# DSAR-14.18

## Safety Analysis

# Fuel Handling Accident in Spent Fuel Pool

## Rev 3

**Safety Classification:** Safety

**Usage Level:** Information

| | |
|---|---|
| **Change No.:** | **EC 69954** |
| **Reason for Change:** | **Updated for reanalysis due to reduced EAB.** |
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**Fort Calhoun Station**

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# 14.18 Fuel Handling Accident in the Spent Fuel Pool

## 14.18.1 General

Per LIC-16-0074 Fort Calhoun Station is in a permanently defueled state and cannot place or store fuel assemblies in the reactor vessel. As a result, fuel cannot be moved from the spent fuel pool into containment, precluding the possibility of a fuel handling accident occurring in containment. All discussions related to a fuel handling accident inside containment have been removed from this section.

An analysis is performed to determine the consequences of a fuel handling accident (FHA) in the spent fuel pool area. A fuel handling accident is defined as dropping of a spent fuel assembly in the spent fuel pool resulting in the rupture of the fuel cladding of a fuel assembly.

The maximum elevation to which the fuel assemblies can be raised is limited by the design of the fuel handling equipment to assure that the minimum depth of water above the top of a fuel assembly required for shielding is always present (Reference 14.18-1). This constraint applies in the spent fuel pool area. Radiation monitors located at the fuel handling area would provide both audible and visual warning of high radiation levels. The possibility of damage to a fuel assembly as a consequence of mishandling is minimized by thorough training, detailed procedures, and the design of fuel handling equipment incorporating built-in interlocks and safety features. Should a fuel assembly be dropped or otherwise damaged during handling, a radioactive release could occur in the auxiliary building.

The release path from the spent fuel pool (SFP) to the environment is through ductwork in the auxiliary building to the discharge stack (release point) (Reference 14.18-3).

The likelihood of dropping a spent fuel cask into the spent fuel pool is extremely low. The auxiliary building crane is licensed as Single-Failure-Proof and is equipped with overload alarms and safety devices. The safety features incorporated into the design of the main hoisting system of the crane preclude a cask drop accident by preventing a load drop in the event of a single failure in the hoisting or braking systems. Interlocks normally prevent the trolley from traversing any part of the spent fuel pool, which precludes the possibility of a load drop on spent fuel.
The auxiliary building crane interlocks can be bypassed under strict administrative control by using a key operated override switch. No material shall be carried over fuel assemblies in the spent fuel pool racks. A crane supervisor must be present when the override switch is operated to prevent any material from passing over fuel assemblies in the spent fuel pool.

Loads may be carried over spent fuel positioned in a cask in the cask pit as allowed by the FCS Part 72 Licensing Basis.

## 14.18.2 Method of Analysis

The FHA was reanalyzed utilizing alternative source term (AST) methods in accordance with Regulatory Guide (RG) 1.183. Control Room and site boundary doses due to airborne radioactivity releases following a FHA in the fuel pool were calculated (References 14.18-5, 14.18-6, and 14.18-11). Table 14.18-1 lists some of the key assumptions/parameters utilized to develop the radiological consequences following a FHA in the fuel pool (Reference 14.18-4).

The analysis in Reference 14.18-5, which generates the LPZ doses assumes that the fuel handling accident occurs 72 hours after reactor shutdown. The analysis in Reference 14.18-6 which generates the control room dose in Section 14.18.3 is performed at a time of 100 days after reactor shutdown. The analysis in Reference 14.18-11, which generates the EAB doses assumes that the fuel handling accident occurs 20 months after reactor shutdown. It is postulated that the accident results in damage to one fuel assembly thus releasing all of the fuel gap activity associated with that assembly. Reference 14.18-4 documents the methods used, the explicit calculations are documented in Reference 14.18-5,14.18-6, and 14.18-11. As discussed in Section 14.1 the gap fractions utilized for non-LOCA analyses at FCS are twice that recommended by RG 1.183 (Reference 14.18-4). The gap fractions were reevaluated for the replacement steam generators and replacement pressurizer (Reference 14.18-10). This allowed use of non-LOCA gap fractions obtained from NUREG/CR-5009. The FHA for the Control Room and Exclusion Area Boundary were updated for Decommissioning and use the gap fractions from NUREG/CR-5009. The FHA for the LPZ was not updated and therefore, continues to use FCS specific gap fractions developed in Reference 14.18-4. The activity (consisting of noble gases, halogens, and alkali metals) is released in a "puff" to the spent fuel pool, which has a minimum of 23 feet of water above the damaged fuel assembly.

The radioiodine released from the fuel gap is assumed to be 95% CsI, 4.85% elemental, and 0.15% organic. Due to the acidic nature of the water in the spent fuel pool (pH less than 7), the CsI will immediately disassociate, thus, changing the chemical form of iodine in the water to 99.85% elemental and 0.15% organic. The chemical form of the iodines above the spent fuel pool is 57% elemental and 43% organic. The current DSAR analysis used to generate the dose at the LPZ (Reference 14.18-5) is based on an overall effective decontamination factor of 285 while Reference 14.18-6 for the control dose and 14.18-11 for the EAB dose use a decontamination factor of 200. Any future revisions to Reference 14.18-5 based on RG 1.183 guidelines shall utilize an overall effective decontamination factor for Iodine of 200. See Reference 14.18-7 for further details. This use of overall effective decontamination factor for Iodine only applies to fuel handling accidents with 23 feet water depth per RG 1.183.

Noble gas and unscrubbed iodines rise to the water surface where they are mixed in the available air space. All of the alkali metals released from the gap are retained in the spent fuel pool water. The activity is collected by the auxiliary building ventilation system and released, unfiltered, to the environment via the auxiliary building vent stack. Since there is no means of isolating the spent fuel pool area all of the airborne activity resulting from the FHA is exhausted out of the auxiliary building in a period of two hours. The closest opening in the auxiliary building to the control room intake is the auxiliary building fresh air intake. However, the auxiliary building vent stack X/Q's were used as they bound that of the auxiliary building fresh air intake.

The event is based on a two-hour release; the worst two-hour period for the Exclusion Area Boundary (EAB) is the zero to two-hour period. The EAB, Low Population Zone (LPZ), and control room doses following a FHA in the spent fuel pool are presented in Section 14.18.3.

Table 14.18-1 - Radiological Analysis Assumptions and Key Parameter Values – Fuel Handling Accident in Fuel Pool Area

| | |
|---|---|
| Power Level | 1530 MWt |
| Number of Damaged Fuel Assemblies | 1 |
| Total Number of Fuel Assemblies | 133 |
| Decay Time Prior to Fuel Movement | 72 hours/100 days/20 months[1] |
| Radial Peaking Factor | 1.8 |
| Fraction of Core Inventory in gap | I-131 (16% / 12%[2])<br>Kr-85 (20% / 30%[2])<br>Other Noble Gases (10%)<br>Other Halides (10%)<br>Alkali Metals (24% / 17%[2]) |
| Equilibrium Core Activity | Table 14.1-5 |
| Iodine Form of gap release before scrubbing | 99.85% Elemental<br>0.15% Organic |
| Scrubbing Decontamination Factors | Elemental Iodine (500[4])<br>Organic Iodine (1)<br>Noble Gas (1)<br>Particulates (∞) |
| Overall Effective Decontamination Factor for Iodine | ~ 285[3]/200[4] |
| Rate of Release from Fuel | "puff" |
| Environmental Release Rate | All airborne activity in a 2-hour period |
| Environmental Release Point | |
| Accident in Fuel Pool Area | Auxiliary building vent stack |

[1] 100 days is used for FHA dose to the control room without credit taken for radioiodine removal by control room charcoal or HEPA filters (Reference 14.18-6) and 20 months is used for FHA dose at the EAB with a reduced EAB (Reference 14.18-11).

[2] The reanalysis performed in Reference 14.18-6 to determine control room dose utilizes updated gap fractions approved in TS Amendment 243

[3] For future revision to FHA analyses an effective overall decontamination factor for Iodine of 200 shall be used (Reference 14.18-7).

[4] The reanalysis performed in Reference 14.18-6 and 14.18-11 to determine control room dose and EAB dose utilizes a decontamination factor of 200.

## 14.18.3 Results

The total effective dose equivalent (TEDE) doses for the EAB, LPZ, and CR following a FHA in the spent fuel pool are shown below.

| Location | TEDE Dose (rem) |
|---|---|
| EAB | 0.50 |
| LPZ | 0.50 |
| Regulatory Limit | 6.3 |
| | |
| Control Room | 0.50 |
| Regulatory Limit | 5.0 |

The maximum two-hour dose for the EAB is the zero to two hour time period. All doses were rounded up to the nearest 0.5 rem.

From Reference 14.18-8 the overall effective decontamination factor ($DF_{eff}$) for a water pool (at least 23 feet deep) accounting for elemental[5] and organic iodine can be calculated using the following formula:

$$DF_{eff} = 1 / [(\%\ \text{elemental Iodine} / DF_{elemental}) + (\%\ \text{organic Iodine} / DF_{organic})]$$

where
$DF_{elemental} = 500$ (Reference 14.18-4)
$DF_{organic} = 1$ (Reference 14.18-4)

Forms of Iodine Credited for FHA

Elemental Iodine = 99.85% (95% CsI goes to elemental form in water plus original 4.85% elemental released (Reference 14.18-4, Page 39))
organic Iodine = 0.15% (RG 1.183)

The $DF_{eff}$ credited for analysis conducted in Reference 14.18-4 was calculated as follows:

$$DF_{eff} = 1 / [(0.9985 / 500) + (0.0015 / 1)] \approx 285$$

This is the $DF_{eff}$ based on assumptions and parameters listed in Table 14.18-1. For future analyses per Reference 14.18-7 a $DF_{eff}$ = 200 shall be utilized. To achieve a lower $DF_{eff}$ one can lower the credit for $DF_{elemental}$ such as shown below:

[5] Reference 14.18-8 defines the equation as $DF_{inorganic}$ and $DF_{organic}$. As noted in Reference 14.18-8, decontamination factors for elemental iodine and hydrogen iodide should be of comparable magnitude, and are not differentiated. Therefore, listing this equation as $DF_{elemental}$ instead of $DF_{inorganic}$ has the same meaning.

$DF_{eff} = 200 = 1 / [(0.9985 / DF_{elemental}) + (0.0015 / 1)]$

Solving this equation for $DF_{elemental}$ yields $DF_{elemental} = 285$.

A $DF_{elemental}$ of 285 is equivalent to stating that 99.65% of elemental iodine is retained in the pool water.

A $DF_{elemental}$ of 500 is equivalent to stating that 99.8% of elemental iodine is retained in the pool water.

Use of a $DF_{eff}$ of 200 in future FHA analysis for EAB dose is conservative and will be in accordance with commitments contained in Reference 14.18-7. The reanalysis performed in Reference 14.18-6 utilized a $DF_{eff}$ of 200.

## 14.18.4 Conclusions

The potential radiological consequences of a fuel assembly drop in the spent fuel pool are presented above and the resultant doses are well within the requirements of 10 CFR 50.67. It is, therefore, concluded that a dropped fuel assembly would not present any undue hazard to the health and safety of the public.

## 14.18.5 Specific References

14.18-1 Refueling System, Fort Calhoun Station, Unit 1, Updated Safety Analysis Report, Section 9.5, Revision 7/89

14.18-2 Radiation Monitoring, Fort Calhoun Station, Unit 1, DSAR Section 11.2.3, Revision 0

14.18-3 P&ID Drawing, GHDR 11405-M-1

14.18-4 OPPD Letter, LIC-01-0010, February 7, 2001, Application for Amendment of Operating License

14.18-5 OPPD Calculation, FC06816, Revision 2, Site Boundary and Control Room Doses following a Fuel Handling Accident in the Fuel Pool Area using Alternate Source Terms

14.18-6 OPPD Calculation, FC08557, Revision 1, Fuel Handling Accident in the Spent Fuel Pool Site Boundary and Control Room Dose

14.18-7 NRC letter, December 5, 2001, Fort Calhoun Station, Unit No. 1-Issuance of Amendment (TAC NO. MB1221), Alan B. Wang (NRC) to Sudesh K. Gambhir (OPPD)

14.18-8 Burley, Evaluation of Fission Product Release and Transport for a Fuel Handling Accident, USNRC, October 1, 1971(Attached to Reference 14.18-9)

14.18-9 OPPD Engineering Analysis, EA17-010, Revision 1, DSAR 14.18, Safety Analysis – Fuel Handling Accident in Spent Fuel Pool, Design & Licensing Basis Reconstitution Report

14.18-10 OPPD Letter, LIC-05-107, October 31, 2005, Application for Amendment of Operating License, Updated Safety Analysis Report Revision for Radiological Consequences Analysis for Replacement NSSS Components

14.18-11 OPPD Calculation, FC08791, Revision 0, Site Boundary (EAB) Dose following a Fuel Handling Accident in the Fuel Pool Area in Support of a Reduced EAB distance during Decommissioning