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UPDATE OF THE ANNUAL OUTAGE DURATION AND DOSES IN EUROPEAN REACTORS (1994-2004)

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This Information Sheet presents, on the basis of three year rolling averages for the time period 1994-2004, an analysis of the evolution and dispersion of outage doses, outage durations and outage doses per day in the reactors participating in ISOE through the European Technical centre (see Annex).

The data from the ISOE 1 database are available on a calendar year basis. Therefore, when an outage starts during one calendar year and ends during the next year, doses and duration for the outage from the first year have been added to those of the second year. In that case, the outage is assigned to the year of the beginning of the outage.

1. Evolution per reactor type

Table 1 gives the three year rolling average of the outage dose, outage duration and outage dose per day, and the number of outages considered for the PWRs, BWRs and VVERs.

Table 1. Three year rolling average of the outage dose, outage duration and outage dose per day in Europe

	Years	PWR	BWR	VVER
Average outage dose (man.mSv)	1994-96	1470.13	1385.40	495.44
	1995-97	1368.15	1515.95	510.23
	1996-98	1197.00	1539.03	608.07
	1997-99	1075.06	1302.89	548.73
	1998-00	962.63	910.85	594.52
	1999-01	905.76	818.72	491.47
	2000-02	850.88	723.17	498.62
	2001-03	805.77	778.67	401.42
	2002-04	768.39	690.03	379.44
Average outage duration (No. of days)	1994-96	51.19	42.76	44.78
	1995-97	51.63	44.47	47.15
	1996-98	49.65	48.45	51.52
	1997-99	51.80	46.19	49.36
	1998-00	53.30	40.00	48.98
	1999-01	53.49	38.96	45.43
	2000-02	51.74	40.14	45.78
	2001-03	49.93	43.64	46.56
	2002-04	49.26	36.78	47.48
Average outage dose/day (man.mSv/day)	1994-96	28.72	32.40	11.07
	1995-97	26.50	34.09	10.82
	1996-98	24.11	31.77	11.80
	1997-99	20.75	28.21	11.12
	1998-00	18.06	22.77	12.14
	1999-01	16.93	21.01	10.82
	2000-02	16.44	18.02	10.89
	2001-03	16.14	17.84	8.62
	2002-04	15.60	18.76	7.99
<i>Total number of outages</i>	<i>1994-96</i>	<i>235</i>	<i>59</i>	<i>40</i>
	<i>1995-97</i>	<i>239</i>	<i>58</i>	<i>41</i>
	<i>1996-98</i>	<i>231</i>	<i>60</i>	<i>42</i>
	<i>1997-99</i>	<i>233</i>	<i>57</i>	<i>42</i>
	<i>1998-00</i>	<i>234</i>	<i>57</i>	<i>42</i>
	<i>1999-01</i>	<i>239</i>	<i>57</i>	<i>44</i>
	<i>2000-02</i>	<i>239</i>	<i>58</i>	<i>46</i>
	<i>2001-03</i>	<i>239</i>	<i>59</i>	<i>50</i>
	<i>2002-04</i>	<i>233</i>	<i>58</i>	<i>52</i>

As far as PWRs are concerned, the three year rolling average outage dose shows a regular decrease from the period 1994-1996 to the period 2002-2004 (reaching -50% at the end of the period). During the same period, the average outage duration has fluctuated around 52 days ($\pm 5\%$). Therefore, the dose decrease cannot be explained by the evolution of the outage length. However, there has been a continuous decrease of the outage dose per day (-45% for the whole period). As the data represent an average over a large number of plants, several factors may have contributed to this reduction as e.g. work management may have allowed a reduction of the number of workers and of the workload in high dose areas; the work during outages may have been reduced by shifting work to the operational period, or larges improvements such as steam generator replacements and reactor vessel head replacements, may have allowed a reduction in dose rates. For the first time, the PWR average outage dose is below 800 man.mSv.

Regarding BWRs, during the whole period, a significant decrease (by 55%) can be noticed up to 2002-2004. A similar evolution may be observed for the outage duration suggesting an impact of the

duration on the outage dose. However, this is not enough to explain the reduction of the collective dose during the last period. Therefore, it is not surprising to notice also a significant decrease of the dose per day during the period 1996-1998 / 2002-2004 (-41%). For the first time, the BWR average outage dose is below 700 man.mSv.

Finally, regarding VVERs, it should be noted that, for the first time, the average outage dose is below 400 man.mSv and that the average dose per day remains under 10 man.mSv/day and continues to decrease being 2 to 3 times lower than the one for the BWR and PWR.

2. Evolution per country

An analysis has also been performed by country. All the detailed results are given in the Annex.

2.1 Evolution of BWR outage dose per country

Within the countries operating BWR reactors, it should be noticed the very good results of Finland both in terms of average outage dose (500 man.mSv) and outage duration (12 man.mSv/day).

2.2 Evolution of PWR outage dose per country

Most countries show a regular decrease in the outage dose during the period. However, two groups of countries may be observed:

- Belgium, Spain, Sweden, Switzerland, Netherlands and the UK with outage doses around 300 to 500 man.mSv in the last periods (2001-2003 and 2002-2004),
- France and Germany with outage doses around 900 man.mSv in the last periods (2001-2003 and 2002-2004).

In the first group, Switzerland and Belgium have good results both in terms of duration and dose per day while the UK has very good results mainly in terms of the dose per day.

2.3 Evolution of VVER outage dose per country

During the whole period, the VVER reactors from the Czech Republic always show an average outage dose lower than the reactors in Finland, Hungary and Slovak Republic, and reaching for the first time an average outage dose below 200 man.mSv.

Since 2001-2003, in addition to the Czech reactors, the Slovak reactors have also good results with an average outage dose around 270 man.mSv.

ANNEX

Table A. Three years rolling average of: outage dose, outage duration and outage dose per day (man.mSv) for countries operating BWRs

	Years	Finland	Germany	Netherlands	Spain	Sweden	Switzerland
Average outage dose (man.mSv)	1994-96	744.96	1165.44	630.70	2984.03	1547.36	1212.55
	1995-97	625.31	946.72	660.77	2326.59	2117.93	1066.08
	1996-98	790.70	998.34	674.06	2326.59	2092.81	1038.70
	1997-99	673.01	926.02	-	1950.18	1666.03	869.82
	1998-00	684.13	742.27	-	2053.50	982.34	706.02
	1999-01	542.82	588.69	-	1798.63	923.60	617.77
	2000-02	584.24	524.40	-	1777.91	837.01	560.92
	2001-03	473.73	568.05	-	1690.41	911.12	612.99
	2002-04	509.14	565.38	-	1909.21	663.15	763.59
Average outage duration (No. of days)	1994-96	15.67	46.87	57.00	43.25	45.36	41.33
	1995-97	15.83	41.20	56.50	34.25	54.96	40.33
	1996-98	17.67	50.35	56.00	34.25	57.54	42.67
	1997-99	15.50	46.80	-	33.25	56.88	37.67
	1998-00	13.83	40.75	-	36.33	47.88	31.83
	1999-01	11.67	29.00	-	35.75	55.84	24.67
	2000-02	12.33	45.70	-	35.00	47.96	22.00
	2001-03	12.17	48.42	-	29.50	55.50	22.00
	2002-04	12.83	47.63	-	28.00	38.25	24.83
Average outage dose/day (man.mSv/day)	1994-96	47.55	24.87	11.06	68.99	34.11	29.34
	1995-97	39.49	22.98	11.69	67.93	38.54	26.43
	1996-98	44.76	19.83	12.04	67.93	36.37	24.34
	1997-99	43.42	19.79	-	58.65	29.29	23.09
	1998-00	49.45	18.22	-	56.52	20.51	22.18
	1999-01	46.53	20.30	-	50.31	16.54	25.04
	2000-02	47.37	11.47	-	50.80	17.45	25.50
	2001-03	38.94	11.73	-	57.30	16.42	27.86
	2002-04	39.67	11.87	-	68.19	17.34	30.75
<i>Total number of outages</i>	1994-96	6	15	3	4	25	6
	1995-97	6	15	2	4	25	6
	1996-98	6	17	1	4	26	6
	1997-99	6	15	0	4	26	6
	1998-00	6	16	0	3	26	6
	1999-01	6	16	0	4	25	6
	2000-02	6	20	0	3	23	6
	2001-03	6	19	0	4	24	6
	2002-04	6	19	0	3	24	6

Table B. Three years rolling average of: outage dose, outage duration and outage dose per day (man.mSv) for countries operating PWRs

	Years	Belgium	France	Germany	Netherlands	Spain	Sweden	Switzerland	UK
Average outage dose (man.mSv)	1994-96	991.21	1570.22	1570.21	1049.77	1943.85	648.44	698.25	485.13
	1995-97	822.59	1457.28	1470.91	1443.42	1836.46	642.54	600.13	476.26
	1996-98	609.14	1353.65	1168.09	1369.87	1338.57	530.16	547.14	476.26
	1997-99	505.15	1218.14	1111.23	1145.03	936.75	486.52	588.57	551.08
	1998-00	489.56	1134.03	976.69	383.69	647.93	419.97	585.75	526.96
	1999-01	437.41	1072.30	918.67	329.43	619.59	342.15	540.22	526.96
	2000-02	425.50	1000.27	912.03	349.83	541.79	373.80	454.56	336.40
	2001-03	433.53	943.74	879.29	269.70	480.96	420.78	355.22	275.53
	2002-04	408.43	858.34	931.44	381.25	484.87	490.30	314.13	275.53
Average outage duration (No. of days)	1994-96	51.20	56.39	35.64	41.00	54.44	40.56	37.63	55.00
	1995-97	43.63	57.78	32.59	79.00	58.59	38.89	37.13	52.00
	1996-98	38.63	58.50	28.03	73.00	49.87	31.56	34.43	52.00
	1997-99	32.71	63.02	26.95	67.33	47.25	30.78	41.29	57.50
	1998-00	28.33	67.65	29.37	21.33	37.75	42.33	41.00	57.00
	1999-01	27.50	69.16	27.19	16.67	33.63	44.00	40.67	57.00
	2000-02	29.89	66.29	28.32	17.67	30.75	48.11	32.67	43.00
	2001-03	32.26	63.17	28.77	15.00	32.44	38.22	26.78	39.50
	2002-04	34.56	60.53	30.64	19.00	32.79	34.33	24.00	39.50
Average outage dose/day (man.mSv/day)	1994-96	19.36	27.84	44.06	25.60	35.71	15.99	18.56	8.82
	1995-97	18.85	25.22	45.13	18.27	31.35	16.52	16.16	9.16
	1996-98	15.77	23.14	41.68	18.77	26.84	16.80	15.89	9.16
	1997-99	15.45	19.33	41.23	17.01	19.83	15.81	14.26	9.58
	1998-00	17.28	16.76	33.26	17.99	17.16	9.92	14.29	9.24
	1999-01	15.91	15.51	33.79	19.77	18.43	7.78	13.28	9.24
	2000-02	14.23	15.09	32.21	19.80	17.62	7.77	13.91	7.82
	2001-03	13.44	14.94	30.56	17.98	14.83	11.01	13.27	6.98
	2002-04	11.82	14.18	30.40	20.07	14.79	14.28	13.09	6.98
<i>Total number of outages</i>	1994-96	20	142	36	3	16	9	8	1
	1995-97	19	144	37	3	17	9	8	2
	1996-98	19	138	38	3	15	9	7	2
	1997-99	17	140	39	3	16	9	7	2
	1998-00	18	137	41	3	16	9	8	2
	1999-01	18	140	42	3	16	9	9	2
	2000-02	19	140	41	3	16	9	9	2
	2001-03	19	142	39	3	16	9	9	2
	2002-04	18	143	36	3	14	9	8	2

Table C. Three years rolling average of: outage dose, outage duration and outage dose per day (man.mSv) for countries operating VVERs

	Years	Czech Rep.	Finland	Hungary	Slovak Rep.
Average outage dose (man.mSv)	1994-96	328.47	895.57	488.46	451.78
	1995-97	338.19	700.74	509.74	594.54
	1996-98	314.26	906.49	582.45	778.27
	1997-99	299.48	698.45	540.05	731.82
	1998-00	262.12	891.59	623.66	749.25
	1999-01	263.61	732.15	569.30	516.92
	2000-02	240.35	937.59	638.65	422.70
	2001-03	218.84	720.91	591.61	289.42
	2002-04	176.68	952.29	512.30	261.49
Average outage duration (No. of days)	1994-96	46.91	34.67	38.42	55.09
	1995-97	50.42	26.33	37.00	66.00
	1996-98	48.58	30.50	39.67	76.83
	1997-99	45.25	22.67	40.00	76.17
	1998-00	40.83	27.50	41.83	75.00
	1999-01	40.58	24.67	39.83	63.29
	2000-02	39.92	31.17	41.50	58.88
	2001-03	42.15	27.17	50.54	53.33
	2002-04	46.13	31.83	51.31	51.06
Average outage dose/day (man.mSv/day)	1994-96	7.00	25.83	12.71	8.20
	1995-97	6.71	26.61	13.78	9.01
	1996-98	6.47	29.72	14.68	10.13
	1997-99	6.62	30.81	13.50	9.61
	1998-00	6.42	32.42	14.91	9.99
	1999-01	6.50	29.68	14.29	8.17
	2000-02	6.02	30.08	15.39	7.18
	2001-03	5.19	26.54	11.71	5.43
	2002-04	3.83	29.91	9.98	5.12
<i>Total number of outages</i>	<i>1994-96</i>	<i>11</i>	<i>6</i>	<i>12</i>	<i>11</i>
	<i>1995-97</i>	<i>12</i>	<i>6</i>	<i>12</i>	<i>11</i>
	<i>1996-98</i>	<i>12</i>	<i>6</i>	<i>12</i>	<i>12</i>
	<i>1997-99</i>	<i>12</i>	<i>6</i>	<i>12</i>	<i>12</i>
	<i>1998-00</i>	<i>12</i>	<i>6</i>	<i>12</i>	<i>12</i>
	<i>1999-01</i>	<i>12</i>	<i>6</i>	<i>12</i>	<i>14</i>
	<i>2000-02</i>	<i>12</i>	<i>6</i>	<i>12</i>	<i>16</i>
	<i>2001-03</i>	<i>13</i>	<i>6</i>	<i>13</i>	<i>18</i>
	<i>2002-04</i>	<i>15</i>	<i>6</i>	<i>13</i>	<i>18</i>