ALNRC 00025
May 15, 2009

Enclosure E

Red-line strikeout changes to Section 5.11 of the ER

5.11 TRANSPORTATION OF RADIOACTIVE MATERIALS

The NRC evaluated the environmental effects of transportation of fuel and waste for light water reactors in the Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Plants (AEC, 1972) and Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants, Supplement 1 (NRC, 1975) and found the impacts to be small. These NRC analyses provided the basis for Table S-4 in 10 CFR 51.52 (CFR, 2007a) which summarizes the environmental impacts of transportation of fuel and radioactive wastes to and from a reference reactor.

The NRC regulations in 10 CFR 51.52 state that:

> Every environmental report prepared for a light-water-cooled nuclear power reactor shall contain a statement concerning transportation of fuel and radioactive wastes to and from the reactor. That statement shall indicate that the reactor and this transportation either meet all of the conditions in paragraph (a) of this section or all of the conditions in paragraph (b) of this section.

The U.S. EPR design varies from the conditions of 10 CFR 51.52(a). Specifically,

> The reactor has a core thermal power level exceeding 3,800 MWth;
>
> The reactor fuel has a uranium-235 enrichment that may exceed 4 percent by weight, and the uranium dioxide pellets are not encapsulated in zircaloy rods; and
>
> The average level of irradiation of the irradiated fuel from the reactor will exceed 33,000 MWd/MTU.

Fuel cladding and heat are discussed in separate sections. Traffic density and dose are discussed in the same section since the calculation of dose is a function of traffic density.

The impact of shipment weight as described in Table S-4 is governed by other restrictions and is unaffected by the U.S. EPR variation from 10 CFR 51.52(a). Table 5.11-1 presents information from Table S-4 of 10 CFR 51.52 (CFR, 2007a).

Reactor core thermal power exceeding 3,800 MWth, uranium-235 enrichment that may exceed 4 percent by weight, and the average fuel assembly burnup of discharged irradiated fuel from the reactor exceeding 33,000 MWd/MTU, all result in the potential for additional heat in irradiated fuel casks during shipment. The potential impact of the heat generated from irradiated fuel in shipping casks during shipment is discussed in Section 5.11.2 below.

5.11.1 FUEL CLADDING ENVIRONMENTAL IMPACT

10 CFR 51.52 describes the use of Zircaloy as fuel rod cladding material. More recently, the NRC has also specified, through rule-making, ZIRLO as an acceptable fuel cladding in 10 CFR 50.46 (CFR, 2007b). Callaway Plant Unit 2 will use AREVA's M5 Advanced Zirconium (M5) fuel rod cladding material.

Several NRC licensees have received approval to use M5 fuel rod cladding with a finding of "no significant impact." For example, NRC approved Davis-Besse Nuclear Power Station, Unit 1 use of M5 cladding, and concluded that the cladding presents no significant environmental impact during transportation (FR, 2000):

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> With regard to the potential environmental impacts associated with the transportation of the M5 clad fuel assemblies, the advanced cladding has no impact on previous assessments determined in accordance with 10 CFR 51.52.

Further, in 2003, the NRC found M5 fuel rod cladding generally acceptable for use in license applications by compliance with the conditions specified in, and reference to AREVA's Topical Report (TR) (NRC, 2003):

> The staff has completed its review of the subject TR and finds it is acceptable for referencing in licensing applications to the extent specified and under the limitations delineated in the report and in the associated safety evaluation (SE).

As described above, the use of M5 fuel cladding has been previously evaluated and determined to not result in significant transportation environmental impact at existing facilities. The use of M5 fuel cladding at Callaway Plant Unit 2 will be equivalent to the M5 fuel cladding previously evaluated at the existing facilities. Therefore it is concluded that the use of M5 cladding at Callaway Plant Unit 2 will result in no environmental impact during transportation.

5.11.2 HEAT (IRRADIATED FUEL CASK IN TRANSIT) ENVIRONMENTAL IMPACT

This section addresses the decay heat generated in irradiated fuel casks during shipment to a repository.

An irradiated fuel cask has not yet been designed for U.S. EPR fuel; however in NUREG-1811, NUREG-1815, and NUREG-1817, the NRC described and addressed future irradiated fuel casks that may carry up to 1.8 MTU (4,000 lbs U) (NRC, 2004; NRC, 2006a; and NRC, 2006b).

Each U.S. EPR fuel assembly contains up to 0.536 MTU (1,200 lbs U). ORIGEN2.1 was used to calculate the decay heat from an U.S. EPR fuel assembly using the information provided in Table 5.11-7 (ORNL, 1991). Based on these calculations, an U.S. EPR irradiated fuel assembly will generate 5,500 Btu/hr (1.6 kW) of decay heat following 5 years of onsite storage after removal from the reactor core (Table 5.11-2).

Therefore, an irradiated fuel cask designed consistent with that described in the referenced NUREGs could carry up to 3.36 irradiated assemblies (1.8 MTU / 0.536 MTU per assembly.) The total cask decay heat generation would then be 18,600 Btu/hr (~~5,450~~5.450 kW) (3.36 assemblies times 5,500 Btu/hr per assembly.)

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10 CFR 51.52(c), Table S-4 (CFR, 2007c) concludes that heat generation of up to 250,000 Btu/hr (73 kW) within a cask is an acceptable environmental impact. This is more than 13 times that which would be generated in a cask transferring the calculated quantity of U.S. EPR irradiated fuel.

An alternative analysis is to assess the maximum number of irradiated fuel assemblies per cask that could be shipped while complying with the 250,000 Btu/hr (73 kW) condition in Table S-4. This method addresses future potential cask designs that could be used to transport greater numbers of assemblies per cask.

The maximum number of U.S. EPR irradiated fuel assemblies based on this evaluation would be 45 assemblies (250,000 Btu/hr / 5,500 Btu/hr per assembly). The largest postulated irradiated fuel transfer cask designs have capacities of about half this number, and their use for transportation of irradiated U.S. EPR fuel would result in proportionally lower heat generation, well below the Table S-4 value (NRC, 2000b).

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Therefore, the decay heat generated by the U.S. EPR fuel per irradiated fuel cask in transit is bounded by 10 CFR 51.52(c) Table S-4, and will not result in significant environmental effects during transportation under normal conditions.

5.11.3 INCIDENT-FREE DOSE AND TRAFFIC DENSITY IMPACT ANALYSIS

This section summarizes the incident-free transportation environmental impacts during normal operations for Callaway Plant Unit 2. Transportation categories include;

- Transport of unirradiated fuel (new fuel) from fuel fabrication facilities to the site;
- Transport of irradiated fuel from the site to a monitored retrievable storage facility or permanent repository; and
- Transport of radioactive waste.

TRAGIS (ORNL, 2003) and RADTRAN (SNL, 2006) computer codes were used to evaluate postulated incident-free dose. Code inputs for each category are presented in Table 5.11-3 and Table 5.11-8. The results are summarized in Table 5.11-5 and Table 5.11-6.

The results presented in Table 5.11-6 provide a comparison to the reference reactor using an analysis that is consistent with the methodology used previously in the Environmental Impact Statements NUREG-1811, NUREG-1815, and NUREG-1817 (NRC, 2004; NRC, 2006a; and NRC, 2006b).

5.11.3.1 Impact of Unirradiated Fuel (New Fuel)

The radiological dose for the environmental impacts of incident-free new fuel shipments to the reactor site was calculated from the farthest (most conservative) currently existing new fuel fabrication facility near Richland, WA, to the Callaway site.

RADTRAN 5.6 was used to model the Callaway Plant Unit 2 location specific environmental impact. The model used TRAGIS (ORNL, 2003) generated Callaway Plant Unit 2 location specific route data to yield dose per shipment. The postulated stop duration was 4.2 hours based on the TRAGIS calculated 1,828 miles (2,942 km) commercial highway route distance and the 0.0023 hr/mi (0.0014 hr/km), consistent with the stop model assumption used in NUREG-1811, NUREG-1815, and NUREG-1817 (NRC, 2004; NRC, 2006a; and NRC, 2006b).

The RADTRAN 5.6 model calculated radiological impact results per shipment are shown in Table 5.11-5.

The dose per shipment was multiplied by the average number of annual shipments to calculate the average dose per reactor year. New fuel shipments during the life of a reactor are expected to total 298 over the 40 year license period for an average of 7.5 shipments per reactor year. This is consistent with the condition described in Table S-4, which indicates that less than one shipment will occur per day.

At an average of 7.5 shipments per year, the average annual radiological impact from new fuel shipments will be as shown in Table 5.11-6.

5.11.3.2 Impact of Irradiated Fuel

The postulated radiological dose from the incident-free shipment of irradiated fuel from the reactor site to the proposed Yucca Mountain Repository located in Nevada was evaluated by

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multiplying conservative dose estimates per shipment by the average annual number of shipments.

A RADTRAN 5.6 model was developed using TRAGIS Highway Route Controlled Quantity distance and demographic data specific to the reactor site. Model conservatism is similar to that found in the irradiated fuel RADTRAN 5 models from NUREG-1811, NUREG-1815, and NUREG-1817 (NRC, 2004; NRC, 2006a; and NRC, 2006b). The bounding commercial route distance calculated with TRAGIS was approximately 1,819 miles (2,927 km) with stop duration of 4.0 hours.

The RADTRAN 5.6 model conservatively calculated radiological impact results per shipment are presented in Table 5.11-5.

Shipping cask capacity assumptions are approximations based on current shipping cask designs. The U.S. EPR will require an average of 21 shipments of irradiated fuel per year assuming an irradiated fuel cask capacity of 1.8 MTU (4,000 lbs U) consistent with NUREG-1811, NUREG-1815, and NUREG-1817 (NRC, 2004; NRC, 2006a; and NRC, 2006b) and using the highest annual reload for the U.S. EPR of 37.5 MTU (83,000 lbs U), This is consistent with the condition described in Table S-4 of less than 1 shipment per day.

The postulated average annual radiological impact from an average of 21 irradiated fuel shipments per year to the proposed Yucca Mountain Repository is provided in Table 5.11-6.

5.11.3.3 Impact of Radioactive Waste (Radwaste)

The transportation dose of the incident-free radwaste shipments from the reactor site was calculated using the same RADTRAN 5.6 inputs and assumptions as described in 5.11.3.2 above including a bounding disposal location for the Callaway site. TRAGIS was used to evaluate the highway route to the Hanford, WA, commercial low level waste disposal repository. This site is not used by AmerenUE, but was used because it is bounding (farthest distance) compared to other existing disposal and processing sites used by AmerenUE. Other sites evaluated were Clive, UT; Barnwell, SC; and Erwin, TN.

Using the same input parameters as the irradiated fuel model ensured a conservative model and is justified by the similar route demographics and conservatively chosen maximum package and vehicle surface dose rates.

The bounding commercial route distance calculated with TRAGIS was approximately (1,855 miles) (2,985 km) with stop duration of 4.5 hours.

The RADTRAN 5.6 conservatively calculated radiological impact results per shipment are provided in Table 5.11-5.

The U.S. EPR average of 15 radwaste shipments per year was derived using current shipping container volume estimates of 55-gallon (0.21 m^3) drums and 90 ft^3 (2.55 m^3) high integrity containers for process wastes, and 1,000 ft^3 (28.32 m^3) SEALAND containers for dry active waste, similar to the analyses in NUREG-1811, NUREG-1815, and NUREG-1817 (NRC, 2004; NRC, 2006a; and NRC, 2006b). Commercially available containers were matched to the appropriate waste type to determine the total number of containers generated per year. The number of shipments was then determined by dividing the number of containers postulated to be generated by an assumed number of containers that can be transferred per shipment. Table 5.11-4 shows the U.S. EPR container generation rates, realistic container per shipment assumptions, and the subsequent annual number of shipments. The calculated 15 shipments

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per year is consistent with the condition in Table S-4 which describes less than one shipment per day.

At this average of 15 shipments per year, the average annual radiological impact from radwaste shipments to the bounding disposal site is shown in Table 5.11-6.

5.11.3.4 Comparison with Table S-4 and Conclusion

Table 5.11-6 summarizes the incident-free transportation environmental impacts per reactor year. The table included consideration of:

- Transport of unirradiated fuel (new fuel) from fuel fabrication facilities to the reactor site;
- Transport of irradiated fuel from the reactor site to a monitored retrievable storage facility or permanent repository; and
- Transport of radioactive waste (radwaste) from the reactor site to offsite disposal facilities.

The cumulative doses shown in Table 5.11-6 were calculated based on the product of thousands of potentially exposed individuals and the very low doses that each of them could receive.

Although radiation may cause cancers at high doses and high dose rates, currently there are no data that unequivocally establish the occurrence of cancer following exposure to low doses below about 10 rem (100 mSv) or at low dose rates. The individual doses and dose rates calculated to occur during normal transportation are many orders of magnitude less than either of these.

Radiation protection experts conservatively assume that any amount of radiation exposure may pose some risk of causing cancer or a severe hereditary effect and that the risk is higher for higher radiation exposures. That is, a linear, no-threshold dose response model is used to describe the relationship between radiation dose and detriments such as cancer induction. This model has been accepted as a conservative model for estimating health risks from radiation exposure, recognizing that the model probably over-estimates those risks.

The NRC staff estimates the risk to the public from radiation exposure using the nominal probability coefficient for total detriment of 730 fatal cancers, nonfatal cancers, and severe hereditary effects per 1,000,000 person-rem (10,000 person-Sv) from ICRP Publication 60 (ICRP, 1991).

All the population doses presented in Table 5.11-6 are less than 100 person-rem/yr (one person-Sv/yr); therefore, the total detriment estimates associated with these postulated doses would all be less than 0.1 fatal cancer, nonfatal cancer, or severe hereditary effect per year.

These risks are very small compared to the fatal cancers, nonfatal cancers, and severe hereditary effects that would occur annually in the same population from exposure to natural sources of radiation.

Based on this the environmental impacts during normal transportation environmental do not represent a significant environmental impact.

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5.11.4 SUMMARY AND CONCLUSION

The use of M5 cladding has been previously evaluated and determined not to result in significant environmental impact during normal conditions of transportation.

A conservative and detailed analysis of the environmental impacts for the transportation of unirradiated fuel, irradiated fuel, and radioactive waste to and from Callaway Plant Unit 2 has been performed in accordance with 10 CFR 51.52(b) (CFR, 2007c). The decay heat generated by U.S. EPR fuel in transit is bounded by 10 CFR 51.52(c) Table S-4 (CFR, 2007c), and will not result in significant environmental effects during transportation under normal conditions. The dose and traffic impact analysis of the incident free transportation of U.S. EPR fuel and radioactive waste generated at the new facility will not result in significant environmental effects during transportation under normal conditions.

Based on this, the U.S. EPR design variation from the conditions of 10 CFR 51.52(a) will not result in significant environmental effects during transportation activities associated with the operation of Callaway Plant Unit 2. As a result, the impacts would be SMALL.

5.11.5 REFERENCES

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Table 5.11-1—Summary of Environmental Impacts of Transportation of Fuel and Waste to and from One Light Water Reactor, taken from 10 CFR 51.52 Table S-4

Normal Conditions of Transport			
		Environmental Impact	
Heat (per irradiated fuel cask in transit)		250,000 Btu/hr (73 kW)	
Weight (governed by Federal or State Restrictions		73,000 lbs. (33,000 kg) per truck; 100 tons (91 MT) per cask per rail car	
Traffic Density:			
Truck		Less than 1 per day	
Rail		Less than 3 per month	
Exposed Population	Estimated Number of Persons Exposed	Range of Doses to Exposed Individuals (per reactor year)	Cumulative Dose to Exposed Population (per reactor year)
Transportation Workers	200	0.01 to 300 mrem (1E-4 to 3 mSv)	4 person rem (40 mSv)
General Public			
Onlookers	1,100	0.003 to 1.3 mrem (0.03 to 13 μSv)	3 person rem (30 mSv)
Along Route	600,000	1E-4 to 6E-2 mrem (1E-3 to 0.6 μSv)	No number provided in 10 CFR 51.52 Table S-4

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Table 5.11-2—Decay Heat for EPR Irradiated Fuel Assembly

Decay Time (year)	Decay Heat per Assembly (Btu/hr)			
	GWd/MTU 62[1]	GWd/MTU 52[2]	GWd/MTU 40[1]	GWd/MTU 10[1]
4.75	7.32E+03		4.01E+03	9.17E+02
5.00	7.09E+03	5.52E+03	3.88E+03	8.82E+02
6.34	5.89E+03		3.17E+03	6.95E+02

Notes:

(1) Linear regression used to determine 5 year decay heat at 62, 40, 10 (GWd/MTU)
(2) Polynomial Regression used to determine 52 GWd/MTU decay heat at 5 years:
(5.52E+03 = 0.896*(52)^2+54.96*(52)+243)

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Table 5.11-3—RADTRAN & TRAGIS Model Input Parameters

Parameter	New Fuel	Spent Fuel	Radwaste
TRAGIS Input:			
Route Mode	Commercial	HRCQ	Commercial
Route Origin	Richland, WA	Callaway Site	Callaway Site
Route Destination	Callaway Site	Yucca Mt, NV	Hanford, WA
RADTRAN Input TRAGIS:			
Total Shipping Distance, mi (km)	1827.8 (2941.4)	1818.5 (2926.5)	1854.7 (2984.7)
Travel Distance - Rural, mi (km)	1562.8 (2515.1)	1556.9 (2505.5)	1587.6 (2554.8)
Travel Distance - Suburban, mi (km)	235.7 (379.4)	219.5 (353.2)	236.8 (381.1)
Travel Distance - Urban, mi (km)	29.4 (47.3)	42.2 (67.8)	30.5 (49.1)
Population Density - Rural, person/mi^2 (person/km^2)	23.3 (9.0)	20.7 (8.0)	23.0 (8.9)
Population Density – Suburban, person/mi^2 (person/km^2)	845.6 (326.5)	897.3 (346.5)	850.6 (328.4)
Population Density – Urban, person/mi^2 (person/km^2)	5697.2 (2199.7)	6050.9 (2336.3)	5686.3 (2195.5)
Stop Time, hr/trip	4.2 [(a)]	4.0 [(b)]	4.5 [(b)]
RADTRAN Input from NRC Models			
Vehicle Speed, mi/hr (km/hr)	55.0 (88.49)	55.0 (88.49)	55.0 (88.49)
Traffic Count - Rural, vehicles/hr	530	530	530
Traffic Count - Suburban, vehicles/hr	760	760	760
Traffic Count - Urban, vehicles/hr	2400	2400	2400
Dose Rate at 3.3 ft (1 m) from Vehicle, mrem/hr (mSv/hr)	0.1 (0.001)	14 (0.14)	14 (0.14)
Packaging Length, ft (m)	24 (7.3)	17 (5.2 [(e)])	17 (5.2)
Number of Truck Crew	2	2	2
Population Density at Stops (radii: 3.3 to 33 ft (1 to10 m)), person/mi^2 (person/km^2)	167,000 (64,300)	78,000 (30,000)	78,000 (30,000)
Population Density at Stops (radii: 33 to 2600 ft (10 to 800 m)), person/mi^2 (person/km^2)	NA	880 (340)	880 (340)
Shielding Factor at Stops (radii: 3.3 to 33 ft (1 to 10 m))	1	1	1
Shielding Factor at Stops (radii: 3.3 to 33 ft (10 to 800 m))	NA	0.2	0.2

Notes

(a) Based on 0.0023 hour/mi (0.0014 hour/km)
(b) Based on TRAGIS output: 8 stops at 30 minutes each for spent fuel shipment 9 stops at 30 minutes each for radwaste shipment
(c) Reference: NRC, 2006a. Table G-2, "RADTRAN 5 Input Parameters for Unirradiated Fuel Shipments".
(d) Reference: NRC, 2006a. Table G-5, "RADTRAN 5 Incident-Free Exposure Parameters".
(e) Cylinder of 1 m diameter

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Table 5.11-4—Annual EPR Solid Radioactive Waste

Waste Type	Annual Max Quantity ft^3 (m^3)	Container Internal Volume ft^3 (m^3)	Maximum Number of Containers	Containers per Shipment[d]	Number of Shipments[d]
Evaporator Concentrates	140 (4.0)	7.3 (0.21 [a])	19.2	40	1
Spent Resins (other)	90 (2.5)	90 (2.55 [b])	1.0	1	1
Spent Resins (Rad Waste Demineralizer System)	140 (4.0)	90 (2.55 [b])	1.6	1	2
Wet Waste from Demineralizers	8 (0.2)	90 (2.55 [b])	0.1	1	1
Waste Drum for Solids Collection from Centrifuge System	8 (0.2)	7.3 (0.21 [a])	1.1	40	1
Filters (quantity)	120 (3.4)	90 (2.55 [b])	1.3	1	2
Sludge	35 (1.0)	90 (2.55 [b])	0.4	1	1
Mixed Waste	2 (0.1)	7.3 (0.21 [a])	0.3	40	1
Non-Compressible Dry Active Waste (DAW)	70 (2.0)	1000 (28.32 [c])	0.1	1	1
Compressible DAW	1415 (40.1)	1000 (28.32 [c])	1.4	2	1
Combustible DAW	5300 (150.1)	1000 (28.32 [c])	5.3	2	3
Overall Totals	**7328 (208)**				**15**

Notes: First two columns from Section 3.5, Table 3.5-10

(a) 7.3 ft^3, 55 gallon drum.
(b) 90 ft^3, medium size container such as an 8 to 120 HIC.
(c) 1000 ft^3, 20 ft. SEALAND container.
(d) Assumed based on container volumes and max number of containers that can be transferred per shipment.

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Table 5.11-5—Evaluated Transportation Dose per Shipment Under Normal Conditions

New Fuel Shipment

Exposed Population	Dose per Shipment	
Transportation Workers[a]	1.57E-05 person-Sv	1.57E-03 person-rem
General public:		
Onlookers[b]	6.18E-05 person-Sv	6.18E-03 person-rem
Along Route[c]	8.91E-07 person-Sv	8.91E-05 person-rem

Irradiated Fuel

Exposed Population	Dose per Shipment	
Transportation Workers	7.07E-04 person-Sv	7.07E-02 person-rem
General public:		
Onlookers	2.76E-03 person-Sv	2.76E-01 person-rem
Along Route	4.40E-05 person-Sv	4.40E-03 person-rem

Radwaste

Exposed Population	Dose per Shipment	
Transportation Workers	7.21E-04 person-Sv	7.21E-02 person-rem
General public:		
Onlookers	3.07E-03 person-Sv	3.07E-01 person-rem
Along Route	4.55E-05 person-Sv	4.55E-03 person-rem

Notes:

(a) Crew dose
(b) On link plus Stop dose
(c) Off link dose

Reference: RADTRAN 5.6 program output.

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Table 5.11-6—Evaluated Annual Transportation Dose Under Normal Conditions

New Fuel Shipment

Exposed Population	Dose per Shipment	
Transportation Workers	1.18E-04 person-Sv	1.18E-02 person-rem
General public:		
Onlookers	4.63E-04 person-Sv	4.63E-02 person-rem
Along Route	6.68E-06 person-Sv	6.68E-04 person-rem

Irradiated Fuel

Exposed Population	Dose per Shipment	
Transportation Workers	1.48E-02 person-Sv	1.48E+00 person-rem
General public:		
Onlookers	5.80E-02 person-Sv	5.80E+00 person-rem
Along Route	9.24E-04 person-Sv	9.24E-02 person-rem

Radwaste

Exposed Population	Dose per Shipment	
Transportation Workers	1.08E-02 person-Sv	1.08E+00 person-rem
General public:		
Onlookers	4.61E-02 person-Sv	4.61E+00 person-rem
Along Route	6.83E-04 person-Sv	6.83E-02 person-rem

Annual Total[1]

Exposed Population	Evaluated U.S. EPR Cumulative Dose per Year		10 CFR 51.52(c) Table S-4 Cumulative Dose
Transportation Workers	2.58E-02 person-Sv	2.58 person-rem	4 person-rem
General public:			
Onlookers	1.05E-01 person-Sv	10.5 person-rem	3 person-rem
Along Route	1.61E-03 person-Sv	1.61E-01 person-rem	Not listed

Notes:

(1) Sum of New Fuel, Irradiated Fuel and Radwaste.

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Table 5.11-7—ORIGEN2.1 Decay Heat Input Parameters for EPR Irradiated Fuel

PARAMETER		VALUE
US EPR core thermal power for design-basis applications	Nominal	4590 MWt
	Measurement Uncertainty	22 MWt (0.48%)
	Total (design-basis)	4612 MWt
Number of fuel assemblies in core		241
Fuel enrichment		5 w/o U-235
Mass of U metal in fuel assembly		535.917 kg
Total mass of U metal in core		1.2916E+05 kg
Fuel isotopic composition (based on ORNL/TM-12294/V4)	U-234	4.423E-02 w/o
	U-235	5.000E+00 w/o
	U-236	2.300E-02 w/o
	U-238	9.493E+01 w/o
	Total	1.00E+02 w/o
Irradiation time interval	5 GWd/MTU	140.026 days
Irradiation times to yield the selected burnups	10 GWd/MTU	280.05 days
	40 GWd/MTU	1120.21 days
	62 GWd/MTU	1736.32 days
Decay time array		0 to 1.0E+09 sec (31.69 yrs)
Computer code and cross-section libraries (RSIC CCC-371, and ORNL/TM-11018)		ORIGEN-2.1 PWRUE

Reference: ORNL, 1991.

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Table 5.11-8—Additional RADTRAN Input Parameters

Parameter	New Fuel	Spent Fuel	Radwaste
Gamma Fraction	1	1	1
Neutron Fraction	0	0	0
Crew Distance, ft (m)	10.2 (3.1)	17.9 (5.45)	17.9 (5.45)
Crew Shielding Factor	1	1	1
Crew View, ft (m)	3.3 (1.0)	3.3 (1.0)	3.3 (1.0)
Exclusive Use	Yes	Yes	Yes
Persons per Vehicle	1.6	1.5	1.5

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