

Original Data from 2002 Background Igloos

Alpha	A1107	B0806	C0912	D0405	E0403	Beta	A1107	B0806
	13	3	1	2	3		234	155
	17	3	5	1	1		255	171
	12	3	3	2	2		272	228
	4	4	1	3	2		206	196
	18	6	2	3	3		283	237
	9	11	0	3	1		199	172
	8	5	0	3	2		235	253
	16	5	2	2	4		202	216
	4	3	1	0	2		220	191
	7	2	2	2	2		215	231
	4	3	3	2	2		183	204
	9	4	1	1	1		225	231
	14	4	0	0	0		213	162
	5	5	0	3	1		243	171
	14	3	2	1	3		203	197
	12	5	0	1	1		252	246
	16	2	0	0	7		197	166
	11	2	1	1	0		226	198
	15	5	0	2	2		220	169
	6	2	1	3	1		181	162
	5	5	0	2	2		222	256
	4	5	0	1	0		231	233
	1	3	3	2	0		241	179
	9	2	3	3	1		228	260
	12	5	1	4	2		277	248
	15	8	2	3	1		260	212
	15	2	1	1	0		387	211
	6	3	3	3	0		216	229
	11	8	13	5	3		596	430
	8	2	3	3	3		163	134
Average	13.33333	6.7	1.8	2.066667	2.766667		242.8333	211.6
SD	19.03596	15.10686	2.483046	1.201532	6.078131		78.13432	53.74692

Data from vent location were removed for this test

C0912	D0405	E0403
334	199	206
168	189	206
205	248	251
170	317	111
210	337	253
274	281	222
243	222	230
229	199	276
159	187	246
187	232	260
202	188	228
224	246	236
168	204	164
185	286	223
173	189	179
233	264	218
169	206	189
182	204	200
200	202	172
168	188	156
240	280	243
215	226	257
181	196	214
197	259	250
214	234	231
216	183	219
199	272	206
249	369	180
209	286	299
138	223	129

204.7	237.2	215.1333
39.07919	48.914	42.06459

Kruskal-Wallis Test, per NUREG-1505 Section 13

Ordered Data	Rank	Adj Rank	A1107	B0806	C0912	D0405	E0403
0	1	9.5			9.5		
0	2	9.5			9.5		
0	3	9.5			9.5		
0	4	9.5			9.5		
0	5	9.5			9.5		
0	6	9.5			9.5		
0	7	9.5			9.5		
0	8	9.5			9.5		
0	9	9.5			9.5		
0	10	9.5				9.5	
0	11	9.5				9.5	
0	12	9.5				9.5	
0	13	9.5					9.5
0	14	9.5					9.5
0	15	9.5					9.5
0	16	9.5					9.5
0	17	9.5					9.5
0	18	9.5					9.5
1	19	30.5	30.5				
1	20	30.5			30.5		
1	21	30.5			30.5		
1	22	30.5			30.5		
1	23	30.5			30.5		
1	24	30.5			30.5		
1	25	30.5			30.5		
1	26	30.5			30.5		
1	27	30.5			30.5		
1	28	30.5				30.5	
1	29	30.5				30.5	
1	30	30.5				30.5	
1	31	30.5				30.5	
1	32	30.5				30.5	
1	33	30.5				30.5	
1	34	30.5				30.5	
1	35	30.5					30.5
1	36	30.5					30.5
1	37	30.5					30.5
1	38	30.5					30.5
1	39	30.5					30.5
1	40	30.5					30.5
1	41	30.5					30.5
1	42	30.5					30.5
2	43	57		57			
2	44	57		57			
2	45	57		57			
2	46	57		57			
2	47	57		57			
2	48	57		57			

2	49	57	57	
2	50	57		57
2	51	57		57
2	52	57		57
2	53	57		57
2	54	57		57
2	55	57		57
2	56	57		57
2	57	57		57
2	58	57		57
2	59	57		57
2	60	57		57
2	61	57		57
2	62	57		57
2	63	57		57
2	64	57		57
2	65	57		57
2	66	57		57
2	67	57		57
2	68	57		57
2	69	57		57
2	70	57		57
2	71	57		57
3	72	85.5	85.5	
3	73	85.5	85.5	
3	74	85.5	85.5	
3	75	85.5	85.5	
3	76	85.5	85.5	
3	77	85.5	85.5	
3	78	85.5	85.5	
3	79	85.5	85.5	
3	80	85.5		85.5
3	81	85.5		85.5
3	82	85.5		85.5
3	83	85.5		85.5
3	84	85.5		85.5
3	85	85.5		85.5
3	86	85.5		85.5
3	87	85.5		85.5
3	88	85.5		85.5
3	89	85.5		85.5
3	90	85.5		85.5
3	91	85.5		85.5
3	92	85.5		85.5
3	93	85.5		85.5
3	94	85.5		85.5
3	95	85.5		85.5
3	96	85.5		85.5
3	97	85.5		85.5
3	98	85.5		85.5

Avg. Rank 124.7414 92.60345 42.81034 57.13793 47.7069

K 0.000567 451251.9 248686.6 53149.04 94677.55 66002.49 517.9599

k-1 4

Kc 9.5

$K > Kc$ therefore significant variability

79.9599

Lower Boundary of Gray Region Calculation, per NUREG-1505 Section 13

Data Groups	Measurements (cpm)					Measurements Squared				
	A1107	B0806	C0912	D0405	E0403	A1107	B0806	C0912	D0405	E0403
	13	3	1	2	3	169	9	1	4	9
	17	3	5	1	1	289	9	25	1	1
	12	3	3	2	2	144	9	9	4	4
	4	4	1	3	2	16	16	1	9	4
	18	6	2	3	3	324	36	4	9	9
	9	11	0	3	1	81	121	0	9	1
	8	5	0	3	2	64	25	0	9	4
	16	5	2	2	4	256	25	4	4	16
	4	3	1	0	2	16	9	1	0	4
	7	2	2	2	2	49	4	4	4	4
	4	3	3	2	2	16	9	9	4	4
	9	4	1	1	1	81	16	1	1	1
	14	4	0	0	0	196	16	0	0	0
	5	5	0	3	1	25	25	0	9	1
	14	3	2	1	3	196	9	4	1	9
	12	5	0	1	1	144	25	0	1	1
	16	2	0	0	7	256	4	0	0	49
	11	2	1	1	0	121	4	1	1	0
	15	5	0	2	2	225	25	0	4	4
	6	2	1	3	1	36	4	1	9	1
	5	5	0	2	2	25	25	0	4	4
	4	5	0	1	0	16	25	0	1	0
	1	3	3	2	0	1	9	9	4	0
	9	2	3	3	1	81	4	9	9	1
	12	5	1	4	2	144	25	1	16	4
	15	8	2	3	1	225	64	4	9	1
	15	2	1	1	0	225	4	1	1	0
	6	3	3	3	0	36	9	9	9	0
	8	2	3	3	3	64	4	9	9	9

sum	289	115	41	57	49	3521	569	107	145	145	
Average	9.9655172	3.9655172	1.4137931	1.965517	1.689655						
Std Dev	4.7845194	2.0086022	1.323341	1.085053	1.490528						
Avg Sqd	99.311534	15.725327	1.9988109	3.863258	2.854935						
count	29	29	29	29	29						
count Sqd	841	841	841	841	841	5.8	5.8	5.8	5.8	5.8	29

4487 sum of squares of all measurements (A)

303601 square of sum of all measurements (B)

3588.862069 sum of squares of averages weighted by number of measurements (C)

145 N

5 k

29.0 n_0

6.415270936 Sw^2

373.7655172 Sb^2

12.66724987 w^2

3.6 w

10.7 LBGR = 3w, per NUREG-1505

Reduced from 13.3

Other LBGR possibilities

3.6 Mean all bkgd data

4 Std Dev all bkgd data

12 Mean + 2*SD

14 95% Percentile All Data

16 Maximum Background Measurement

Spreadsheet Formulas for the Wilcoxon Rank Sum Test and Power Calculation*

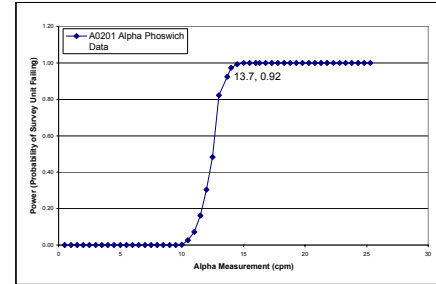
Wilcoxon Rank Sum Test, per NUREG-1505
 10.7 (For this calculation, LBGR = 3w for 2002 (glo Background) (Reference Dataset - 2002 (glo Alpha Phoswich))
 LBGR

DATA	AREA	ADJUSTED DATA	RANKS	SURVEY AREA RANKS
13	R	13	166	0
17	R	17	174	0
12	R	12	164	0
4	R	4	134	0
18	R	18	175	0
9	R	9	159	0
8	R	8	156	0
16	R	16	172.5	0
4	R	4	134	0
7	R	7	153.5	0
4	R	4	134	0
9	R	9	159	0
14	R	14	167.5	0
5	R	5	144	0
14	R	14	167.5	0
12	R	12	164	0
16	R	16	172.5	0
11	R	11	161.5	0
15	R	15	170	0
6	R	6	151	0
5	R	5	144	0
4	R	4	134	0
1	R	1	60.5	0
9	R	9	159	0
12	R	12	164	0
15	R	15	170	0
15	R	15	170	0
6	R	6	151	0
8	R	8	156	0
3	R	3	115.5	0
3	R	3	115.5	0
3	R	3	115.5	0
4	R	4	134	0
6	R	6	151	0
11	R	11	161.5	0
5	R	5	144	0
5	R	5	144	0
3	R	3	115.5	0
2	R	2	87	0
3	R	3	115.5	0
4	R	4	134	0
4	R	4	134	0
3	R	3	115.5	0
5	R	5	144	0
2	R	2	87	0
2	R	2	87	0
2	R	2	87	0
2	R	2	87	0
5	R	5	144	0
5	R	5	144	0
3	R	3	115.5	0
2	R	2	87	0
5	R	5	144	0
8	R	8	156	0
2	R	2	87	0
3	R	3	115.5	0
2	R	2	87	0
1	R	1	60.5	0
5	R	5	144	0
3	R	3	115.5	0
1	R	1	60.5	0
0	R	0	39.5	0
0	R	0	39.5	0
2	R	2	87	0
1	R	1	60.5	0
3	R	3	115.5	0
0	R	0	39.5	0
0	R	0	39.5	0
3	R	3	115.5	0
3	R	3	115.5	0
1	R	1	60.5	0
2	R	2	87	0
1	R	1	60.5	0
3	R	3	115.5	0
3	R	3	115.5	0
2	R	2	87	0
1	R	1	60.5	0
2	R	2	87	0
3	R	3	115.5	0

Survey Unit Stats	C Measurement	(C-LBGR)/SD	Rounded	p1	p2	Ei(Wmw)	Var(Wmw)/SD(Wmw)	z	Power
Count	30	m	0.5	0.03855	0.008465	167.6925	5534.63	74.39509	33.6296
SD	1.7		-2.302	0.03855	0.008465	167.6925	5534.63	74.39509	33.6296
Median	2		1.5	0.03855	0.008465	167.6925	5534.63	74.39509	33.6296
Reference Stats	2		-2.1341	0.03855	0.008465	167.6925	5534.63	74.39509	33.6296
Count	145	n	2.5	0.07865	0.023066	342.1275	13312.11	115.3781	20.1723
SD	4.1		3	0.089555	0.027714	389.5643	15518	124.5713	18.30282
Median	3		3.5	0.101546	0.033114	441.7251	17953.59	133.991	16.62882
			4	0.12895	0.046501	560.9325	23489.24	153.262	13.73838
			4.5	0.144422	0.054656	628.2357	26560.49	162.9739	12.52553
			5	0.161099	0.063897	700.7807	29802.95	172.6353	11.40432
Critical Value	3135.1		5.5	0.178985	0.074301	778.5848	33181.45	182.1578	10.38103
			6	0.198072	0.085944	861.6132	36656.46	191.4588	9.44306
			6.5	0.218338	0.098892	949.7703	40179.64	200.4486	8.579753
Bkgd Median plus LBGR	13.7		7	0.23975	0.113202	1042.913	43695.98	209.0358	7.781715
			7.5	0.262259	0.12892	1140.827	47146.59	217.1327	7.040595
Bkgd Median plus LBGR Reduced from 16.3			8	0.310309	0.164691	1349.844	53595.04	231.506	5.70061
SD Reduced from 12			8.5	0.361837	0.206266	1573.991	59012.48	242.9249	4.50995
			9	0.388649	0.229172	1690.623	61181.1	247.3562	3.957639
			9.5	0.416002	0.253419	1809.609	62931.02	250.8606	3.428044
			10	0.443769	0.27893	1930.395	64208.93	253.3948	2.917087
			10.5	0.471931	0.305663	2063.226	65074.74	255.4403	2.484146
			11	0.500496	0.333333	2208.000	65574.74	256.9999	2.149084
			11.5	0.529461	0.361905	2364.725	65854.01	257.7275	1.884904
			12	0.558826	0.391392	2533.450	65854.01	257.7275	1.666667
			12.5	0.588591	0.421415	2714.175	65574.74	256.9999	1.481481
			13	0.618756	0.451875	2906.900	64208.93	253.3948	1.326433
			13.5	0.649321	0.482778	3111.625	61181.1	247.3562	1.190476
			14	0.680286	0.514121	3328.350	56464.38	237.6224	1.066667
			14.5	0.711651	0.545924	3556.075	50467.37	224.6494	0.966667
			15	0.743516	0.578287	3794.800	43695.98	209.0358	0.881481
			15.5	0.775881	0.611210	4044.525	36656.46	191.4588	0.800000
			16	0.808746	0.644703	4344.250	31181.45	182.1578	0.729903
			16.5	0.842111	0.678656	4663.975	26560.49	162.9739	0.666667
			17	0.875976	0.713069	5013.700	22931.02	143.7900	0.611905
			17.5	0.910341	0.747942	5393.425	19902.95	124.6061	0.566667
			18	0.945206	0.783275	5813.150	17353.59	113.991	0.529903
			18.5	0.980571	0.819068	6282.875	15187.77	104.3221	0.499903
			19	0.91215	0.865767	4007.873	13312.88	115.3815	0.475894
			19.8	0.931218	0.881527	4050.798	11335.13	106.4666	0.457335
			20.3	0.948062	0.908982	4124.07	8037.23	89.6506	0.442241
			20.8	0.955157	0.920777	4154.933	6694.018	81.81698	0.4315471
			21.3	0.96145	0.931365	4182.308	5534.63	74.39509	0.423384
			21.8	0.967004	0.940817	4206.467	4543.114	67.40262	0.418175
			22.3	0.971881	0.949208	4227.682	3703.243	60.85428	0.413099
			22.8	0.979848	0.963118	4262.339	2407.984	49.07122	0.408381
			23.3	0.983053	0.968795	4276.281	1921.735	43.8376	0.404143
			23.8	0.985811	0.973725	4288.278	1525.039	39.05175	0.400304
			24.3	0.988174	0.977981	4298.557	1200.482	34.64798	0.396816
			24.8	0.991895	0.984758	4314.743	729.7038	27.01303	0.394296
			25.3	0.993336	0.98741	4321.012	562.8257	23.72395	0.392616

Retrospective Power Curve Calculation
 From Example in Section 10.5 of NUREG-1505

p1 and p2 pull data from Table 10-3 sheet



Based on the number of measurements and the observed standard deviation, a survey unit with a median measurement equal to the background median plus the LBGR (13.7) will have a 0.92 probability that the survey unit will **correctly** fail (i.e., the null hypothesis that the difference between the survey unit median and the background median is less than the LBGR [i.e., the survey unit is indistinguishable from background] is rejected).

3	R	3	115.5	0
3	R	3	115.5	0
3	R	3	115.5	0
2	R	2	87	0
0	R	0	39.5	0
2	R	2	87	0
2	R	2	87	0
1	R	1	60.5	0
0	R	0	39.5	0
3	R	3	115.5	0
1	R	1	60.5	0
1	R	1	60.5	0
0	R	0	39.5	0
1	R	1	60.5	0
2	R	2	87	0
3	R	3	115.5	0
2	R	2	87	0
1	R	1	60.5	0
2	R	2	87	0
3	R	3	115.5	0
4	R	4	134	0
3	R	3	115.5	0
1	R	1	60.5	0
3	R	3	115.5	0
3	R	3	115.5	0
3	R	3	115.5	0
1	R	1	60.5	0
2	R	2	87	0
2	R	2	87	0
3	R	3	115.5	0
1	R	1	60.5	0
2	R	2	87	0
4	R	4	134	0
2	R	2	87	0
2	R	2	87	0
2	R	2	87	0
1	R	1	60.5	0
0	R	0	39.5	0
1	R	1	60.5	0
3	R	3	115.5	0
1	R	1	60.5	0
7	R	7	153.5	0
0	R	0	39.5	0
2	R	2	87	0
1	R	1	60.5	0
2	R	2	87	0
0	R	0	39.5	0
0	R	0	39.5	0
1	R	1	60.5	0
2	R	2	87	0
1	R	1	60.5	0
0	R	0	39.5	0
0	R	0	39.5	0
3	R	3	115.5	0
1	S	-9.7	6.5	6.5
3	S	-7.7	19	19
1	S	-9.7	6.5	6.5
4	S	-6.7	23.5	23.5
5	S	-5.7	28	28
2	S	-8.7	14.5	14.5
0	S	-10.7	1	1
7	S	-3.7	30	30
4	S	-6.7	23.5	23.5
5	S	-5.7	28	28
1	S	-9.7	6.5	6.5
2	S	-8.7	14.5	14.5
2	S	-8.7	14.5	14.5
4	S	-6.7	23.5	23.5
4	S	-6.7	23.5	23.5
1	S	-9.7	6.5	6.5
1	S	-9.7	6.5	6.5
1	S	-9.7	6.5	6.5
2	S	-8.7	14.5	14.5
4	S	-6.7	23.5	23.5
3	S	-7.7	19	19
1	S	-9.7	6.5	6.5
4	S	-6.7	23.5	23.5
1	S	-9.7	6.5	6.5
1	S	-9.7	6.5	6.5
3	S	-7.7	19	19
5	S	-5.7	28	28
1	S	-9.7	6.5	6.5
2	S	-8.7	14.5	14.5
Sum =			15400	465

* This spreadsheet is originally designed to work with a set of twenty measurements, 10 from the survey unit (S) and 10 from the background reference area (R).
 If a different number of measurements have been performed, it is necessary to modify the spreadsheet to account for the change in the number of measurements.

of R: 145 *n*
 # of S: 30 *m*
 Avg Rank R: 103
 Avg Rank S: 16

For m or n greater than 20, the critical value (k) can be calculated for Scenario B from

$$\frac{m(n+m+1)}{2} + z \sqrt{\frac{nm(n+m+1)}{12}}$$

$z = 97.5\%$ percentile of standard normal distribution = 1.960

$$k = 3135.1$$

Since the sum of survey unit ranks is less than the critical value, the null hypothesis that the difference between the survey unit median and the background median is less than the LBGR (i.e., the survey unit is indistinguishable from background) is accepted and the survey unit passes **Scenario B**

Recreation of Table 10-3 from NUREG-1505

(C-LBGR)/SD	p1	p2
-6.0	0.00001	0
-5.0	0.000204	0.00001
-4.0	0.002339	0.000174
-3.5	0.006664	0.000738
-3.0	0.016947	0.00269
-2.5	0.03855	0.008465
-2.0	0.07865	0.023066
-1.9	0.089555	0.027714
-1.8	0.101546	0.033114
-1.7	0.114666	0.039348
-1.6	0.12895	0.046501
-1.5	0.144422	0.054656
-1.4	0.161099	0.063897
-1.3	0.178985	0.074301
-1.2	0.198072	0.085944
-1.1	0.218338	0.098892
-1.0	0.23975	0.113202
-0.9	0.262259	0.12892
-0.8	0.285804	0.146077
-0.7	0.310309	0.164691
-0.6	0.335687	0.18476
-0.5	0.361837	0.206266
-0.4	0.388649	0.229172
-0.3	0.416002	0.253419
-0.2	0.443769	0.27893
-0.1	0.471814	0.305606
0.0	0.5	0.333333
0.1	0.528186	0.361978
0.2	0.556231	0.391392
0.3	0.583998	0.421415
0.4	0.611351	0.451875
0.5	0.638163	0.482593
0.6	0.664313	0.513387
0.7	0.689691	0.544073
0.8	0.714196	0.574469
0.9	0.737741	0.604402
1.0	0.76025	0.633702
1.1	0.781662	0.662216
1.2	0.801928	0.6898
1.3	0.821015	0.716331
1.4	0.838901	0.741698
1.5	0.855578	0.765812
1.6	0.87105	0.788602
1.7	0.885334	0.810016
1.8	0.898454	0.830022
1.9	0.910445	0.848605
2.0	0.92135	0.865767
2.1	0.931218	0.881527
2.2	0.940103	0.895917
2.3	0.948062	0.908982
2.4	0.955157	0.920777
2.5	0.96145	0.931365
2.6	0.967004	0.940817
2.7	0.971881	0.949208
2.8	0.976143	0.956616
2.9	0.979848	0.963118
3.0	0.983053	0.968795
3.1	0.985811	0.973725
3.2	0.988174	0.977981
3.3	0.990188	0.981636
3.4	0.991895	0.984758
3.5	0.993336	0.98741
4.0	0.997661	0.995497
5.0	0.999796	0.999599
6.0	0.999989	0.999978