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# BROWNS FERRY NUCLEAR STATION RADIOLOGICAL IMPACT OF VENTILATION DAMPER CLOSING TIME DURING A DESIGN BASIS FUEL HANDLING ACCIDENT

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# RADIOLOGICAL IMPACT OF VENTILATION DAMPER CLOSING TIME DURING A DESIGN BASIS FUEL HANDLING ACCIDENT

This work was performed for Tennessee Valley Authority to review the damper ventilation closure time at the Browns Ferry Nuclear Station during a design basis fuel handling event. The closure time for these valves has been specified as 2 seconds. During actual tests it was found that the valves required more than 2 seconds to close. The concern is what the impact of the slower closing time would be on radiation dose at the site boundary. The goal is to justify fuel movement during the current outage even if the valve closure time is slower than 2 seconds. The problem was approached by evaluating the design basis fuel handling accident with several different closure times for the dampers. In all cases the off site dose rates to the public were found to be a small fraction of 10CFR100, the regulations specifying acceptable dose limits under accident conditions.

## Analysis Approach

The design basis fuel handling accident assumes that during the refueling period a fuel bundle is dropped either into the reactor pressure vessel or into the fuel storage pool. The dropped fuel bundle strikes additional bundles in the pressure vessel or fuel storage pool fracturing 125 fuel pins. Ten percent of the halogen isotopes inventory plus 10% of all noble gases inventory (except Kr 85 which is 30% of the inventory) will be released from the fractured fuel rods. A decontamination factor of 100 is applicable for the elemental iodine released at depth under water. The radioactive releases to the air space above the pool are released through the standby gas treatment system in two hours. The assumptions used to evaluate the fuel handling design basis accident event are defined in Nuclear Regulatory Commissions Regulatory Guide 1.25. Further guidance is contained in the standard review plans in NUREG 800 Section 15.74.

In order to evaluate the damper closure time the standard FSAR analysis needs to be modified to include dose rates from air by passing the stand-by gas treatment system, (SGTS). The by-pass is occurring through the ventilation system. For this evaluation it is assumed that the portion of the ventilation system dedicated to the pressure vessel pool and the spent fuel storage pool provides the by-pass flow. The gases released from the damaged fuel bundles are assumed to be confined to an air volume bounded by the perimeter of the pool and mixed to a height of no more than 4 feet above the pool. The activity released to the environment before the dampers close is the fraction of the air volume over the pool expelled through the ventilation system. For this analysis the activity released is greater for a fuel handling accident in the spent fuel storage pool than for an accident in the reactor pressure vessel. Normally the number of fuel rods fractured in a drop into the pressure pool is slightly larger than the number of rods fractured in a drop into the storage pool. This provides a bigger source for the vessel event. However, the ventilation flow from the storage pool area is twice the size of the flow from the pressure vessel area. The difference in flows transports more activity to the environment in a given time period. To evaluate damper closure time flow times of 2 seconds, 5 seconds and 10 seconds were considered. The effect of damper closure time is determined by the change in the 2 hour dose at the exclusion area boundary and the low population zone boundary.

The by-pass flow not only by-passes the SGTS filters, it is also released from a roof vent rather than the main stack. The atmospheric dispersion, X/Q, of stack releases are significantly smaller than the atmospheric dispersion factors for the roof vent releases. The result of this change is to make the dose contribution from the roof vent releases more important than if all releases were through the stack.

The evaluation of the dose was carried out using a computer code designed to model the radiological consequences of the NRC design basis accidents as defined in the regulatory guides. This is the code used by GE to provide the radiological evaluations in the safety analysis reports. The program has been qualified as an approved engineering program, following the requirements of 10CFR50. For this application the calculations were set-up with an initial time without filtration of the releases. Following the initial time period the releases are filtered. Two sets of computations were prepared. The first with

an atmospheric dispersion, X/Q, taken from the Browns Ferry final safety analysis report for elevated releases. The second set with X/Q data taken from Regulatory Guide 1.3 for ground level releases appropriate for the boundaries. The final dose evaluations become the dose contributions from the initial time period with the ground level X/Q data plus the contribution from the release of the balance of the activity through the stack. The data used to prepare the programs is summarized in Table 1.

## Results

Tabulated results from the analysis are given in Table 2. The calculated dose assumes that the by-pass activity is exhausted through a roof vent and after the dampers close the activity is processed through the SGTS and the plant stack. The maximum dose is 890 mrem thyroid plus 11 mrem whole body for 10 seconds by-pass flow. In this case approximately 75% of the activity by-passes the SGTS.

## Evaluation

Boundary dose resulting from design basis accident events have been judged by comparing the dose to the dose in 10CFR100 Reactor Site Criteria. This regulation uses radiation doses of 300 rem to the thyroid and 25 rem whole body as guides for doses to the public under accident conditions. Fuel handling accidents in the past have been judged as having acceptable consequences if the dose is a small part of 10CFR100. In the standard review plan NUREG 800 a small part has been defined as 10%. It would then be the goal to keep the calculated dose below 30 rem thyroid and 2.5 rem whole body. The calculated dose even with a change in the damper closure time to 10 seconds is much less than the guidelines.

A second basis for evaluating the event is by comparing the calculated dose rates to the Protective Action guides as established by the Environmental Protection Agency. These guides are used to establish requirements for alerts and/or evacuation. Projected whole body doses or thyroid doses less than 1 rem

require no action. The calculated results are below this criteria even with a 10 second closure time.

## Discussion

In all cases the radiation levels calculated in this analysis are greater than the fuel handling design basis accident reported in the Final Safety analysis report for Browns Ferry. In part this is because the FSAR includes no by-pass and it is assumed that no activity is released in the first two seconds. The controlling parameters affecting the magnitude of the calculated dose are the volume of air in which the released isotopes are mixed and the amount of atmospheric dispersion occurring before the boundary is reached. The assumptions of limited mixing immediately above the pool appear to be reasonable. Mixing in large volumes in a few seconds is an unreasonable assumption. The degree of mixing before being sucked into the ventilation duct will be partly dependent on where the gas bubbles surface with respect to the ventilation intakes. After the air is taken into the ventilation system there is a finite travel time to reach the dampers. The fuel storage pool is serviced by a portion of the ventilation system capable of moving 20,000 cfm. The ducts for this system are listed as holding 42 inch diameter valves. Using a duct diameter equivalent to the valve diameter the air volume travels through 34 feet of duct per second. Whether by-pass ventilation air can escape in two seconds depends on whether the signal to shut the damper comes from a monitor at the pool or a monitor in the duct. In this analysis it has been assumed that detection would come from a monitor in the duct and the dampers would not begin to close until after flow reached the monitors.

The second controlling parameter is the atmospheric dispersion from the roof vent. For releases of equal sizes the exclusion area or low population zone boundary is 100 times greater for a roof vent release than for a stack release. However, the events are not equal. The roof vent release is a burst release lasting 2-10 seconds. The stack release is a continuous release lasting several hours. In Table 2 a correction has been applied to the computed results for the roof vent releases. The site boundary doses were calculated as if the dose came

from a semi infinite cloud of activity. For a short burst the cloud is finite. A semi infinite to finite correction has been applied from Slade (1968) as reported in "Reactor Safety Study" PB-248-206 US Dept. of Commerce October 1975. This results in the by-pass flow still being controlling but with a smaller magnitude than the uncorrected semi infinite data.

## Conclusion

In this analysis the standard fuel handling design basis accident has been modified to include the effect of by-pass flow. The analysis has been conservatively handled. The mixing volume above the pools has been limited. The atmospheric dispersion from the roof vents are standard values from the Regulatory Guides. The approximations to transform semi infinite dose values to finite cloud doses assumed conservative values of cloud height. The most unfavorable pool conditions were used and it was assumed that the bundles had experienced only 24 hours of isotopic decay. In spite of all these conservative assumptions the calculated dose was only 900 mrem, thyroid plus whole body. This value is greater than the original FSAR data, but a very small part of 10CFR100 and below the EPA protective action guides requirements to issue alerts. On this basis increasing the damper closure time from 2 to 10 seconds is acceptable.

TABLE 1

ASSUMPTIONS USED TO CALCULATE THE SITE
BOUNDARY DOSE RATES

| | |
|---|---|
| Core Thermal Power (105%) | 3458 MW thermal |
| Previous Core Operating History | 3 years operation |
| Decay Time | 24 hours |
| Number of Fuel Rods Fractured | 125 |
| Fraction of Fuel Rod Inventory Released | |
| Noble Gasses (Except Kr 85) | 10% |
| Kr 85 | 30% |
| Iodines | 10% |
| Decontamination Factor in Pool Water | 100 |
| Air Volume over Storage Pool | 4900 $FT^3$ |
| Ventilation Air Fuel From Storage Pool | 20000 CFM |
| Closure Time for Dampers | 2 seconds<br>5 seconds<br>10 seconds |
| All activity released to the environment in 2 hours | |
| Stand-by Gas Treatment System Filter Efficiency | 0.90 |
| Height of the Main Stack | 183 meters |
| Distance to Excusion Area Boundary | 1465 meters |
| Distance to Low Population zone | 3200 meters |

Atmospheric Dispersion Factors (X/Q) Extracted from FSAR

| | EA | L.P.Z. |
|---|---|---|
| 0-2 hours | 9.70E-7 | 8.0E-7 |
| 2-8 hours | 9.7E-7 | 8.0E-7 |
| 8-24 hours | 9.7E-7 | 4.0E-7 |
| 1-4 days | 9.7E-7 | 2.0E-7 |
| 4-30 days | 9.7E-7 | 6.50E-8 |

Atmospheric Dispersion Factors (X/Q) from Regulatory Guide 1.3
Ground Level Release

| | EA | L.P.Z. |
|---|---|---|
| 0-2 hours | 1.22E-4 | 5.65E-5 |
| 2-4 hours | 1.22E-4 | 5.65E-5 |
| 8-24 hours | 7.71E-5 | 2.24E-5 |
| 1-4 days | 2.76E-5 | 7.94E-6 |
| 4-30 days | 6.05E-6 | 1.71E-6 |

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TABLE 2

CALCULATED DOSE RESULTING FROM A DESIGN BASIS FUEL HANDLING ACCIDENT WITH EXTENDED DAMPER CLOSING TIMES

2 Hour Dose at Exclusion Boundary (1465 Meters)

| Damper Closing Time | Thyroid Dose m Rem | Whole Body Dose m Rem |
|---|---|---|
| 2 sec | 320 | 5.3 |
| 5 sec | 570 | 7.8 |
| 10 sec | 890 | 11.1 |

2 Hour Dose at Low Population Zone (3200 meters)

| | | |
|---|---|---|
| 2 sec | 155 | 3.0 |
| 5 sec | 267 | 4.1 |
| 10 sec | 412 | 5.4 |

Dose computations based on finite cloud ground level release of by-pass activity plus elevated release of all remaining activity within two hours.

1. NEDO 21143-1 "Radiological Accident Evaluation - The CONACO3 Code" H. A. Careway, Van-Dat Nguyen, P. P. Stancavage, General Electric Company, December 1981.