U.S. NUCLEAR REGULATORY COMMISSION

September 1975

REGULATORY GUIDE

OFFICE OF STANDARDS DEVELOPMENT

REGULATORY GUIDE 3.31

EMERGENCY WATER SUPPLY SYSTEMS FOR FUEL REPROCESSING PLANTS

A. INTRODUCTION

Paragraph 50.34(a)(3)(i) of 10 CFR Part 50 requires that an application for a construction permit for a fuel reprocessing plant include the principal design criteria for the proposed facility. The principal design criteria establish the design, fabrication, construction, testing, and performance requirements for structures, systems, and components important to safety, that is, structures, systems, and components that provide reasonable assurance that the facility can be operated without undue risk to the health and safety of the public.

The emergency water supply system (EWSS) for a fuel reprocessing plant is considered a system important to safety. Therefore, it should be designed to meet the safety demands under normal and abnormal conditions and should include redundancy to the extent necessary to maintain, with adequate capacity, the ability to perform safety functions assuming a single failure. In addition, the emergency water supply system should be designed to permit testing of the functional operability and capacity, including the full operational sequence, of each system for transfer between normal and emergency supply sources and of the operation of associated safety systems.

This guide describes sources of emergency water acceptable to the NRC staff and presents bases for the design of systems that furnish emergency water to the fuel storage pool, high-level radioactive waste storage, fire protection system, certain process vessels, and any other safety-related equipment or system requiring a supply of water to perform the design safety function, directly or indirectly.

B. DISCUSSION

The emergency water supply system (EWSS) for the cooling water system, the fire protection system, and other safety-related systems includes the water sources, the retaining structures (e.g., pond with its dam), pumps, and connecting conduits up to, but not including, the main headers of the fuel storage pool, waste storage tanks, and process vessel cooling systems; the loop distribution system of the fire protection system; or intake structures of other safety-related systems or equipment that require a supply of water. If surge storage tanks, reservoirs, or portions thereof are required to accomplish the cooling, fire protection, or other safety functions that demand a supply of water, it is important that they too satisfy the requirements of the emergency water source.

The emergency water supply system performs the following safety functions:

1. Provides water to meet the heat rejection requirements for the fuel storage pool, waste storage tanks, and certain process vessels in the event the normal operating source is disrupted,

2. Provides water to the loop distribution system of the fire protection system in the event the normal supply is disrupted, and

3. Provides water for the operation of any safety-related equipment or system in the event the normal design source is disrupted.

It is important that the emergency water supply system be capable of providing sufficient water to permit all of these safety functions to be accomplished.

An acceptable emergency water source is capable of providing adequate water for an indefinite period of time or for that period of time needed to evaluate the situation and to take the corrective action necessary to provide an adequate supply. Some finite capacity may be acceptable if it can be demonstrated that replenishment can be effected to ensure the continuous capability of the EWSS to perform its safety functions (particularly the cooling functions), taking into account the availability of replenishment equipment and the limitations that may be imposed on the mobility of such equipment as a result of an accident.

The emergency water supply system safety functions may incorporate natural or man-made features or a combination of the two. More than one water source may be involved to provide the safety function under different conditions. Because of the importance of the EWSS to safety, it is necessary to design the system to ensure its operation during and following the design-basis natural phenomena postulated for the site. In addition, it is also necessary that the safety function of the EWSS be ensured during other applicable site-related events that may be caused by natural phenomena such as stream blockage or diversion or reservoir depletion or, if applicable, events caused by acts of industrial sabotage or events caused by accidents from processing irregularities or equipment malfunction.

Combinations of less severe natural and accidental phenomena or conditions may also be considered to the extent needed for a consistent level of conservatism; for example, such combinations could be evaluated in cases where the probability of their existing at the same time is comparable to the probability associated with the occurrence of the most severe phenomena.

It is most important to have a high level of assurance that the water supply for the EWSS will be available when the need arises. In the case of natural supply sources, historical experience indicates that severe natural events may result in blockage or diversion of streams as well as changes in levels of bodies of water. Furthermore, failures of man-made portions of an EWSS are not uncommon. Because of these factors, it is desirable to give consideration to an EWSS composed of at least two water sources, each capable of performing the specified safety functions, unless it can be demonstrated that there is an extremely low probability of losing the capability of a single source. For those cases in which an applicant believes that a single water source is adequate to meet the needs of the safety function, the applicant should demonstrate that the source can withstand individually, without loss of the design safety function, each of the following events: (1) The most severe natural phenomena expected at the site with appropriate ambient conditions, but with no two or more such phenomena occurring simultaneously, (2) the site-related events that have occurred or that may occur during the plant lifetime, (3) reasonably probable combinations of less severe natural phenomena and site-related events and (4) a single failure of man-made structural features. In applying the "single failure," various mechanistic failure modes can be postulated. One can be ultraconservative and choose to assume a complete functional loss, but this is not necessarily required. For example, it is desirable to consider the consequences of a postulated major rupture of a dam (including the time-related effects of forces imposed at the time of rupture); however, it is not necessarily required that one assume the dam disintegrates instantaneously with total loss of function.

Where conduits and pumps are required as part of the EWSS, it is desirable to have at least two complete delivery systems. However, a single delivery system (conduit, pump, and valves) may be acceptable if it can be demonstrated that the capability will exist, following a natural phenomenon, to repair the damage or to install a reliable emergency line within a time period that is small in comparison with the time required to develop a hazard.

Where the EWSS includes more than one source of water, the individual water sources may have different design requirements. It is important that multiple water sources (including their associated retaining structures, required conduits, and pumps) be separated and protected so that failure of any one will not induce failure in any other so as to preclude accomplishing the safety function of EWSS. It is desirable that the complex (but not necessarily all its individual features) be capable of withstanding each of the most severe natural phenomena expected, other site-related events, reasonable combinations of natural phenomena and/or site-related events, and a single failure of man-made structural features without loss of capability of the EWSS to accomplish its safety functions. The most severe phenomena may be considered to occur independently and not simultaneously. In addition, the single failure of man-made structural features need not be considered to occur simultaneously with severe natural phenomena or site-related events.

It would be acceptable if Water Source No. 1 (say a man-made pond with a dam), connecting conduits and pumps were capable of withstanding only the safe shutdown earthquake, tornado, and drought, and Water Source No. 2 (say a stream with an existing dam) and its conduits and pumps were capable of withstanding only the probable maximum flood. It would be necessary, however, that the complex as a whole be capable of withstanding any reasonably probable combination of natural or accidental phenomena without loss of the safety functions. It is important that the EWSS, as a complex, be shown to be highly reliable by indicating that certain conditions are satisfied. For example, consider Water Source No. 2, above. Such conditions would include: (1) the stream cannot be diverted or blocked sufficiently to affect the availability of water at the connecting conduits; (2) no serious transportation accidents have occurred or can be reasonably expected;

and (3) the dam was designed to appropriately conservative requirements, has functioned properly over its lifetime, and (based on projection of the best available data) will function properly for the lifetime of the fuel reprocessing plant it serves. Compliance with these conditions would not, however, remove the need for another source of cooling water if a single failure of the dam could result in losing the safety function of this source of water.

An acceptable EWSS would be designed to permit testing of its capacity and functional operability for transfer between normal and emergency water supply with subsequent testing of each associated safety system. It is important that the transfer from normal to emergency water supply be accomplished by a method which ensures that the facility can be operated without undue risk to the health and safety of the public. In general, a method involving automatic transfer would be preferred. However, where it can be demonstrated that the design safety function of the associated systems is not impaired by delays inherent in a manual transfer method, such a method could be acceptable.

It would expedite the licensing process to include in the technical specifications a description of and schedule for tests to be performed and to include a statement of actions to be taken in the event the above tests indicate that the required capability of the EWSS is inadequate to perform its designed safety functions.

C. REGULATORY POSITION

1. The emergency water supply system (EWSS) should be capable of providing a sufficient quantity of water to satisfy (1) the safety needs of the fire protection system; (2) the safety needs of the cooling systems for the fuel storage pools, the waste storage tanks, and certain process vessels;[1] and (3) the safety needs[2] of any other equipment or system requiring a supply of water to perform its design safety function, directly or indirectly. This adequate supply of water should be provided for an indefinite period or for some finite number of days if it can be demonstrated that replenishment or use of an alternative water supply can be effected to ensure the continuous capability of the EWSS to perform its safety functions, taking into account the availability of replenishment equipment and limitations that may be imposed on "freedom of action"[3] following an accident or the occurrence of severe natural phenomena.

Sufficient conservatism should be provided to ensure that the water supply is available and that design-basis temperatures of safety-related equipment are not exceeded so as to lead to an unacceptable loss of function. For EWSS where the supply may be limited and/or the temperature of plant intake water from the source may eventually become crucial (e.g., ponds, lakes, or cooling towers, where recirculation between plant cooling water discharges and intake can occur), transient analyses of supply and/or temperature should be performed and adequate safety margins verified.

These analyses should include sufficient information to substantiate the assumptions and analytical methods used. Where possible, this information should include actual performance data for a similar cooling method operating under load near the specified design conditions, or justification that conservative values (e.g., heat transfer) have been used.

2. The EWSS complex, whether composed of single or multiple water sources, should be capable of withstanding individually, without loss of safety functions specified in regulatory position C.1, each of the following events:

a. The most severe design-basis natural phenomena expected, but with no two or more such phenomena occurring simultaneously,

b. The site-related events (e.g., transportation accident, stream diversion, or blockage) that historically have occurred,

c. Combinations of less severe natural phenomena and site-related events,

d. A single failure of man-made structural features.

3. The EWSS should consist of at least two sources of water, including their retaining structures, each with the capability to perform the safety functions specified in regulatory position C.1 above, unless it can be demonstrated that there is an extremely low probability of losing the capability of a single source.

4. There should be at least two conduits, each with a pump (if a pumping head is required), connecting the source(s) with the intake structures of the plant, unless it can be demonstrated that the capability will exist, following a natural or accidental phenomenon, to repair damage or to install an emergency conduit within a time period that is small in comparison with the time required for a hazard to develop. The conduits and pumps should be separated and protected so that failure of any one will not induce failure of any other.

5. The EWSS should be designed to permit testing of its functional operability and capacity, including the full operational sequence of the system, for transfer between

[1] These are process vessels that might self-concentrate as a result of heat generated by the fission products. Vessels in this category could include (1) dissolvers, (2) input accountability and feed adjustment tanks, (3) solvent extraction feed tanks, (4) high-level waste evaporators, and (5) waste accountability tanks.

[2] An example of such a need would be the water necessary to operate an emergency boiler supplying steam to sump and transfer jets in the high-level liquid waste storage complex.

[3] "Freedom of action" includes mobility of equipment as well as options available to the plant management.

normal and emergency supply sources, and testing of the operation of associated safety systems.

6. The EWSS should incorporate devices to detect and indicate low flow in the system or system components. These devices can be provided as an integral part of a safety system (cooling, fire, etc.) if such devices are located downstream from the intake structure (header, fire loop, etc.) for the particular system.

7. The technical specifications for the plant should include:

a. A description of and schedule for tests to be performed,

b. Provisions for action to be taken in the event that conditions threaten partial loss of capability of the EWSS.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the staff's plans for utilizing this regulatory guide.

Except in those cases in which the applicant proposes an alternative method of complying with specified portions of the Commission's regulations, the method described herein will be used in the evaluation of submittals for construction permit applications docketed after May 31, 1976.

If an applicant wishes to use this regulatory guide in developing submittals for applications docketed on or before May 31, 1976, the pertinent portions of the application will be evaluated on the basis of this guide.