unit 2. The function of this system will be to collect, treat, store, and dispose of treated liquids by return to condensate systems, storage awaiting disposal off-site, or disposal after substantial dilution with cooling water to the Illinois River. Solid radioactive wastes resulting from operations and maintenance of the plant will be appropriately treated, packaged, and stored for ultimate shipment off-site for disposal.

The waste treatment facility will be located in the radwaste building next to the reactor building. The radwaste building will be a two-floor concrete structure containing the control, processing, and storage areas necessary to operate the solid and liquid waste processing equipment. The guide lines for building arrangement are controlled access, adequate shielding, proper ventilation, convenient operation, and economy of space.

I INTRODUCTION AND SUMMARY

I-5 IDENTIFICATION OF CONTRACTORS

5.0 IDENTIFICATION OF CONTRACTORS

The Unit 2 addition to the Dresden Nuclear Power Station will be designed and built by General Electric Company as prime contractor for Commonwealth Edison Company. General Electric has undertaken to provide a complete, safe, and operable nuclear power plant ready for commercial service in February, 1969. The project will be directed by General Electric from the offices of its Atomic Power Equipment Department in San Jose, California, and by General Electric representatives at the plant site during construction and initial plant operation. General Electric has engaged the architect-engineering services of Sargent and Lundy, Incorporated, Chicago, Illinois, to provide the design of the non-nuclear portions of the power plant and to prepare specifications for the purchase and construction thereof. Commonwealth will review the designs and construction and purchase specifications prepared by Sargent and Lundy and General Electric to assure that the general plant arrangements, equipment and operating provisions will be satisfactory to it.

The plant will be constructed under the general direction of General Electric and through a construction management organization at the site, utilizing appropriate construction, erection, and equipment subcontracts. Preoperational testing of equipment and systems and initial plant operation will be performed by Commonwealth personnel under the technical direction of General Electric. Personnel to be provided by Commonwealth for plant operation will be drawn largely from its experienced operating staff of Dresden Unit 1, trained and qualified in the startup and several years of operational experience of this boiling water reactor. The plant will be turned over to, and responsibility for its subsequent operation will be assumed by, Commonwealth after completion of a demonstration of plant operational capability at a specified plant output.