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**North American Technical Center
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Kewaunee PWR Low Dose Outage Worker Study

NATC ISOE Information Sheet No. 2014-08

NATC ISOE Information Sheet 2014-08 presents an outage worker dose study conducted by the Kewaunee Nuclear Plant RPM, Mike Hale, and his dosimetry and ALARA staff. Kewaunee is a Westinghouse PWR located in Wisconsin, USA and is owned and operated by Dominion Energy.

The outage worker study evaluated the Electronic Dosimeter (ED) results of refueling outage workers from outages in years 2009, 2011 and 2012. The study focused on the number of containment entries vs workers' individual dose vs percentage of total outage dose. The RPM commented that the study was a kind of a reverse way to look at individual worker outage dose: most RPMs and Station

ALARA Committees focus on the higher dose jobs. What the Kewaunee study showed was the station was doing a good job controlling high dose rate jobs, but **every mrem counts!** Remarkably low individual doses by a large number of outage workers really added up to be a significant increase to the total outage dose. For example, the 2012 worker dose analysis showed that **94.499%** of the Kewaunee outage dose was received **from outage workers receiving 5 mrem or less** during the outage! The total outage dose was 39,533 mrem by ED (395.33 person mSv). 37,358 mrem (373.58 person mSv) was received on containment entries of 5 mrem or less (one and two mrem per entry added up to 6,593mrem).

Mr. Hale stated, “I used this information to reinforce in a big way that all those ‘I only picked up 1 or 2 mrem’ really do add up. As they say there are no low dose waiting areas in Containment ... just areas of lower dose to wait in... so get out of Containment and wait for the part or tool.”

The Kewaunee outage worker low dose study provided the following results:

1. The outage workers receiving less than 5 mRem (0.05 mSv) were of particular interest to RP management.
2. Results of the ED dose analysis of all refueling outage workers showed that over 89% of the outage workers received less than 5 mrem for the years of 2009, 2011, and 2012 as shown in the following chart.

Year	Percent of Dose 5mrem or less
2009	89.525
2011	90.830
2012	94.499

The data suggests the importance of low dose entry accumulation. Higher dose jobs are often the major focus for ALARA management at nuclear reactors but every mrem can add up.

Table 1: Number of Entries per Accumulated DDE - 2009

Table 2: Number of Entries per Accumulated DDE - 2011

Table 3: Number of Entries per Accumulated DDE - 2012

Table 1: Number of Entries per Accumulated DDE – 2009

Criteria Selected			
Starting Date/Time 26-SEP-2009 00:00:00			
Ending Date/Time 23-OCT-2009 00:00:00			

DDE (mm)	Number of Entries	Percent of Total	Cummulative Percent
0	14947	67.368	67.368
1	2327	10.488	77.856
2	991	4.467	82.323
3	696	3.137	85.460
4	481	2.168	87.628
5	421	1.898	89.525
6	310	1.397	90.923
7	234	1.055	91.977
8	181	0.816	92.793
9	165	0.744	93.537
10	162	0.730	94.267
11	107	0.482	94.749
12	97	0.437	95.186
13	87	0.392	95.578
14	69	0.311	95.889
15	63	0.284	96.173
16	59	0.266	96.439
17	60	0.270	96.710
18	42	0.189	96.899
19	42	0.189	97.088
20	42	0.189	97.278
21	35	0.158	97.435
22	33	0.149	97.584
23	30	0.135	97.719
24	27	0.122	97.841
25	38	0.171	98.012
26	24	0.108	98.121
27	24	0.108	98.229
28	19	0.086	98.314
29	17	0.077	98.391
30	23	0.104	98.495
31	20	0.090	98.585
32	13	0.059	98.643
33	13	0.059	98.702
34	7	0.032	98.733
35	15	0.068	98.801
36	16	0.072	98.873
37	13	0.059	98.932
38	6	0.027	98.959
39	8	0.036	98.995
40	7	0.032	99.026
41	12	0.054	99.081
42	10	0.045	99.126
43	6	0.027	99.153
44	7	0.032	99.184
45	7	0.032	99.216
46	5	0.023	99.238
47	10	0.045	99.283
48	6	0.027	99.310
49	4	0.018	99.328
50	10	0.045	99.374
51	5	0.023	99.396
52	3	0.014	99.410
53	7	0.032	99.441
54	4	0.018	99.459
55	4	0.018	99.477

DDE (mrem)	Number of Entries	Percent of Total	Cummulative Percent
56	3	0.014	99.491
57	7	0.032	99.522
58	7	0.032	99.554
59	5	0.023	99.576
60	6	0.027	99.603
61	3	0.014	99.617
62	3	0.014	99.630
63	4	0.018	99.648
64	1	0.005	99.653
65	1	0.005	99.657
66	1	0.005	99.662
67	3	0.014	99.675
68	5	0.023	99.698
69	3	0.014	99.712
70	5	0.023	99.734
71	3	0.014	99.748
73	4	0.018	99.766
74	2	0.009	99.775
76	2	0.009	99.784
77	4	0.018	99.802
78	2	0.009	99.811
79	3	0.014	99.824
82	2	0.009	99.833
85	1	0.005	99.838
88	1	0.005	99.842
89	1	0.005	99.847
92	3	0.014	99.860
95	4	0.018	99.878
96	2	0.009	99.887
97	1	0.005	99.892
102	2	0.009	99.901
103	3	0.014	99.914
106	2	0.009	99.923
108	1	0.005	99.928
109	1	0.005	99.932
110	1	0.005	99.937
113	1	0.005	99.941
114	1	0.005	99.946
117	1	0.005	99.950
120	1	0.005	99.955
122	1	0.005	99.959
125	1	0.005	99.964
129	1	0.005	99.968
135	1	0.005	99.973
152	1	0.005	99.977
160	1	0.005	99.982
171	1	0.005	99.986
217	1	0.005	99.991
253	1	0.005	99.995
287	1	0.005	100.000

Total Number of Entries Reported: 22187
Average DDE/Entry (mrem): 2.409
Average Time/Entry (hours): 2.063

Table 2: Number of Entries per Accumulated DDE – 2011

Criteria Selected			
Starting Date/Time 26-FEB-2011 00:00:00			
Ending Date/Time 26-MAR-2011 23:30:00			

DDE (mrem)	Number of Entries	Percent of Total	Cummulative Percent
0	19904	66.179	66.179
1	3889	12.931	79.110
2	1447	4.811	83.921
3	970	3.225	87.146
4	665	2.211	89.357
5	443	1.473	90.830
6	314	1.044	91.874
7	257	0.855	92.728
8	233	0.775	93.503
9	170	0.565	94.068
10	149	0.495	94.564
11	111	0.369	94.933
12	99	0.329	95.262
13	103	0.342	95.604
14	71	0.236	95.841
15	76	0.253	96.093
16	62	0.206	96.299
17	48	0.160	96.459
18	54	0.180	96.639
19	45	0.150	96.788
20	53	0.176	96.964
21	44	0.146	97.111
22	37	0.123	97.234
23	32	0.106	97.340
24	25	0.083	97.423
25	36	0.120	97.543
26	27	0.090	97.633
27	20	0.066	97.699
28	35	0.116	97.816
29	31	0.103	97.919
30	27	0.090	98.008
31	28	0.093	98.101
32	20	0.066	98.168
33	27	0.090	98.258
34	30	0.100	98.357
35	27	0.090	98.447
36	28	0.093	98.540
37	18	0.060	98.600
38	22	0.073	98.673
39	27	0.090	98.763
40	20	0.066	98.830
41	18	0.060	98.889
42	14	0.047	98.936
43	15	0.050	98.986
44	10	0.033	99.019
45	9	0.030	99.049
46	10	0.033	99.082
47	8	0.027	99.109
48	10	0.033	99.142
49	9	0.030	99.172
50	10	0.033	99.205
51	12	0.040	99.245
52	9	0.030	99.275
53	11	0.037	99.312
54	8	0.027	99.338
55	12	0.040	99.378
56	2	0.007	99.385

DDE (mrem)	Number of Entries	Percent of Total	Cummulative Percent
57	7	0.023	99.408
58	8	0.027	99.435
59	9	0.030	99.465
60	9	0.030	99.495
61	7	0.023	99.518
62	7	0.023	99.541
63	6	0.020	99.561
64	3	0.010	99.571
65	5	0.017	99.588
66	4	0.013	99.601
67	3	0.010	99.611
68	7	0.023	99.634
69	6	0.020	99.654
70	5	0.017	99.671
71	4	0.013	99.684
72	3	0.010	99.694
73	2	0.007	99.701
74	2	0.007	99.707
75	2	0.007	99.714
76	1	0.003	99.717
77	4	0.013	99.731
78	5	0.017	99.747
80	2	0.007	99.754
81	2	0.007	99.761
82	5	0.017	99.777
83	1	0.003	99.781
84	1	0.003	99.784
85	1	0.003	99.787
86	3	0.010	99.797
87	4	0.013	99.810
88	1	0.003	99.814
89	1	0.003	99.817
90	1	0.003	99.820
92	1	0.003	99.824
93	4	0.013	99.837
94	3	0.010	99.847
95	1	0.003	99.850
96	1	0.003	99.854
98	1	0.003	99.857
99	1	0.003	99.860
102	3	0.010	99.870
104	2	0.007	99.877
105	1	0.003	99.880
106	3	0.010	99.890
107	1	0.003	99.894
108	2	0.007	99.900
109	1	0.003	99.904
111	2	0.007	99.910
114	1	0.003	99.914
115	1	0.003	99.917
116	1	0.003	99.920
120	1	0.003	99.924
124	2	0.007	99.930
126	1	0.003	99.934
128	1	0.003	99.937
131	1	0.003	99.940
133	1	0.003	99.943
138	2	0.007	99.950
140	1	0.003	99.953
143	1	0.003	99.957
149	1	0.003	99.960
150	1	0.003	99.963
158	1	0.003	99.967
162	1	0.003	99.970
163	1	0.003	99.973
166	1	0.003	99.977
170	2	0.007	99.983
172	1	0.003	99.987
178	1	0.003	99.990
188	1	0.003	99.993
199	1	0.003	99.997
287	1	0.003	100.000

Total Number of Entries Reported: 30076
Average DDE/Entry (mrem): 2.463
Average Time/Entry (hours): 1.876

Table 3: Number of Entries per Accumulated DDE – 2012

Criteria Selected	
Starting Date/Time	06-APR-2012 00:00:00
Ending Date/Time	10-MAY-2012 13:30:00

<u>DDE (mrem)</u>	<u>Number of Entries</u>	<u>Percent of Total</u>	<u>Cummulative Percent</u>
0.0	22726	71.972	71.972
1.0	3717	11.772	83.744
2.0	1438	4.554	88.298
3.0	940	2.977	91.275
4.0	619	1.960	93.235
5.0	399	1.264	94.499
6.0	273	0.865	95.364
7.0	203	0.643	96.006
8.0	164	0.519	96.526
9.0	130	0.412	96.938
10.0	122	0.386	97.324
11.0	79	0.250	97.574
12.0	77	0.244	97.818
13.0	62	0.196	98.014
14.0	59	0.187	98.201
15.0	56	0.177	98.379
16.0	48	0.152	98.531
17.0	36	0.114	98.645
18.0	37	0.117	98.762
19.0	28	0.089	98.850
20.0	33	0.105	98.955
21.0	26	0.082	99.037
22.0	26	0.082	99.120
23.0	19	0.060	99.180
24.0	16	0.051	99.230
25.0	20	0.063	99.294
26.0	19	0.060	99.354
27.0	12	0.038	99.392
28.0	12	0.038	99.430
29.0	11	0.035	99.465
30.0	8	0.025	99.490
31.0	8	0.025	99.515
32.0	11	0.035	99.550
33.0	16	0.051	99.601
34.0	14	0.044	99.645
35.0	5	0.016	99.661
36.0	9	0.029	99.690
37.0	7	0.022	99.712
38.0	4	0.013	99.724
39.0	8	0.025	99.750
40.0	7	0.022	99.772
41.0	4	0.013	99.785
42.0	1	0.003	99.788
43.0	7	0.022	99.810
44.0	8	0.025	99.835
45.0	4	0.013	99.848
46.0	3	0.010	99.857
47.0	1	0.003	99.861
48.0	2	0.006	99.867
49.0	4	0.013	99.880
50.0	3	0.010	99.889
51.0	4	0.013	99.902
52.0	2	0.006	99.908
53.0	1	0.003	99.911
54.0	2	0.006	99.918
55.0	5	0.016	99.933
57.0	1	0.003	99.937

<u>DDE (mrem)</u>	<u>Number of Entries</u>	<u>Percent of Total</u>	<u>Cummulative Percent</u>
58.0	2	0.006	99.943
59.0	2	0.006	99.949
60.0	1	0.003	99.952
61.0	1	0.003	99.956
63.0	1	0.003	99.959
64.0	1	0.003	99.962
65.0	2	0.006	99.968
66.0	1	0.003	99.971
70.0	1	0.003	99.975
73.0	1	0.003	99.978
75.0	1	0.003	99.981
90.0	1	0.003	99.984
97.0	1	0.003	99.987
126.0	2	0.006	99.994
159.0	1	0.003	99.997
171.0	1	0.003	100.000
Total Number of Entries Reported:		31576	
Average DDE/Entry (mrem):		1.252	
Average Time/Entry (hours):		1.783	