May 28, 1970

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D. R. Muller, Chief, PWR Branch #1, DRL

ACRS INPUT FOR INDIAN POINT 2

Enclosed is our input for the Indian Point Unit No. 2 ACRS Report.

P. W. Howe, Chief
Site, Environmental & Radiation
Safety Group, DRL

Enclosure:
ACRS Input - I.P. 2

cc w/encl:
P. A. Morris, DRL
R. C. DeYoung, DRL
K. Kniel, DRL

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UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

May 28, 1970

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SITE

Description

The Indian Point site is located in upper Westchester County, New York approximately 24 miles north of the New York City boundary line. Indian Point Unit No. 2 is located adjacent to and north of Unit No. 1. This site has most recently been reviewed by the Committee in connection with the construction permit review of Unit No. 3. For this reason, we have presented a summary of the important site related features below and emphasized those areas in which our current review differs from that of the construction permit review of Unit No. 3.

Population Distribution

The population in the vicinity of the site is large. The estimated population distribution is presented below. For comparison, the Zion distribution is also presented.

CUMULATIVE POPULATION

	Indian Point			
Distance (Miles)	1960	1980	1960	1985
1	1,080	2,100	1,000	2,340
2	10,810	20,900	8,800	25,600
3	29,630	59,520	18,300	50,000
4	38,730	78,800	29,700	75,000
5	53,040	108,060	52,600	106,000
10	155,510	312,640	188,800	390,000

The minimum exclusion distance from Unit No. 3 is 520 meters and the nearest corporate boundary of Peekskill, the population center, is approximately 800 meters (0.5 mi.) from the unit. Using these figures, a literal interpretation of 10 CFR 100, the Commission's site criteria, which states that the population center distance should be at least 1-1/3 times the low population distance, would require the outer boundary of the low population zone to be less than 600 meters from the unit. Nevertheless, Con Ed has chosen 1100 meters as the outer boundary of the low population zone because of the limited population within this distance from the plant. We conclude that this is acceptable (1) because of the limited population within the low population zone (66)., and (2) because Peekskill is of a generally industrial nature in the vicinity of the unit so that resident population is low and control of the people would not be difficult.

Meteorology

The meteorology of the Indian Point site is governed by its position in a deep river valley. Consequently, wind direction generally follows a pronounced diurnal cycle with unstable (lapse) flow in the upriver direction during the daytime and stable flow in the downriver direction at night.

The applicant has presented two years of accumulated meteorological measurements taken at the site including wind speed, wind direction, temperature lapse rate data with heights. We and our meteorological consultants, ESSA, have reviewed the data presented by the applicant and conclude that the data are adequate to provide a basis for establishing routine release limits for the site. Based upon our review of this data, we feel that our standard accident meteorological model is adequately conservative for this site. This model yields slightly higher accident doses than does the model used by the applicant. The comments of our meteorological consultants at ESSA have been previously forwarded to the ACRS.

Geology and Seismology

No new developments have occurred since our construction permit reviews for Indian Point Units 2 and 3 to change our previous conclusion on the acceptability of the geological and seismological features of the Indian Point site.

A ground acceleration of 0.10g was used for the Operational Basis Earthquake and 0.15g for the Design Basis Earthquake. These values were selected at the time of the construction permit reviews for Units 2 and 3 and are acceptable for the Indian Point plants.

Hydrology

The applicant has reevaluated the potential flooding that could occur at the site due to the "Probable Maximum Hurricane" (PMH) and "Probable Maximum Flood (PMF). The applicant's analysis and our review of the consequences of the PMH are completed. The applicant estimates that the PMH would result in a water level of less than the 14.5 feet above MSL at the Indian Point site.

Both we and our consultants at CERC agree with the applicant that the 14.5 feet above MSL calculated by the applicant is a reasonable estimate for PMH level at the site. The comments of our hurricane surge consultants at CERC have been previously forwarded to the ACRS.

The applicant's evaluation of the PMF for the Indian Point site has not yet been completed. The applicant understands what analyses are necessary to evaluate the PMF levels and has agreed to perform the appropriate analyses. We will report to the Committee on our evaluation of the applicant's analysis in a supplemental report when these analyses become available.

Environmental Monitoring

The radioactivity levels in the vicinity of the Indian Point site have been measured by Consolidated Edison since 1958. The operational environmental radiation monitoring program for the Indian Point Unit No. 2 facility will be a continuation of this long standing program. The following samples will be taken: Fallout, air particulate, airborne iodine, water from various surface drinking water supplies, Hudson River water, water from lakes near the site, well water, lake aquatic vegetation, Hudson River vegetation, river bottom sediment, river aquatic biota, terrestrial vegetation, soil, and direct gamma.

We conclude that the applicant's proposed program will provide an adequate basis for evaluating the effects of reactor operations on the environs.

The comments of the Fish and Wildlife Service have not as yet been received. These comments will be forwarded to the Committee when available.

Radwaste Releases

Both the applicant and staff agree that the routine radwaste releases from the three facilities at the Indian Point will be treated as if there was only one facility at the site, that is the combined releases from the three facilities when added together will result in doses at the restricted area boundary less than those specified in 10 CFR 20.

The liquid effluent releases from the three nuclear facilities will be into the same discharge canal and then into the Hudson River. The nearest public drinking water supplies in the Hudson River are at Chelsea, New York (backup water supply for New York City) and the Castle Point Veteran's Hospital, 22 and 20.5 miles upstream of the Indian Point site, respectively. Tidal action could during dry, low fresh water river flow periods carry the radioactivity discharged into the river at the Indian Point site upstream to these river water intake points. Conservative analyses made by the applicant indicate that the concentration of radionuclides at these public-water intake would be less than 1% of the concentration of the radionuclides being discharged into the river at Indian Point. Since the releases at the site will be less than the 10 CFR 20 levels (in all probability less than 1% of the 10 CFR 20 levels based upon past experience with Indian Point 1 and other pressurized water reactors) the radioactivity levels at these intakes due to the discharges at Indian Point will be insignificant.

The routine gaseous radioactivity releases from the three nuclear facilities will be from three different stacks. The applicant has presented analyses of estimating routine gaseous effluent release rates such that the maximum off-site doses for the three combined effluents are less than those specified in 10 CFR 20. We have performed independent analyses of the routine gaseous effluent limits for these three facilities which resulted in somewhat lower allowable release rates. The differences in our calculations have not as yet been resolved. We will report to the Committee later on the resolution of these differences. However, it should be noted that even with the lower calculated staff limits, past experienced with pressurized water reactors have shown that releases will be probably be less than one percent of the calculated staff release limits. Therefore, the maximum doses off-site from the routine gaseous releases from these facilities will be well below the 10 CFR 20 level.

Iodine Reduction

Installed engineered safeguard systems designed to remove iodine from the containment atmosphere and thus minimize leakage of iodine from the containment following a loss-of-coolant accident include a chemical additive containment spray system and an impregnated charcoal adsorber system.

Sodium hydroxide is used as the additive in the spray system, with a minimum expected final solution pH$>$ 8 value. The evaluation of this system is based on operation of one out of two subsystems. The filter system consists of five units, three of which are considered operational for evaluation of post-accident doses. The air flow through each carbon bed is 8000 cfm at 50 fpm face velocity. Carbon beds are preceded by demisters and HEPA filters. The staff has evaluated these two systems in terms of combined functions, crediting the spray system solely with the capability of reducing the concentration of elemental and other inorganic forms of iodine and the charcoal adsorber system with the capability of removing both inorganic and organic iodides.

The iodine reduction effect of the alkaline spray solutions, has been evaluated using a more conservative model than that

that applied by the applicant. The removal constant for elemental iodine by the spray system derived by the staff is 4.5 hr^{-1}, based on minimum performance characteristics of the system. The comparable value stated by the applicant is 32 hr^{-1}. ¶ The materials compatibility aspects of the spray solution with exposed materials have been considered and documented by the applicant. Storage conditions have been analyzed and both the structural integrity of materials and absence of caustic corrosion have been substantiated. All major construction materials in the containment building exposed to the spray solution have been tested under simulated DBA conditions for time periods in excess of those required to assure operation of engineered safeguard systems and/or containment integrity. The only material adversely affected by the spray solution was aluminum. Preliminary analysis by the staff indicates that the solubility in water of the principal solid reaction product Al $(OH)_3$ is sufficiently large at pH≈9 to dissolve more than 1000 lbs. aluminum as $NaAlO_2$. A small fraction of this may precipitate and/or plate out in the form of some of the less soluble crystalline hydrated aluminum oxides, such as boehmite, bayerrite, or hydraagillite. Higher temperatures enhance the solubility of all of these compounds. All items manufactured of aluminum or its alloys have been itemized as to total weight and surface area. A total mass of 2265 lbs. is listed, including a contingency allowance of 250 lbs. None of these items are required for post-accident purposes and all are assumed to corrode at a finite rate. Of those, only the reactor insulation and painted surfaces have large exposed areas and are rapidly consumed. The staff has analyzed the solubility aspects in terms of the temperature dependent corrosion rates and concluded that the limiting concentration is not attained in less than 50-100 days. Therefore, the staff believes that the total quantity of aluminum used in this reactor will not adversely affect the post-accident behavior of the engineered safeguard systems (see hydrogen section).

Protective coatings have been evaluated under the requisite temperature conditions and found to survive without loss of adhesion or formation of decomposition products.

The probability of chloride stress corrosion has been determined to be acceptably low for the alkaline solution, both in terms of published data and of specific laboratory tests at ORNL. Other metals and alloys also have been shown to have suitably low corrosion rates.

The effectiveness of organic iodide removal by impregnated charcoals under conditions of high relative humidity and high temperatures has been recently investigated both at ORNL and at the Battelle Northwest Laboratory. The ORNL data were obtained from small scale experiments under a variety of conditions; the BNWL data resulted from a run in the relatively large Containment Systems Experiment (CSE) facility. The ORNL data show that impregnated charcoal effectively removes organic iodides from a flowing steam-air mixture, with decreasing efficiency as the relative humidity approaches 100% and with some residual effectiveness even after prolonged flooding of the charcoal beds. Even though total flooding of an entire unit is highly improbable, the most conservative analysis by the staff of organic iodide retention by charcoal filters is based on the measured efficiencies with a steam-air mixture following prolonged flooding of the bed. The average observed organic iodide decontamination factor for a two inch charcoal depths and downward flow under these conditions is stated as 15.3%; for upward flow, 4.3%. The air flow in the filter installation is equally divided between down and upflow. Therefore, the averaged organic iodide removal efficiency of such a bed following flooding is calculated to be at least 9.8%, based on the ORNL experimental data.

The results for Runs A-14 and A-15 in the large CSE facility, using a scaled internal recirculation filter loop system, have been reported recently. These CSE runs indicate removal efficiencies of 70-85% for organic iodides under the conditions of the experiment, with no observed flooding. In fact, a significant initial charcoal temperature rise was observed, due to the exothermic heat of adsorption of water on the charcoal, and resulted in significantly lowered surface relative humidity and enhanced performance.

In view of these results, and preponderant evidence* indicating relatively high removal efficiencies for organic iodide by impregnated charcoal adsorbers under nearly all circumstances, the staff is continuing its evaluation of the minimum effectiveness of these units under post-accident conditions. It is anticipated that considerably larger organic iodide efficiencies can be justified and the value of 10% per pass assumed here must be considered extremely conservative. However, even with this minimum value, the site satisfies the criteria of 10 CFR 100.

* Representative results are reported in ORNL-4040, ORNL-4180, ORNL-TM-2728 and IAEA Conf. on Treatment of Airborne Radioactive Wastes Paper SM 110/60

The overall iodine removal effectiveness for all available engineered safety features has been evaluated by the staff on the basis of the above spray removal constant of 4.5 $hours^{-1}$ applied to the inorganic iodine fraction only, an additional incremental removal constant of 0.49 hrs^{-1} for inorganic iodine due to the charcoal adsorber system, and a removal constant of 0.048 hrs^{-1} (based on a minimum removal effectiveness of 10% of the residual fraction per pass) for the organic iodide fraction.

Potential Offsite Doses (Rem)

	2 Hour Dose at Site Boundary		Course of Accident Dose at LPZ	
Accident	Thyroid	Whole Body	Thyroid	Whole Body
LOCA	180	4	269	7
Refueling	1460*	4	770*	2
Steam Line Break	48	0.1	30	0.1
Steam Generator Tube Rupture	21	0.8	11	0.4
Rod Ejection	250	7	130	3
Gas Decay Tank Rupture	—	9	—	4

* The applicant will need to install a charcoal trap on the ventilation system which serves the spent fuel storage pool area. This will reduce the thyroid doses by a factor of 10 and the 10 CFR 100 guideline values will then not be exceeded.

Assumptions Used in Staff Accident Assumptions

1. Steam Line Break Outside Containment

(1) Prior to the accident the plant is operating with 1% failed fuel equilibrium primary coolant activity with average energy of 0.7 MEV and a 10 gpm primary-to-secondary leakage with 10 gpm steam generator blowdown.

(2) Secondary equilibrium activity calculated assuming all iodine remains in the liquid phase with credit given for normal 10 gpm steam generator blowdown.

(3) Equilibrium activity in the affected steam generator (25% of secondary activity) and all activity in the primary system leakage released (1.7% of primary system in 2 hours and 4.3% in 8 hours) to the atmosphere without partition since all liquid in the steam generator is assumed to flash.

(4) Standard ground release meteorology and dose conversion factors.

2. Steam Generator Tube Rupture

(1) Prior to the accident the plant is operating with 1% failed fuel equilibrium primary coolant activity with an average energy of 0.7 MEV and 10 gpm primary-to-secondary leakage.

(2) Secondary system equilibrium activity determined as in 1(2) above.

(3) Blowdown of approximately 10% of the primary system volume to the secondary system.

(4) Loss of offsite power occurs requiring operation of the steam line relief valves and reliance upon steam generator boiloff to dissipate decay heat.

(5) Resulting flashing to atmosphere releases all noble gases in the primary-to-secondary blowdown to atmosphere. Equilibrium iodine in the secondary system and in blowdown from the primary system released with a water to steam partition factor of 10.

(6) Standard ground release meteorology and dose conversion factors.

3. Control Rod Ejection

(1) Prior to the accident the plant is operating with 1% failed fuel equilibrium primary coolant activity with an average energy of 0.7 MEV and 10 gpm primary to secondary leakage.

(2) Secondary system equilibrium activity determined as in 1(2) above.

(3) 10% additional fuel fails as a result of the control rod ejection with the release of 20% of the noble gases and 10% of iodines in the affected fuel rods to the primary coolant.

(4) Approximately 2.6% of the primary system activity (equilibrium activity and 10% failed fuel activity) is released to the secondary system in 2 hours.

(5) Loss of off-site power occurs requiring operation of the steam generator boiloff to dissipate decay heat.

(6) All the noble gases in the primary to secondary blowdown to the atmosphere and 2% of the iodine in the primary to secondary blowdown to the atmosphere.

(7) Standard ground release meteorology and dose conversion factors.

4. Refueling Accident

(1) Perforation of 204 fuel rods (one whole assembly).

(2) Gap activity in the rods is released. This is assumed to be 20% of the noble gases and 10% of the iodine in the rods with a peaking factor 1.43.

(3) The accident occurs 90 hours after shutdown. This represents a reasonable estimate of the time required to cooldown, remove the pressure vessel head and the upper internal package, and begin the refueling operation.

(4) 90% of the released iodine is retained in the water of the spent fuel pit or canal.

(5) Standard ground release meteorology and dose conversion factors.

(6) No credit given for spent fuel building confinement.

5. Design Basis Accident

(1) Power level of 3217 MW(t).

(2) TID-14844 releases (100% noble gases, 25% iodines, and 1% solids).

(3) Design containment leakage rate, 0.1% per day, for first day, and 0.045% per day thereafter.

(4) Spray removal constant for inorganic iodines of 4.5 hours^{-1}.

(5) Charcoal removal constant of 0.49 hr.$^{-1}$ for inorganic iodines and 0.048 hrs^{-1} for organic iodine (90% per pass inorganic removal and 10% per pass organic removal).

(6) 10% organic iodide fraction.

(7) Standard ground release meteorology and standard dose conversion factors.