Rev.01 of May 4, 2002

Doses from the VJ beam pipe

Here are given results of simulations of dose rate that results from activation of the beam pipe section placed inside removable part of the Forward Shield (Z_{min}=1300 cm, Z_{max}= 1865 cm).

1. Both high-energy hadrons and low-energy neutrons activation was taken into account.
2. Design of VJ beam-pipe was taken after LHCVC1J_0002 drawing. The beam-pipe is made of stainless steel (316 L), accept for Vacuum Support structure which assumed to be5 mm thick aluminum.
3. Geometry taken for activation calculations is given in the table 1 (VJ) and table 2 (Vacuum Support structure). A sketch of the beam pipe is given on fig. 1.
4. For the purpose of the study the beam pipe was subdivided onto a set of circular radiation sources centered along Z-axis and the dose was calculated as sum over all the sources. At that the doses will be conservative as no self-attenuation of gamma radiation was taken into account. Consequently doses may be slightly overestimated by some 10%. The only element, which self-attenuation cannot be neglected is thick aluminum flange at the end of vacuum support structure (see table 2, #36). Contribution from the flange was calculated separately with DOT-3.0.
5. Results for VJ beam-pipe without vacuum support structure are given in tables 3 (hadron activation) and 4 (neutron activation). Results for VJ beam-pipe with vacuum support structure are given in tables 5 (hadron activation) and 6 (neutron activation). All doses are in μSv/h. Dimensions are given in cm from the interaction point.

Table 1

Material zones of the VJ beam pipe section (SS)

##	Z_{min}, cm	Z_{max}, cm	R_{min}, cm	R_{max}, cm	Mass, kg	Comment
1	1300.7	1302.9	4	6.3	1.276	Flange
2	1302.9	1320.7	4	4.1	0.353	Tube
3	1320.7	1332.1	4	4.18	0.411	Bellows
4	1332.1	1392.8	4	4.1	1.204	Tube
5	1392.8	1404.2	4	4.18	0.411	Bellows
6	1404.2	1434.2	4	4.1	0.595	Tube
7	1434.2	1441.6	5.1	5.2	0.187	Cone
8	1441.6	1792.5	6	6.15	15.663	Tube
9	1792.5	1805	6	6.19	0.709	Bellows
10	1805	1832	6	6.15	1.205	Tube
11	1832	1844.5	6	6.19	0.709	Bellows
12	1844.5	1862.8	6	6.15	0.817	Tube
13	1862.8	1865	6	8.3	1.772	Flange

Table 2

Material zones of the Vacuum Support structure (AL)

##	Z_{min}, cm	Z_{max}, cm	R_{min}, cm	R_{max}, cm	Mass, kg	Comment
14	1312.6	1337.6	8.69	9.19	1.89	Cone
15	1337.6	1362.6	9.22	9.72	2.01	Cone
16	1362.6	1387.6	9.74	10.24	2.12	Cone
17	1387.6	1412.6	10.27	10.77	2.23	Cone
18	1412.6	1437.6	10.8	11.3	2.34	Cone
19	1437.6	1462.6	11.32	11.82	2.45	Cone
20	1462.6	1487.6	11.85	12.35	2.56	Cone
21	1487.6	1512.6	12.38	12.88	2.68	Cone
22	1512.6	1537.6	12.9	13.4	2.79	Cone
23	1537.6	1562.6	13.43	13.93	2.90	Cone
24	1562.6	1587.6	13.96	14.46	3.01	Cone
25	1587.6	1612.6	14.48	14.98	3.12	Cone
26	1612.6	1637.6	15.01	15.51	3.23	Cone
27	1637.6	1662.6	15.54	16.04	3.35	Cone
28	1662.6	1687.6	16.06	16.56	3.46	Cone
29	1687.6	1712.6	16.59	17.09	3.57	Cone
30	1712.6	1737.6	17.12	17.62	3.68	Cone
31	1737.6	1762.6	17.64	18.14	3.79	Cone
32	1762.6	1787.6	18.17	18.67	3.90	Cone
33	1787.6	1812.6	18.7	19.2	4.02	Cone
34	1812.6	1837.6	19.22	19.72	4.13	Cone
35	1837.6	1862.6	19.75	20.25	4.24	Cone
36	1862.6	1867.6	20	60	135.65	Flange

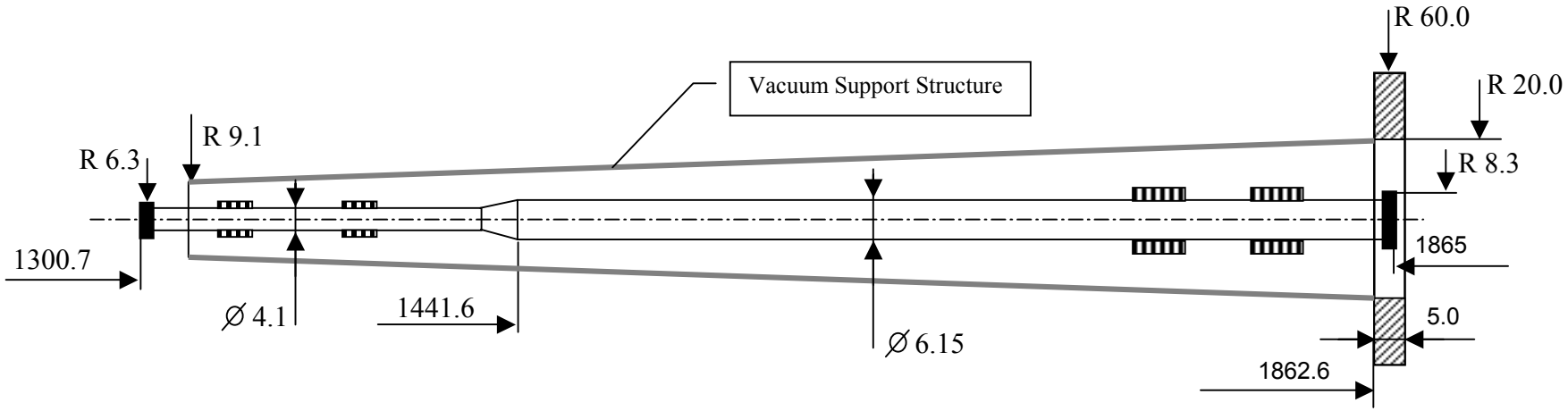

Fig. 1 Sketch of the VJ Beam pipe section.

Table 3

Equivalent dose rate induced by high-energy hadrons from VJ Beam Pipe without support structure for T= 100d, t=1d

R/Z, cm	1300	1310	1325	1360	1400	1440	1500	1560	1620	1680	1740	1800	1840	1855	1865
0	3276														1036
6	2757	2049	1659	874	1301										998
8	2239	1504	1069	616	812	647	682	590	548	516	469	517	711	969	960
10	1361	1140	798	485	592	498	487	424	394	370	338	372	507	691	922
15	608	623	488	326	353	319	297	260	241	226	209	230	302	369	358
20	365	390	342	247	251	234	215	190	176	165	153	167	210	230	211
25	251	270	254	198	194	184	168	150	138	129	121	131	157	160	146
50	84	89	93	91	87	84	78	71	66	62	59	60	59	56	52
75	46	48	51	53	53	52	49	45	42	40	38	36	33	31	30
100	30	31	33	35	36	36	34	32	30	28	27	25	22	21	20
125	22	22	23	25	26	26	26	24	23	22	20	18	17	16	15
150	17	17	18	19	20	20	20	19	18	17	16	14	13	12	12
175	13	14	14	15	16	16	16	15	15	14	13	12	11	10	10
200	11	11	11	12	13	13	13	13	12	12	11	10	8.9	8.6	8.4
225	9	9	9	10	10	11	11	11	10	9.8	9.1	8.2	7.6	7.4	7.2

Table 3 (continuation)

Equivalent dose rate induced by high-energy hadrons from VJ Beam Pipe without support structure for T= 100 d, t= 5d

R/Z, cm	1300	1310	1325	1360	1400	1440	1500	1560	1620	1680	1740	1800	1840	1855	1865
0	2334														723
6	1965	1461	1184	622	924										696
8	1596	1072	763	438	576	459	483	417	387	364	330	364	499	677	669
10	970	812	569	346	420	353	345	299	278	261	238	262	356	483	643
15	433	444	348	232	251	226	210	184	170	160	147	162	212	258	250
20	260	278	244	176	178	166	152	134	124	116	108	118	147	161	148
25	179	193	181	141	138	130	119	106	98	91	86	92	110	112	102
50	60	64	66	65	62	60	55	50	47	44	41	42	41	39	36
75	33	34	36	38	38	37	34	32	30	28	26	25	23	22	21
100	21	22	23	25	25	25	24	23	21	20	19	17	16	15	14
125	15	16	17	18	18	19	18	17	16	15	14	13	12	11	11
150	12	12	13	13	14	14	14	14	13	12	11	10	9.2	8.8	8.5
175	9.4	9.6	9.9	11	11	11	11	11	10	9.9	9.1	8.2	7.5	7.2	7.0
200	7.7	7.9	8.1	8.5	8.9	9.1	9.2	9.0	8.7	8.2	7.6	6.8	6.3	6.1	5.9
225	6.4	6.6	6.7	7.1	7.4	7.6	7.7	7.5	7.3	6.9	6.4	5.8	5.4	5.2	5.1

Table 3 (continuation)

Equivalent dose rate induced by high-energy hadrons from VJ Beam Pipe without support structure for T= 100 d, t= 100d

R/Z, cm	1300	1310	1325	1360	1400	1440	1500	1560	1620	1680	1740	1800	1840	1855	1865
0	399														136
6	337	249	201	105	154										131
8	274	183	130	74	96	77	81	70	64	61	56	63	89	124	127
10	166	139	97	58	70	59	58	50	46	44	40	46	64	89	122
15	74	76	59	39	42	38	35	31	28	27	25	28	38	47	47
20	44	47	41	30	30	28	26	22	21	19	18	21	27	30	27
25	30	33	31	24	23	22	20	18	16	15	15	16	20	20	19
50	10	11	11	11	10	10	9.3	8.4	7.8	7.3	7.1	7.3	7.3	7.0	6.5
75	5.5	5.8	6.1	6.4	6.3	6.2	5.8	5.4	5.0	4.7	4.5	4.4	4.1	3.9	3.7
100	3.6	3.8	3.9	4.2	4.3	4.3	4.1	3.8	3.6	3.4	3.2	3.0	2.8	2.6	2.5
125	2.6	2.7	2.8	3.0	3.1	3.1	3.1	2.9	2.8	2.6	2.4	2.2	2.0	1.9	1.9
150	2.0	2.1	2.1	2.3	2.4	2.4	2.4	2.3	2.2	2.1	1.9	1.7	1.6	1.5	1.5
175	1.6	1.6	1.7	1.8	1.9	1.9	1.9	1.9	1.8	1.7	1.6	1.4	1.3	1.2	1.2
200	1.3	1.3	1.4	1.4	1.5	1.6	1.6	1.5	1.5	1.4	1.3	1.2	1.1	1.0	1.0
225	1.1	1.1	1.1	1.2	1.3	1.3	1.3	1.3	1.2	1.2	1.1	1.0	0.9	0.9	0.9

Table 3 (continuation)

Equivalent dose rate induced by high-energy hadrons from VJ Beam Pipe without support structure for T= 10y, t=1d

R/Z, cm	1300	1310	1325	1360	1400	1440	1500	1560	1620	1680	1740	1800	1840	1855	1865
0	3580														1142
6	3014	2237	1814	956	1423										1100
8	2448	1643	1168	673	888	707	745	646	599	565	514	568	783	1067	1058
10	1487	1245	872	531	647	544	532	464	430	405	370	409	558	761	1016
15	664	681	533	356	386	348	324	285	264	248	229	252	333	406	394
20	398	427	373	270	274	255	235	208	192	180	168	184	232	254	233
25	274	296	278	217	212	201	184	164	151	142	133	144	172	177	161
50	92	98	102	100	96	92	85	78	72	68	64	66	65	61	57
75	50	53	55	58	58	56	53	49	46	43	41	39	36	34	33
100	33	34	36	38	39	39	37	35	33	31	29	27	25	23	22
125	24	25	26	27	28	29	28	27	25	24	22	20	18	17	17
150	18	19	19	21	22	22	22	21	20	19	17	16	14	14	13
175	14	15	15	16	17	17	17	17	16	15	14	13	12	11	11
200	12	12	12	13	14	14	14	14	13	13	12	11	9.8	9.4	9.2
225	10	10	10	11	11	12	12	12	11	11	9.9	9.0	8.3	8.1	7.9

Table 3 (continuation)

Equivalent dose rate induced by high-energy hadrons from VJ Beam Pipe without support structure for T= 10 y, t=5d

R/Z, cm	1300	1310	1325	1360	1400	1440	1500	1560	1620	1680	1740	1800	1840	1855	1865
0	2625														828
6	2210	1643	1335	702	1043										797
8	1796	1206	859	494	650	518	546	471	437	412	374	413	567	773	767
10	1091	914	641	390	474	399	390	339	314	295	270	297	405	551	737
15	487	500	392	261	283	255	237	208	193	181	167	183	241	294	286
20	292	313	274	198	201	187	172	152	140	131	122	134	168	184	169
25	201	217	204	159	156	147	134	120	110	103	97	105	125	128	117
50	67	72	75	73	70	67	62	57	53	49	47	48	47	44	41
75	37	39	41	43	42	41	39	36	34	32	30	29	26	25	24
100	24	25	26	28	29	29	27	26	24	23	21	20	18	17	16
125	17	18	19	20	21	21	20	19	18	17	16	15	13	13	12
150	13	14	14	15	16	16	16	15	15	14	13	11	10	10	9.6
175	11	11	11	12	12	13	13	12	12	11	10	9.3	8.5	8.2	7.9
200	8.7	8.9	9.1	9.7	10	10	10	10	9.8	9.3	8.6	7.7	7.1	6.9	6.7
225	7.3	7.4	7.6	8.0	8.3	8.6	8.7	8.5	8.2	7.8	7.2	6.6	6.1	5.9	5.7

Table 3 (continuation)

Equivalent dose rate induced by high-energy hadrons from VJ Beam Pipe without support structure for T= 10y, t=100d

R/Z, cm	1300	1310	1325	1360	1400	1440	1500	1560	1620	1680	1740	1800	1840	1855	1865
0	604														211
6	509	377	306	160	236										204
8	414	277	197	113	147	118	125	108	99	94	87	98	138	194	197
10	251	210	147	89	107	91	89	77	72	67	63	71	99	139	190
15	112	115	90	60	64	58	54	48	44	41	39	44	59	74	73
20	67	72	63	45	46	43	39	35	32	30	28	32	41	46	43
25	46	50	47	36	35	33	31	27	25	24	23	25	31	32	29
50	15	16	17	17	16	15	14	13	12	11	11	11	11	11	10
75	8.4	8.8	9.3	9.7	9.7	9.5	8.9	8.3	7.7	7.3	7.0	6.8	6.4	6.0	5.72
100	5.5	5.8	6.0	6.4	6.6	6.5	6.3	5.9	5.6	5.3	5.0	4.7	4.3	4.1	3.88
125	4.0	4.1	4.3	4.6	4.8	4.8	4.7	4.5	4.2	4.0	3.8	3.5	3.1	3.0	2.89
150	3.1	3.1	3.3	3.5	3.6	3.7	3.7	3.5	3.4	3.2	3.0	2.7	2.5	2.4	2.28
175	2.4	2.5	2.6	2.7	2.9	2.9	2.9	2.9	2.7	2.6	2.4	2.2	2.0	1.9	1.87
200	2.0	2.0	2.1	2.2	2.3	2.4	2.4	2.4	2.3	2.2	2.0	1.8	1.7	1.6	1.57
225	1.7	1.7	1.7	1.8	1.9	2.0	2.0	2.0	1.9	1.8	1.7	1.5	1.4	1.4	1.34

Table 4

Equivalent dose rate induced by low-energy neutrons from VJ Beam Pipe without support structure for T= 100d, t=1d

R/Z, cm	1300	1310	1325	1360	1400	1440	1500	1560	1620	1680	1740	1800	1840	1855	1865
0	65.7														141.0
6	56.1	36.9	22.7	11.7	15.6										140.0
8	46.5	27.7	15.3	8.4	10.0	11.8	17.6	15.6	15.9	17.0	20.7	33.6	59.8	108.4	139.0
10	27.6	21.1	11.9	6.7	7.4	9.0	12.5	11.3	11.5	12.3	15.1	24.4	44.3	80.5	138.0
15	11.8	11.4	7.7	4.6	4.7	5.8	7.5	7.0	7.1	7.6	9.5	15.3	27.9	42.9	47.1
20	6.9	7.0	5.6	3.6	3.5	4.3	5.4	5.1	5.2	5.7	7.1	11.3	19.8	25.8	25.7
25	4.6	4.8	4.2	3.0	2.9	3.4	4.2	4.1	4.1	4.5	5.7	9.0	14.8	17.3	16.7
50	1.5	1.6	1.6	1.5	1.5	1.7	1.9	2.0	2.1	2.3	2.9	4.1	5.0	5.0	4.8
75	0.9	0.9	0.9	1.0	1.0	1.1	1.2	1.3	1.4	1.6	1.9	2.4	2.5	2.5	2.4
100	0.6	0.6	0.6	0.7	0.7	0.8	0.9	0.9	1.0	1.2	1.3	1.5	1.6	1.5	1.5
125	0.5	0.5	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.9	1.0	1.1	1.1	1.0	1.0
150	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.7	0.8	0.8	0.8	0.8	0.8
175	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6
200	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5
225	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4

Table 4 (continuation)

Equivalent dose rate induced by low-energy neutrons from VJ Beam Pipe without support structure for T= 100d, t=5d

R/Z, cm	1300	1310	1325	1360	1400	1440	1500	1560	1620	1680	1740	1800	1840	1855	1865
0	62.6														128.9
6	53.4	35.1	21.5	11.1	14.7										128.0
8	44.3	26.3	14.5	7.9	9.4	11.1	16.6	14.6	14.8	15.6	18.7	30.1	53.9	98.6	127.1
10	26.3	20.0	11.2	6.3	7.0	8.5	11.8	10.5	10.7	11.3	13.7	21.9	40.0	73.3	126.2
15	11.2	10.8	7.3	4.4	4.4	5.4	7.1	6.5	6.6	7.0	8.6	13.8	25.3	39.1	43.0
20	6.6	6.7	5.3	3.4	3.3	4.0	5.1	4.8	4.8	5.2	6.5	10.2	18.0	23.5	23.5
25	4.4	4.6	4.0	2.8	2.7	3.2	3.9	3.8	3.9	4.2	5.2	8.1	13.4	15.7	15.2
50	1.4	1.5	1.5	1.5	1.4	1.6	1.8	1.8	1.9	2.1	2.7	3.7	4.6	4.6	4.4
75	0.8	0.8	0.9	0.9	1.0	1.0	1.1	1.2	1.3	1.4	1.7	2.2	2.3	2.3	2.2
100	0.6	0.6	0.6	0.7	0.7	0.7	0.8	0.9	0.9	1.1	1.2	1.4	1.4	1.4	1.3
125	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.9	1.0	1.0	0.9	0.9
150	0.3	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.7	0.7	0.7	0.7	0.7
175	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.5	0.5	0.5
200	0.2	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5	0.5	0.4	0.4	0.4
225	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.3

Table 4 (continuation)

Equivalent dose rate induced by low-energy neutrons from VJ Beam Pipe without support structure for T= 100 d, t=100 d

R/Z, cm	1300	1310	1325	1360	1400	1440	1500	1560	1620	1680	1740	1800	1840	1855	1865
0	27.8														64.7
6	23.8	15.7	9.7	5.0	6.8										64.3
8	19.7	11.8	6.5	3.6	4.3	5.1	7.6	6.8	7.1	7.7	9.8	16.1	28.3	50.2	63.8
10	11.7	8.9	5.1	2.9	3.2	3.9	5.4	4.9	5.1	5.6	7.1	11.7	20.9	37.2	63.3
15	5.0	4.8	3.3	2.0	2.0	2.5	3.3	3.1	3.2	3.5	4.5	7.3	13.1	19.9	21.7
20	2.9	3.0	2.4	1.6	1.5	1.9	2.3	2.3	2.3	2.6	3.3	5.4	9.3	12.0	11.9
25	2.0	2.1	1.8	1.3	1.2	1.5	1.8	1.8	1.9	2.1	2.7	4.3	6.9	8.0	7.7
50	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.9	0.9	1.1	1.4	1.9	2.3	2.3	2.3
75	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.9	1.1	1.2	1.2	1.1
100	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.7	0.7	0.7	0.7
125	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.5	0.5	0.5
150	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4
175	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3
200	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
225	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table 4 (continuation)

Equivalent dose rate induced by low-energy neutrons from VJ Beam Pipe without support structure for T= 10y, t=1d

R/Z, cm	1300	1310	1325	1360	1400	1440	1500	1560	1620	1680	1740	1800	1840	1855	1865
0	92.7														315.0
6	79.3	53.0	34.8	18.7	25.5										312.5
8	65.9	39.8	23.3	13.4	16.3	19.3	29.1	27.2	29.8	35.8	50.8	87.9	149.8	251.6	310.0
10	39.3	30.3	17.9	10.7	12.1	14.8	20.8	19.7	21.5	26.0	36.9	63.4	109.6	185.6	307.5
15	17.0	16.5	11.6	7.4	7.7	9.5	12.6	12.3	13.5	16.3	23.2	39.2	67.7	99.1	106.4
20	10.0	10.3	8.4	5.8	5.8	7.1	9.1	9.1	10.0	12.2	17.2	28.7	47.6	59.9	58.7
25	6.8	7.2	6.4	4.8	4.7	5.7	7.1	7.3	8.0	9.8	13.8	22.5	35.3	40.2	38.5
50	2.4	2.5	2.5	2.5	2.5	2.9	3.4	3.7	4.1	5.1	6.9	10.0	11.9	11.8	11.3
75	1.4	1.4	1.5	1.6	1.7	1.9	2.2	2.4	2.8	3.4	4.4	5.6	6.0	5.8	5.6
100	1.0	1.0	1.1	1.2	1.3	1.4	1.6	1.8	2.1	2.5	3.1	3.6	3.6	3.5	3.5
125	0.8	0.8	0.8	0.9	1.0	1.1	1.3	1.4	1.7	1.9	2.3	2.5	2.5	2.4	2.4
150	0.6	0.7	0.7	0.8	0.8	0.9	1.0	1.2	1.3	1.5	1.7	1.8	1.8	1.8	1.7
175	0.5	0.6	0.6	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.4	1.3	1.3
200	0.5	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.9	1.0	1.1	1.1	1.1	1.1	1.0
225	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.8	0.8	0.9	0.9	0.9	0.9	0.9

Table 4 (continuation)

Equivalent dose rate induced by low-energy neutrons from VJ Beam Pipe without support structure for T= 10y, t=5d

R/Z, cm	1300	1310	1325	1360	1400	1440	1500	1560	1620	1680	1740	1800	1840	1855	1865
0	89.3														302.1
6	76.3	51.0	33.5	18.0	24.5										299.7
8	63.4	38.3	22.4	12.8	15.6	18.6	28.0	26.2	28.6	34.3	48.7	84.2	143.6	241.3	297.3
10	37.8	29.2	17.2	10.3	11.7	14.2	20.0	19.0	20.7	24.9	35.3	60.8	105.0	178.0	294.9
15	16.3	15.9	11.2	7.1	7.4	9.1	12.1	11.8	12.9	15.7	22.2	37.6	64.9	95.0	102.1
20	9.6	9.9	8.1	5.5	5.5	6.8	8.7	8.8	9.6	11.7	16.5	27.5	45.6	57.4	56.3
25	6.6	6.9	6.2	4.6	4.5	5.4	6.8	7.0	7.7	9.4	13.2	21.6	33.8	38.6	36.9
50	2.3	2.4	2.5	2.4	2.4	2.7	3.2	3.5	4.0	4.9	6.6	9.6	11.4	11.3	10.8
75	1.3	1.4	1.5	1.6	1.7	1.8	2.1	2.3	2.7	3.3	4.2	5.4	5.7	5.6	5.4
100	0.9	1.0	1.0	1.1	1.2	1.4	1.5	1.8	2.0	2.4	2.9	3.4	3.5	3.4	3.3
125	0.7	0.8	0.8	0.9	1.0	1.1	1.2	1.4	1.6	1.9	2.2	2.4	2.4	2.3	2.3
150	0.6	0.6	0.7	0.7	0.8	0.9	1.0	1.1	1.3	1.5	1.6	1.7	1.7	1.7	1.7
175	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.9	1.1	1.2	1.3	1.3	1.3	1.3	1.3
200	0.5	0.5	0.5	0.5	0.6	0.6	0.7	0.8	0.9	1.0	1.0	1.1	1.0	1.0	1.0
225	0.4	0.4	0.4	0.5	0.5	0.5	0.6	0.7	0.8	0.8	0.9	0.9	0.8	0.8	0.8

Table 4 (continuation)

Equivalent dose rate induced by low-energy neutrons from VJ Beam Pipe without support structure for T= 10y, t=100d

R/Z, cm	1300	1310	1325	1360	1400	1440	1500	1560	1620	1680	1740	1800	1840	1855	1865
0	48.3														223.7
6	41.4	28.0	19.6	10.9	15.0										221.9
8	34.5	21.1	13.0	7.7	9.6	11.4	17.3	16.9	19.3	24.8	37.5	66.6	111.8	181.9	220.0
10	20.6	16.1	10.0	6.2	7.2	8.8	12.4	12.3	14.0	18.0	27.2	48.0	81.3	133.8	218.2
15	9.0	8.9	6.4	4.3	4.5	5.7	7.6	7.7	8.8	11.4	17.1	29.5	49.8	71.4	76.0
20	5.4	5.6	4.6	3.3	3.4	4.2	5.5	5.7	6.6	8.5	12.7	21.5	34.9	43.3	42.1
25	3.7	3.9	3.5	2.8	2.8	3.4	4.3	4.6	5.3	6.8	10.1	16.8	25.8	29.1	27.7
50	1.3	1.4	1.5	1.5	1.5	1.7	2.1	2.4	2.8	3.6	5.0	7.3	8.7	8.6	8.2
75	0.8	0.8	0.9	1.0	1.1	1.2	1.4	1.6	1.9	2.4	3.2	4.1	4.3	4.2	4.1
100	0.6	0.6	0.7	0.7	0.8	0.9	1.0	1.2	1.4	1.8	2.2	2.6	2.6	2.6	2.5
125	0.5	0.5	0.5	0.6	0.6	0.7	0.8	1.0	1.1	1.4	1.6	1.8	1.8	1.7	1.7
150	0.4	0.4	0.4	0.5	0.5	0.6	0.7	0.8	0.9	1.1	1.2	1.3	1.3	1.3	1.2
175	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.7	0.8	0.9	1.0	1.0	1.0	1.0	0.9
200	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.6	0.6	0.7	0.8	0.8	0.8	0.8	0.8
225	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6

Table 5

Equivalent dose rate induced by high-energy hadrons from VJ Beam Pipe with Aluminum support structure for T= 100d, t=1d

R/Z, cm	1300	1310	1325	1360	1400	1440	1500	1560	1620	1680	1740	1800	1840	1855	1865
0	3301														
6	2782	2106													
8	2263	1565													
10	1384	1196	941	653											
15	628	659	548	396	426	392	372	340							
20	382	417	380	294	299	282	261	235	222	215	212	261	419	525	
25	266	291	282	233	231	220	203	183	172	166	164	200	308	443	
50	93	99	104	105	103	100	94	87	82	80	83	102	144	183	
75	52	54	58	62	62	62	59	56	54	53	55	64	72	69	68
100	34	36	38	41	42	43	42	40	39	39	40	43	43	39	38
125	25	26	27	30	31	32	31	31	30	30	31	31	29	27	26
150	20	20	21	23	24	24	25	24	24	24	24	24	22	20	20
175	16	16	17	18	19	20	20	20	20	20	19	19	17	16	15
200	13	13	14	15	15	16	16	17	17	16	16	15	14	13	13
225	11	11	12	12	13	13	14	14	14	14	13	13	11	11	11

Table 5 (continuation)

Equivalent dose rate induced by high-energy hadrons from VJ Beam Pipe with Aluminum support structure for T= 100 d, t= 5d

R/Z, cm	1300	1310	1325	1360	1400	1440	1500	1560	1620	1680	1740	1800	1840	1855	1865
0	2339														
6	1970	1473													
8	1601	1086													
10	975	825	601	383											
15	438	452	361	248	267	243	227	202							
20	264	284	252	186	189	177	163	145	135	128	123	143	207	247	
25	182	197	188	149	146	139	127	114	106	100	96	111	154	196	
50	62	66	69	68	66	63	59	54	51	48	48	54	66	74	
75	34	36	38	40	40	39	37	35	33	31	31	33	34	32	31
100	22	23	24	26	27	27	26	25	24	23	22	23	21	20	19
125	16	17	18	19	20	20	20	19	18	18	17	16	15	14	14
150	13	13	13	14	15	15	15	15	14	14	13	13	11	11	10
175	10	10	11	11	12	12	12	12	12	11	11	10	9.1	8.7	8.5
200	8.2	8.4	8.7	9.2	10	10	10	10	10	9.5	9.0	8.3	7.5	7.2	7.0
225	6.9	7.0	7.2	7.6	8.0	8.2	8.4	8.4	8.2	8.0	7.6	6.9	6.4	6.1	6.0

Table 5 (continuation)

Equivalent dose rate induced by high-energy hadrons from VJ Beam Pipe with Aluminum support structure for T= 100 d, t= 100d

R/Z, cm	1300	1310	1325	1360	1400	1440	1500	1560	1620	1680	1740	1800	1840	1855	1865
0	404														
6	341	259													
8	278	193													
10	170	148	120	86											
15	77	82	69	51	54	50	48	44							
20	47	52	48	37	38	36	33	30	29	28	29	39	69	92	
25	33	36	35	30	29	28	26	23	22	22	22	30	52	81	
50	12	12	13	13	13	13	12	11	11	11	12	16	25	32	
75	6.5	6.9	7.3	7.8	7.9	7.9	7.6	7.3	7.1	7.2	7.9	10	12	11	11
100	4.4	4.6	4.8	5.2	5.4	5.5	5.4	5.3	5.2	5.4	5.8	6.7	6.7	6.0	5.9
125	3.2	3.3	3.5	3.8	4.0	4.1	4.1	4.1	4.1	4.2	4.5	4.8	4.4	4.0	3.9
150	2.5	2.6	2.7	2.9	3.1	3.2	3.2	3.3	3.3	3.4	3.5	3.5	3.2	3.0	2.9
175	2.0	2.1	2.2	2.3	2.5	2.6	2.6	2.7	2.7	2.8	2.8	2.7	2.5	2.3	2.3
200	1.7	1.7	1.8	1.9	2.0	2.1	2.2	2.2	2.3	2.3	2.3	2.2	2.0	1.9	1.8
225	1.4	1.5	1.5	1.6	1.7	1.8	1.8	1.9	1.9	1.9	1.9	1.8	1.6	1.5	1.5

Table 5 (continuation)

Equivalent dose rate induced by high-energy hadrons from VJ Beam Pipe with Aluminum support structure for T= 10y, t= 1d

R/Z, cm	1300	1310	1325	1360	1400	1440	1500	1560	1620	1680	1740	1800	1840	1855	1865
0	3622														
6	3055	2331													
8	2488	1743													
10	1526	1338	1106	805											
15	698	740	631	472	506	469	449	416							
20	428	470	436	347	354	334	312	283	269	264	269	347	605	787	
25	299	330	323	274	272	260	242	220	208	203	206	266	447	691	
50	106	114	120	123	121	119	112	105	100	99	106	140	217	284	
75	60	63	67	72	74	73	71	68	66	66	72	89	105	99	98
100	40	42	44	48	50	51	50	49	48	49	53	60	60	54	53
125	30	31	32	35	37	38	38	38	37	38	40	43	40	36	36
150	23	24	25	27	28	29	30	30	30	31	32	32	29	27	26
175	19	19	20	21	23	24	24	25	25	25	26	25	22	21	21
200	16	16	16	18	19	19	20	21	21	21	21	20	18	17	17
225	13	13	14	15	16	16	17	17	18	18	18	16	15	14	14

Table 5 (continuation)

Equivalent dose rate induced by high-energy hadrons from VJ Beam Pipe with Aluminum support structure for T= 10 y, t=5d

R/Z, cm	1300	1310	1325	1360	1400	1440	1500	1560	1620	1680	1740	1800	1840	1855	1865
0	2647														
6	2232	1691													
8	1816	1257													
10	1111	961	760	529											
15	505	530	442	320	345	318	303	277							
20	308	335	306	238	242	228	212	191	181	176	178	226	388	502	
25	214	234	228	188	187	178	165	149	141	136	137	175	289	438	
50	75	80	84	85	84	81	77	71	68	67	70	92	137	173	
75	42	44	47	50	51	50	48	46	44	44	47	58	66	61	60
100	28	29	31	33	35	35	34	33	33	33	35	39	38	34	33
125	21	21	22	24	25	26	26	26	25	26	27	28	26	23	23
150	16	16	17	18	19	20	20	20	20	21	21	21	19	17	17
175	13	13	14	15	16	16	17	17	17	17	17	16	15	14	13
200	11	11	11	12	13	13	14	14	14	14	14	13	12	11	11
225	9.1	9.3	10	10	11	11	11	12	12	12	12	11	10	9.3	9.1

Table 5 (continuation)

Equivalent dose rate induced by high-energy hadrons from VJ Beam Pipe with Aluminum support structure for T= 10y, t=100d

R/Z, cm	1300	1310	1325	1360	1400	1440	1500	1560	1620	1680	1740	1800	1840	1855	1865
0	623														
6	528	421													
8	432	323													
10	269	252	253	214											
15	128	142	135	112	119	114	112	108							
20	81	92	91	80	82	79	75	70	68	70	78	114	237	329	
25	58	65	68	63	63	61	58	54	52	53	58	87	176	307	
50	22	24	26	28	28	28	27	26	25	27	32	50	91	125	
75	13	14	15	16	17	17	17	17	17	19	23	32	41	38	38
100	9.0	9.4	10	11	12	12	12	13	13	14	17	21	22	19	19
125	6.8	7.1	7.4	8.2	8.7	9.1	10	10	10	11	13	15	14	12	12
150	5.4	5.6	5.9	6.4	6.9	7.2	7.6	8.0	8.5	9.2	10	11	10	8.9	8.8
175	4.5	4.6	4.8	5.2	5.6	5.9	6.3	6.6	7.1	7.6	8.2	8.3	7.4	6.8	6.7
200	3.8	3.9	4.0	4.3	4.7	4.9	5.3	5.6	6.0	6.4	6.7	6.5	5.8	5.4	5.3
225	3.3	3.3	3.5	3.7	4.0	4.2	4.5	4.8	5.1	5.4	5.5	5.3	4.7	4.4	4.3

Table 6

Equivalent dose rate induced by low-energy neutrons from VJ Beam Pipe with Aluminum support structure for T= 100d, t=1d

R/Z, cm	1300	1310	1325	1360	1400	1440	1500	1560	1620	1680	1740	1800	1840	1855	1865
0	65.8														
6	56.3	37.0													
8	46.6	27.8													
10	27.7	21.2	12.1	7.0											
15	11.9	11.5	7.9	4.8	4.9	6.0	7.8	7.4							
20	7.0	7.2	5.7	3.8	3.7	4.5	5.7	5.5	5.7	6.6	8.9	16.5	35.3	52.6	
25	4.7	4.9	4.4	3.1	3.0	3.6	4.4	4.4	4.7	5.4	7.4	13.8	29.0	45.9	
50	1.6	1.7	1.7	1.7	1.7	1.8	2.1	2.3	2.5	3.1	4.4	7.9	14.0	18.8	
75	0.9	1.0	1.0	1.1	1.2	1.3	1.4	1.6	1.8	2.3	3.1	5.0	6.4	5.6	5.5
100	0.7	0.7	0.7	0.8	0.9	0.9	1.1	1.2	1.4	1.8	2.4	3.3	3.4	2.6	2.6
125	0.5	0.5	0.6	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.8	2.2	2.1	1.6	1.6
150	0.4	0.5	0.5	0.5	0.6	0.6	0.7	0.8	1.0	1.2	1.4	1.6	1.4	1.1	1.1
175	0.4	0.4	0.4	0.4	0.5	0.5	0.6	0.7	0.8	1.0	1.1	1.2	1.0	0.8	0.8
200	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.7	0.8	0.9	0.9	0.8	0.6	0.6
225	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.7	0.7	0.6	0.5	0.5

Table 6 (continuation)

Equivalent dose rate induced by low-energy neutrons from VJ Beam Pipe with Aluminum support structure for T= 100d, t=5d

R/Z, cm	1300	1310	1325	1360	1400	1440	1500	1560	1620	1680	1740	1800	1840	1855	1865
0	62.6														
6	53.5	35.1													
8	44.3	26.4													
10	26.3	20.1	11.3	6.4											
15	11.3	10.9	7.3	4.4	4.5	5.5	7.1	6.6							
20	6.6	6.7	5.3	3.5	3.3	4.1	5.1	4.8	4.9	5.3	6.7	10.7	19.4	25.6	
25	4.4	4.6	4.0	2.8	2.7	3.2	4.0	3.8	3.9	4.3	5.4	8.6	14.6	17.9	
50	1.5	1.5	1.6	1.5	1.4	1.6	1.8	1.9	2.0	2.2	2.8	4.1	5.4	6.0	
75	0.8	0.9	0.9	0.9	1.0	1.0	1.2	1.2	1.3	1.5	1.8	2.4	2.7	2.6	2.5
100	0.6	0.6	0.6	0.7	0.7	0.8	0.8	0.9	1.0	1.1	1.3	1.6	1.6	1.5	1.5
125	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.7	0.8	0.9	1.0	1.1	1.1	1.0	1.0
150	0.3	0.4	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.8	0.8	0.8	0.7	0.7
175	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6
200	0.2	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.4	0.4
225	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4

Table 6 (continuation)

Equivalent dose rate induced by low-energy neutrons from VJ Beam Pipe with Aluminum support structure for T= 100 d, t=100 d

R/Z, cm	1300	1310	1325	1360	1400	1440	1500	1560	1620	1680	1740	1800	1840	1855	1865
0	27.9														
6	23.8	15.7													
8	19.7	11.8													
10	11.7	9.0	5.1	3.0											
15	5.0	4.9	3.3	2.0	2.1	2.5	3.3	3.1							
20	2.9	3.0	2.4	1.6	1.5	1.9	2.4	2.3	2.4	2.6	3.4	5.5	9.6	12.4	
25	2.0	2.1	1.8	1.3	1.3	1.5	1.8	1.8	1.9	2.1	2.7	4.3	7.1	8.4	
50	0.7	0.7	0.7	0.7	0.7	0.7	0.9	0.9	0.9	1.1	1.4	2.0	2.5	2.5	
75	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.7	0.9	1.1	1.2	1.2	1.2
100	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.7	0.8	0.7	0.7
125	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.5	0.5	0.5
150	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4
175	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3
200	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
225	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table 6 (continuation)

Equivalent dose rate induced by low-energy neutrons from VJ Beam Pipe with Aluminum support structure for T= 10y, t=1d

R/Z, cm	1300	1310	1325	1360	1400	1440	1500	1560	1620	1680	1740	1800	1840	1855	1865
0	92.9														
6	79.5	53.1													
8	66.0	39.9													
10	39.4	30.5	18.2	11.0											
15	17.1	16.7	11.8	7.6	7.9	9.8	12.9	12.8							
20	10.1	10.4	8.6	5.9	6.0	7.3	9.4	9.5	10.6	13.1	19.2	34.2	63.9	88.0	
25	6.9	7.3	6.5	4.9	4.9	5.9	7.4	7.6	8.6	10.7	15.6	27.6	50.3	70.2	
50	2.5	2.6	2.7	2.6	2.7	3.0	3.6	4.0	4.6	5.9	8.4	13.9	21.3	26.3	
75	1.5	1.5	1.6	1.8	1.9	2.1	2.4	2.8	3.3	4.1	5.7	8.4	10.1	9.1	8.9
100	1.1	1.1	1.2	1.3	1.4	1.6	1.8	2.1	2.5	3.2	4.1	5.4	5.6	4.7	4.6
125	0.9	0.9	0.9	1.0	1.1	1.3	1.5	1.7	2.0	2.5	3.1	3.7	3.5	3.0	2.9
150	0.7	0.7	0.8	0.9	1.0	1.1	1.2	1.4	1.7	2.0	2.4	2.6	2.4	2.1	2.1
175	0.6	0.6	0.7	0.7	0.8	0.9	1.0	1.2	1.4	1.7	1.9	2.0	1.8	1.6	1.6
200	0.6	0.6	0.6	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.5	1.5	1.4	1.2	1.2
225	0.5	0.5	0.5	0.6	0.6	0.7	0.8	0.9	1.0	1.2	1.2	1.2	1.1	1.0	1.0

Table 6 (continuation)

Equivalent dose rate induced by low-energy neutrons from VJ Beam Pipe with Aluminum support structure for T= 10 y, t= 5 d

R/Z, cm	1300	1310	1325	1360	1400	1440	1500	1560	1620	1680	1740	1800	1840	1855	1865
0	89.3														
6	76.4	51.0													
8	63.4	38.3													
10	37.8	29.2	17.4	10.4											
15	16.4	15.9	11.2	7.2	7.5	9.2	12.2	12.0							
20	9.7	10.0	8.1	5.6	5.6	6.9	8.8	8.9	9.7	11.9	16.8	28.3	47.9	60.8	
25	6.6	6.9	6.2	4.6	4.6	5.5	6.9	7.1	7.8	9.5	13.5	22.3	35.8	42.1	
50	2.3	2.4	2.5	2.4	2.5	2.8	3.3	3.6	4.0	5.0	6.8	10.1	12.7	13.5	
75	1.3	1.4	1.5	1.6	1.7	1.9	2.1	2.4	2.8	3.4	4.4	5.8	6.3	6.1	5.6
100	1.0	1.0	1.0	1.2	1.3	1.4	1.6	1.8	2.1	2.5	3.1	3.7	3.7	3.6	3.4
125	0.7	0.8	0.8	0.9	1.0	1.1	1.2	1.4	1.6	1.9	2.3	2.5	2.5	2.4	2.3
150	0.6	0.6	0.7	0.7	0.8	0.9	1.0	1.2	1.3	1.5	1.7	1.9	1.8	1.7	1.7
175	0.5	0.5	0.6	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.4	1.4	1.4	1.3	1.3
200	0.5	0.5	0.5	0.5	0.6	0.7	0.7	0.8	0.9	1.0	1.1	1.1	1.1	1.0	1.0
225	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.8	0.8	0.9	0.9	0.9	0.8	0.8

Table 6 (continuation)

Equivalent dose rate induced by low-energy neutrons from VJ Beam Pipe with Aluminum support structure for T= 10y, t=100d

R/Z, cm	1300	1310	1325	1360	1400	1440	1500	1560	1620	1680	1740	1800	1840	1855	1865
0	48.3														
6	41.4	28.1													
8	34.5	21.1													
10	20.6	16.2	10.1	6.3											
15	9.0	8.9	6.5	4.3	4.6	5.7	7.6	7.8							
20	5.4	5.6	4.7	3.4	3.5	4.3	5.5	5.8	6.6	8.6	12.8	21.7	35.5	44.2	
25	3.7	3.9	3.6	2.8	2.8	3.4	4.4	4.6	5.3	6.9	10.2	17.0	26.2	29.9	
50	1.3	1.4	1.5	1.5	1.5	1.8	2.1	2.4	2.8	3.6	5.1	7.4	8.9	9.0	
75	0.8	0.9	0.9	1.0	1.1	1.2	1.4	1.6	1.9	2.4	3.2	4.2	4.4	4.4	4.2
100	0.6	0.6	0.7	0.7	0.8	0.9	1.0	1.2	1.5	1.8	2.2	2.6	2.7	2.6	2.6
125	0.5	0.5	0.5	0.6	0.6	0.7	0.8	1.0	1.1	1.4	1.6	1.8	1.8	1.8	1.7
150	0.4	0.4	0.4	0.5	0.5	0.6	0.7	0.8	0.9	1.1	1.2	1.3	1.3	1.3	1.3
175	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.7	0.8	0.9	1.0	1.0	1.0	1.0	1.0
200	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.6	0.6	0.7	0.8	0.8	0.8	0.8	0.8
225	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6