



## RADIATION EXPOSURE

# Annual collective dose declines at U.S. LWRs

**T**HE DOWNWARD TREND in radiation exposure levels continued for the 105 nuclear power plants that operated in the United States in 1998. The average annual collective dose per reactor in 1998 was 125 person-rem, a 26 percent decrease from that reported for 1997. Data for 1998 are contained in the Nuclear Regulatory Commission's *Occupational Radiation Exposure at Commercial Nuclear Power Reactors and other Facilities 1998—Thirty-First Annual Report*, published in December.

By reactor type, the average annual collective dose per unit for 36 boiling water reactors was 190 person-rem in 1998, and for 69 pressurized water reactors was 92 person-rem. In 1998 the NRC removed Big Rock Point (a BWR), Zion-1 and -2 (two PWRs), and Maine Yankee (a PWR) from the count of operating

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reactors. This, according to the NRC, represented the first reduction in the number of operating BWRs in nine years and the first reduction in the number of operating PWRs in five years.

The number of workers with measurable dose at the 105 reactors in 1998 declined to 71 344, the lowest number of measured workers at nuclear power plants since 1979, when 64 073 received measurable dose. (But, in comparison, only 67 reactors were operating in 1979.) The average measurable dose per

worker in 1998 was 0.18 rem, down from 0.20 rem the previous year when 84 473 workers had measurable dose. The NRC defines the average measurable dose as the total collective dose (that is, total effective dose equivalent, TEDE) divided by the number of workers receiving measurable dose.

The report averaged three-year collective TEDE for BWRs and PWRs. Based on the 108 reactor-years (36 reactors × three years) of operation accumulated by the 36 BWRs, the average three-year (1996–1998) collective

THREE-YEAR TOTALS AND AVERAGES LISTED IN ASCENDING ORDER OF COLLECTIVE TEDE PER U.S. BWR, 1996–1998

Site name*	Reactor years	Collective TEDE per reactor	Collective TEDE per site	Numbers of workers with measurable TEDE	Average TEDE per worker	Total MW-years	Average TEDE per MW-year
COOPER STATION	3	135	404	2 570	0.16	1 918.7	0.21
FERMI 2	3	138	414	3 387	0.12	2 028.7	0.20
LIMERICK 1, 2	6	138	825	4 971	0.17	5 929.6	0.14
BROWNS FERRY 1, 2, 3	9	140	1 261	5 418	0.23	5 858.1	0.22
VERMONT YANKEE	3	162	487	2 155	0.23	1 322.0	0.37
SUSQUEHANNA 1, 2	6	181	1 083	4 651	0.23	5 791.7	0.19
NINE MILE POINT 1, 2	6	183	1 097	4 765	0.23	4 303.1	0.25
MONTICELLO	3	185	555	1 830	0.30	1 347.9	0.41
HOPE CREEK 1	3	188	563	3 436	0.16	2 529.7	0.22
DUANE ARNOLD	3	190	570	2 464	0.23	1 388.2	0.41
PEACH BOTTOM 2, 3	6	190	1 138	5 432	0.21	5 844.4	0.19
PERRY	3	207	621	3 531	0.18	2 986.9	0.21
MILLSTONE POINT 1	3	213	639	2 147	0.30	—	—
CLINTON	3	222	666	2 758	0.24	632.9	1.05
DRESDEN 2, 3	6	225	1 350	6 846	0.20	3 061.8	0.44
HATCH 1, 2	6	247	1 483	5 050	0.29	4 348.5	0.34
BRUNSWICK 1, 2	6	254	1 523	7 001	0.22	4 252.6	0.36
GRAND GULF	3	255	766	3 488	0.22	3 377.3	0.23
PILGRIM	3	258	775	2 702	0.29	1 772.2	0.44
LASALLE 1, 2	6	260	1 557	6 542	0.24	1 431.8	1.09
FITZPATRICK	3	269	806	3 827	0.21	1 940.6	0.42
OYSTER CREEK	3	269	807	3 750	0.22	1 583.5	0.51
RIVER BEND 1	3	293	878	4 230	0.21	2 506.8	0.35
WASHINGTON NUCLEAR 2	3	303	910	3 891	0.23	2 147.6	0.42
QUAD CITIES 1, 2	6	407	2 440	6 899	0.35	2 604.3	0.94
<b>Grand Totals and Averages</b>	<b>108</b>		<b>23 618</b>	<b>103 741</b>	<b>0.23</b>	<b>70 908.9</b>	<b>0.33</b>
<b>Averages Per Reactor-Year</b>			<b>219</b>	<b>961</b>		<b>656.6</b>	

\* Sites where not all reactors had completed 3 full years of commercial operation as of 12/31/98 are not included.

(Source: NUREG-0713, Vol. 20)

THREE-YEAR TOTALS AND AVERAGES LISTED IN ASCENDING ORDER OF COLLECTIVE TEDE PER U.S. PWR, 1996–1998

Site name*	Reactor years	Collective TEDE per reactor	Collective TEDE per site	Numbers of workers with measurable TEDE	Average TEDE per worker	Total MW-years	Average TEDE per MW-year
WATERFORD 3	3	66	199	1 810	0.11	2 813.2	0.07
PRAIRIE ISLAND 1, 2	6	67	403	1 893	0.21	2 667.3	0.15
SEABROOK	3	72	215	2 336	0.09	3 030.0	0.07
THREE MILE ISLAND 1	3	79	237	1 596	0.15	2 336.6	0.10
ARKANSAS 1, 2	6	82	489	3 885	0.13	4 708.1	0.10
MILLSTONE POINT 2, 3	6	82	492	3 598	0.14	782.5	0.63
PALO VERDE 1, 2, 3	9	82	740	4 712	0.16	10 296.8	0.07
SALEM 1, 2	6	86	516	2 973	0.17	1 908.6	0.27
GINNA	3	88	264	1 670	0.16	1 283.4	0.21
INDIAN POINT 3	3	90	271	2 110	0.13	2 062.5	0.13
KEWAUNEE	3	90	270	1 136	0.24	1 072.2	0.25
POINT BEACH 1, 2	6	90	537	2 580	0.21	1 665.8	0.32
SUMMER 1	3	91	274	1 806	0.15	2 612.6	0.10
OCONEE 1, 2, 3	9	94	846	4 553	0.19	5 395.6	0.16
DIABLO CANYON 1, 2	6	95	568	4 106	0.14	5 901.9	0.10
SOUTH TEXAS 1, 2	6	99	594	3 899	0.15	7 104.0	0.08
HARRIS	3	100	299	2 506	0.12	2 298.1	0.13
CALVERT CLIFFS 1, 2	6	109	655	3 300	0.20	4 457.3	0.15
NORTH ANNA 1, 2	6	110	660	3 260	0.20	4 909.6	0.13
COMANCHE PEAK 1, 2	6	111	666	3 299	0.20	5 840.0	0.11
DAVIS-BESSE	3	111	332	2 142	0.15	2 293.5	0.14
SAN ONOFRE 2, 3	6	111	666	4 015	0.17	5 613.9	0.12
ROBINSON 2	3	117	350	2 313	0.15	1 989.0	0.18
SURRY 1, 2	6	120	718	3 483	0.21	4 415.1	0.16
CATAWBA 1, 2	6	122	730	4 272	0.17	5 908.6	0.12
TURKEY POINT 3, 4	6	126	757	3 783	0.20	3 848.2	0.20
VOGTLE 1, 2	6	129	772	3 383	0.23	6 296.2	0.12
BEAVER VALLEY 1, 2	6	136	814	3 779	0.22	2 948.0	0.28
COOK 1, 2	6	145	869	4 133	0.21	3 123.3	0.28
MCGUIRE 1, 2	6	145	872	4 860	0.18	5 574.7	0.16
WOLF CREEK 1	3	149	446	2 159	0.21	3 129.5	0.14
BRAIDWOOD 1, 2	6	152	914	4 918	0.19	5 685.0	0.16
CALLAWAY 1	3	154	461	2 157	0.21	3 057.5	0.15
SEQUOYAH 1, 2	6	156	934	4 776	0.20	6 085.3	0.15
FARLEY 1, 2	6	157	942	3 635	0.26	4 308.6	0.22
BYRON 1, 2	6	162	971	4 965	0.20	5 480.1	0.18
FORT CALHOUN	3	164	491	1 786	0.27	1 197.5	0.41
CRYSTAL RIVER 3	3	184	551	2 478	0.22	1 030.0	0.53
PALISADES	3	194	583	2 342	0.25	1 914.3	0.30
ST. LUCIE 1, 2	6	194	1 165	4 917	0.24	4 436.5	0.26
INDIAN POINT 2	3	237	711	2 882	0.25	1 568.6	0.45
<b>Grand Totals and Averages</b>	<b>204</b>		<b>24 244</b>	<b>130 206</b>	<b>0.19</b>	<b>153 049.5</b>	<b>0.16</b>
<b>Averages Per Reactor-Year</b>			<b>119</b>	<b>638</b>		<b>750.2</b>	

\* Sites where not all reactors had completed 3 full years of commercial operation as of 12/31/98 are not included.

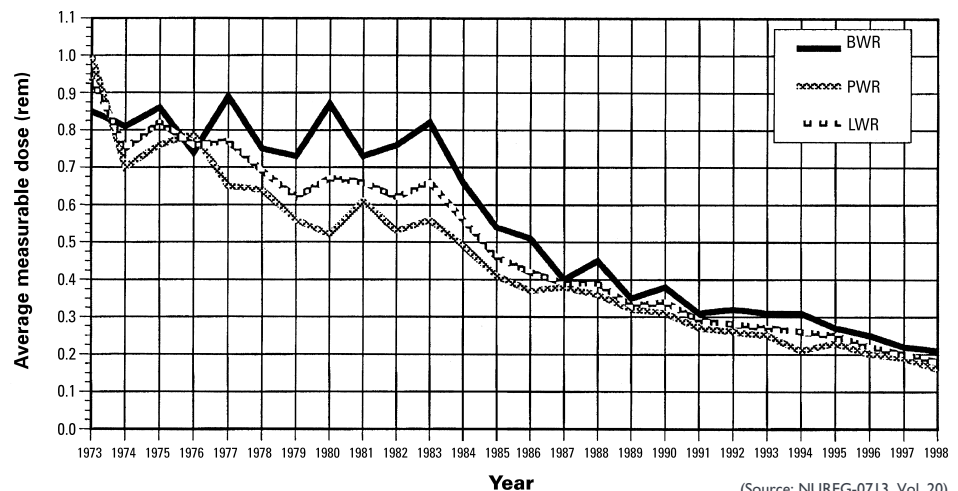
(Source: NUREG-0713, Vol. 20)

TEDE per reactor was 219 person-rem, average measurable TEDE per worker was 0.23 rem, and average collective TEDE per megawatt-year was 0.33 rem.

Based on the 204 reactor-years of operation for the 68 PWRs, the average three-year collective TEDE per reactor was 119 person-rem, average measurable TEDE per worker was 0.19 rem, and average collective TEDE per megawatt-year was 0.16 rem.

All dose values at both types of reactors were lower than for the previous three-year period. The average three-year collective TEDE per BWR for 1996–1998 is 8 percent less than the average for 1995–1997, and the average three-year collective TEDE per PWR for 1996–1998 is 17 percent less than the average for 1995–1997.

For BWRs, Nebraska Public Power District's Cooper plant recorded the lowest three-



Average measurable dose per worker at U.S. nuclear power plants

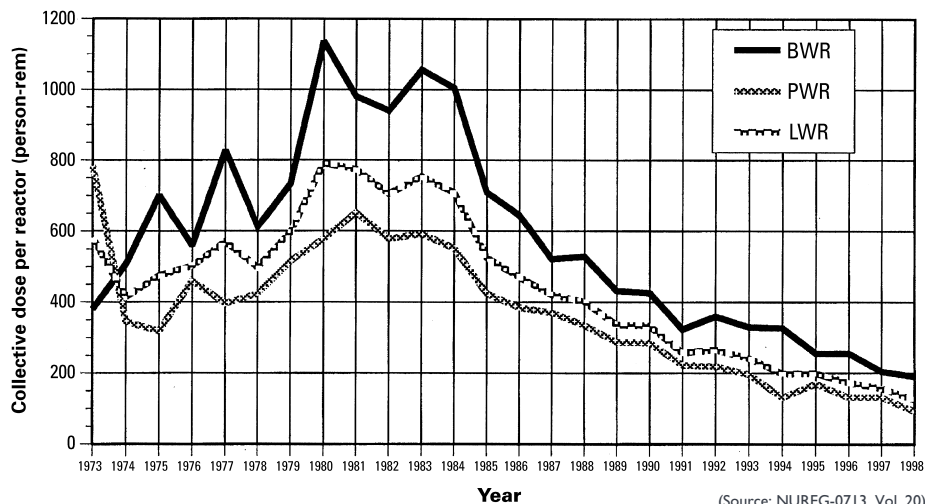
(Source: NUREG-0713, Vol. 20)

year average for collective TEDE per reactor, with 135 person-rem. Cooper was followed by Detroit Edison Company's Fermi-2 and PECO Energy Company's Limerick-1 and -2, each with 138 person-rem. Fermi-2 also had the lowest three-year average TEDE per worker, at 0.12 rem, followed by Cooper and Public Service Electric & Gas Company's Hope Creek, each at 0.16 rem.

At the other end of the spectrum for BWRs was Commonwealth Edison Company's Quad Cities-1 and -2, which had a three-year average for collective TEDE per reactor of 407 person-rem. Next highest TEDE in this category was Energy Northwest's WNP-2, at 303 person-rem. The highest three-year average TEDE per worker was Quad Cities-1 and -2, at 0.35 rem, followed by Northern States Power Company's Monticello and Northeast Utilities' Millstone-1, each at 0.30 rem.

For PWRs, Entergy Operations' Waterford-3 had the lowest three-year average for collective TEDE per reactor, with 66 person-rem. That was followed by Northern States Power's Prairie Island-1 and -2, at 67 person-rem, and North Atlantic Energy Service Corporation's Seabrook, at 72 person-rem. Seabrook also had the lowest three-year average TEDE per worker, at 0.09, followed by Waterford-3, at 0.11 rem, and Carolina Power & Light Company's Shearon Harris, at 0.12 rem.

At the high end of the list for PWRs was Consolidated Edison Company's Indian Point-2, which had a three-year average for collective TEDE per reactor of 237 person-



Average annual collective dose at U.S. nuclear power plants

(Source: NUREG-0713, Vol. 20)

rem. Next highest TEDE in this category were Florida Power and Light Company's St. Lucie-1 and -2 and Consumer Energy's Palisades, each at 194 person-rem. The highest three-year average TEDE per worker was Omaha Public Power District's Fort Calhoun, at 0.27 rem, followed by Southern Nuclear Operating Company's Farley-1 and -2, at 0.26 rem, and Indian Point-2, at 0.25 rem.

For the nuclear industry as a whole, annual reports for 1998 were received from a total of 288 NRC licensees in the six categories of industrial radiography, manufacturing and distribution, low-level waste disposal, inde-

pendent spent fuel storage installation, fuel cycle, and light-water power reactors.

Compilations of the reports indicated that 132 032 workers were monitored, 65 070 of whom received a measurable dose. The collective dose incurred by these workers in 1998 was 16 383 person-rem, which represents a 17 percent decrease from 1997. The number of workers receiving a measurable dose also decreased, resulting in the average measurable dose of 0.25 rem for 1998.

The report can be downloaded as a PDF file from the NRC's Web site at <[www.reirs.com/nureg98/nureg98.htm](http://www.reirs.com/nureg98/nureg98.htm)>. **IN**