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**PREPARATION OF
ENVIRONMENTAL REPORTS
FOR
NUCLEAR POWER STATIONS**

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U.S. NUCLEAR REGULATORY COMMISSION

CHAPTER 10

STATION DESIGN ALTERNATIVES

This chapter should show how the applicant arrived at the design of the proposed station through consideration of alternative designs of identifiable systems and through their comparative assessment.

The significant environmental interfaces of a nuclear power station will be associated with the operation of certain identifiable systems. The applicant's proposed station should incorporate a combination of these identifiable systems, each of which has been selected through a cost-effectiveness analysis of economic and other factors as the preferred choice within its category. In some instances, the interaction of these systems may be such as to require their selection on the basis of a preferred combination rather than on the basis of individual preferred systems. For example, an alternative cooling system may have to be evaluated in combination with a preferred chemical effluent system that would be used with it.

The applicant's discussion should be organized on the basis of station systems and arranged according to the following list:

- Circulating water system (exclusive of intake and discharge)
- Intake system for circulating water
- Discharge system for circulating water
- Other cooling systems (including intake and discharge where not treated in the preceding three items)
 - Biocide systems (all cooling circuits)¹
 - Chemical waste treatment¹
 - Sanitary waste system
 - Liquid radwaste systems (see Section 10.7)
 - Gaseous radwaste systems (see Section 10.8)
 - Transmission facilities
 - Other systems.

The following should be considered in preparing the discussion:

1. **Range of alternatives.** The applicant's discussion should emphasize those alternative station systems that appear promising in terms of environmental protection.

¹Systems that are subject to effluent limitation guidelines and new source performance standards of 40 CFR Part 423.

Different designs for systems that are essentially identical with respect to environmental effects should be considered only if their costs are appreciably different. The applicant should include alternatives that meet the following criteria: (1) they provide improved levels of environmental protection (in the case of systems subject to 40 CFR Part 423, the analysis should focus on alternative systems that comply with 40 CFR Part 423 but that are a better environmental solution, taking into account impacts on air quality, esthetics, etc.) and (2) although not necessarily economically attractive, they are based on feasible technology available to the applicant during the design state.

In cases where the system proposed in the application does not comply with thermal effluent limitations under Sections 301 and 306 of Public Law 92-500 [the Federal Water Pollution Control Act (FWPCA) as amended] and no disposition of any request for waiver under Section 316(a) is expected until after issuance of a construction permit, the environmental report should clearly identify the most feasible alternative cooling system that would be selected in the event that alternative thermal effluent limitations are not imposed.

2. **Normalization of cost comparison.** Alternatives should be compared on the basis of an assumed fixed amount of energy generated for distribution outside the station. Thus, any effect of an alternative on station power consumption should be discussed.

3. **Effect of capacity factor.** The projected effect of alternatives on station capacity factor should be given and explained for capacity factors of 60, 70, and 80 percent.

4. **Monetized costs.** The acquisition and operation costs of individual systems and their alternatives (as well as costs of the total station and transmission facility and alternatives) should be expressed as power generating costs. The latter will be derived from cost elements compounded or discounted (as appropriate) to their present values as of the date of initial commercial operation and will be converted to their annualized values. The method of computation is shown in Table 4. The individual cost items in this table should be used as applicable. The total cost will be the sum of:

- Capital to be expended up until the scheduled date of operation.²

- Interest to the date of operation on all expenditures prior to that date.

²For operating license proceedings, costs should be based on capital to be expended to complete the facility.

• Expenditures subsequent to the scheduled date of operation discounted to that date. In calculations, the applicant should assume a 30-year station life.³

In computing the annualized present value of station systems and their alternatives, the following cost elements are suggested:

- Engineering design and planning costs
- Construction costs
- Interest on capital expended prior to operation
- Operating, maintenance, and fuel (if applicable) costs over the 30-year life of the station
- Taxes
- Insurance costs
- Cost of modification or alteration of any other station system if required for accommodation of alternatives to maintain station capacity (see Item 2 above)
- Maintenance costs for the transmission facility (if applicable)
- Cost of supplying makeup power during a delay resulting from an alternative design choice that will not meet the power requirement by the scheduled inservice date.

5. Environmental costs. Environmental effects of alternatives should be documented and supported by available information. To the extent practicable, the magnitude of each effect should be quantified. Where quantification is not possible, qualitative evaluations should be expressed in terms of comparison to the effects of the subsystem chosen for the proposed design. In either case, the derivation of the evaluations should be completely documented.

Table 5 presents a set of environmental factors that should be considered in comparing alternative station systems in the cost-effectiveness analysis. Although incomplete, the factors listed are believed to represent the principal environmental effects of power station construction and operation that can be evaluated by generally accepted techniques. The table provides for three key elements of environmental cost evaluation:

- a. A description of each effect to be measured (Column 3).

³Use 30-year life for steam-electric generating stations. For other types of electric generating plants, use generally accepted values.

b. Suggested units to be used for measurement (Column 4). The NRC recognizes the difficulty, if not the impossibility, of using the assigned units for every item in Table 5 in each case, given the current state of the art. The applicant may elect to use other units, provided they are meaningful to the informed public and adequately reflect the impact of the listed environmental effects.

c. A suggested methodology of computation (Column 5). Computation of effects in response to each block in Table 5, e.g., 1.1, 1.2, etc., should be given without adjustment for effects computed in other blocks for the same population or resource affected. However, provision is made in Table 5 (i.e., 1.9 and 4.9) to account for combined effects that may be either less than or greater than the sum of individual effects.

In discussing environmental effects, the applicant should specify not only the magnitude of the effect (e.g., pounds of fish killed or acres of a particular habitat destroyed) but also the relative effect, that is, the fraction of the population or resource that is affected. (See the discussion in Section 5.7.)

In some specific cases, accurate estimation of an effect which the applicant believes to be very small may require a data collection effort that would not be commensurate with the value of the information to be obtained. In such cases, the applicant may substitute a preferred measure which conservatively estimates environmental costs for the effect in question, provided the substituted measure is clearly documented and realistically evaluates the potentially detrimental (i.e., worst case) aspects of the effect, and provided the measure is applied consistently to all alternatives.

6. Supporting details. In the following sections, the applicant should discuss design alternatives for each of the relevant station systems (e.g., cooling system, intake system). The discussion should describe each alternative, present estimates of its environmental impact, and compare the estimated impact with that of the proposed system. The assumptions and calculations on which the estimates are based should be presented. Engineering design and supporting studies, e.g., thermal modeling, performed to assess the impact of alternative station systems should be limited in scope to those efforts required to support the cost-effectiveness analysis that led to selection of the proposed design.

7. Presentation of alternative designs. The results should be tabulated for each station system in a format consistent with the definitions in Table 5.

The monetized costs of the proposed systems and alternatives should be presented on an incremental basis. This means that the costs of the proposed system should appear at zeroes in appropriate columns of summary

tables and costs of the other alternative systems should appear as cost differences, with any negative values enclosed in parentheses. The environmental costs are not incremental, and the tabulations should therefore show these as total costs, whether monetized or not. (If an environmental effect is considered beneficial, the entry should be enclosed in parentheses.)

In addition to the information displayed in the tables, the applicant should provide a textual description of the process by which the tradeoffs were weighed and balanced in arriving at the proposed design. This discussion may include any factors not provided for in the tabulation.

10.1 Circulating System (exclusive of intake and discharge)

The applicant should identify and describe alternatives to the proposed cooling system design. Estimates of environmental effects should be prepared and tabulated. Where cooling towers are discussed, the analysis should include variations in drift and blowdown and optional control ranges that might minimize the environmental impact to the receiving air, water, or land with respect to time or space.

When an applicant proposes to create a lake or pond for primary cooling, the environmental report at the construction permit stage should consider the effects of variations in the size of the cooling reservoir on the performance of the power station, the environmental impacts (including the loss of agricultural lands and woodlands and the products therefrom and the impacts on terrestrial and aquatic life), and the economic costs. The environmental report should also discuss the matter of making the cooling reservoir and its surroundings a multiple-use facility, including a public recreational resource, and should present the reasons for the decision in favor of or opposing such a development.

If the applicant decides to provide a recreational facility, the environmental report at the construction permit stage should contain a general plan to provide for public recreational use. The specific plan for public recreational use should be provided at the operating license stage. The plan should include a discussion of recreational needs in the area; a description (including maps and artist conceptions) of the proposed recreational facilities, lake management and fisheries stocking program, and associated landscaping; a schedule of installation, estimated costs of construction, operation and maintenance, and the source of funds to pay these costs; and estimated public use of the facilities. Describe the participation in planning, if any, by local, State, and Federal governments. A commitment to implement the plan must be made if the potential benefit is considered in balancing the costs and benefits.

10.2 Intake System

The applicant should identify and describe alternatives to the proposed intake system design, such as shoreline and offshore intakes, traveling screens (vertical, horizontal, angle-mounted, single entry—double exit), barriers (lower, electric, sound, light, bubble), perforated-pipe intakes, and infiltration-bed intakes. Estimates of environmental effects should be prepared and tabulated. Alternatives should be referenced to any requirements for intake systems imposed under Section 316(b) of PL 92-500.

10.3 Discharge System

The applicant should identify and describe alternatives to the proposed discharge system design. Estimates of environmental effects should be prepared and tabulated. Appropriate graphic illustrations of visible plumes or hydraulic mixing zones (air or water as applicable) should be included.

10.4 Chemical Waste Treatment

Alternative chemical systems that meet EPA effluent guidelines but involve differing external environmental impacts associated with ultimate waste disposal of end products should be evaluated. Management of corrosion and resulting corrosion products released with cooling tower blowdown should be treated in detail. The description should include specification of both maximum and average concentrations and dilution sources. (If a discharge is not continuous, the discharge schedule should be specified.) Any toxicity and lethality to affected biota should be documented for all potential points of exposure. Specifically, information should be sufficient to define the impacts to entrained organisms at their points of exposure, as well as the impacts beyond the point of discharge. Estimates of environmental effects should be prepared and tabulated.

10.5 Biocide Treatment

The applicant should describe alternatives to the use of biocide for control of fouling organisms, including both mechanical and chemical methods where such alternatives may be expected to have less severe environmental effects than the proposed system. The information provided on chemical biocides should be similar to that specified above for chemical effluent treatment. Estimates of environmental effects should be prepared and tabulated.

10.6 Sanitary Waste System

Alternative sanitary waste systems that meet EPA guidelines for municipal waste treatment should be

identified and discussed with regard to the environmental implications of both waste products and chemical additives for waste treatment. Estimates of environmental effect on receiving land, water, and air should be considered and tabulated to the extent that measurable effects can be identified.

10.7 Liquid Radwaste Systems

For proposed light-water-cooled reactor installations in which the quantities of radioactive material in effluents will be limited to levels that are within the numerical guides for design objectives and limiting conditions of operation set forth in Appendix I of 10 CFR Part 50, no further consideration need be given to the reduction of radiological impacts in formulating alternative plant designs. If the reactor is not a light-water-cooled reactor, the possibility must be explored of an alternative radwaste system that reduces the level of radioactivity in the effluents and direct radiation to the levels in Appendix I. In any case, for reactors to which Appendix I does not apply, the applicant should demonstrate sufficient consideration of alternative radwaste systems and their radiological output to ensure that releases from the proposed facility will be as low as is reasonably achievable.

10.8 Gaseous Radwaste Systems

Consideration of systems for the disposal of gaseous radwaste is subject to the qualifying condition noted in Section 10.7 above.

10.9 Transmission Facilities

The applicant should discuss the cost and environmental effects of alternative routes for new transmission facilities required for tie-in of the proposed facility to the applicant's system. The documentation should include maps of the alternative routes. These maps should clearly indicate topographic features important to evaluation of the routes and boundaries of visually sensitive areas. The applicant may find the documents cited in Section 3.9 helpful in this analysis. Estimates of environmental effects should be prepared and tabulated.

10.10 Other Systems

Any station system, other than those specified above, that is associated with an adverse environmental effect should be discussed in terms of practicable and feasible alternatives that may reduce or eliminate this environmental effect.