2015

Archive Disc Test Center
– NPO Entity

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[寿命推定試験報告書]

ISO/IEC 16963:2015 準拠

BD-R　三層ディスク

はじめに

本報告書は三菱化学メディア株式会社殿（以下 MKM 殿と略す）に既に提出済みである報告書「寿命推定試験報告書-BD-R 三層ディスク」に対して、ISO/IEC 16963:2015(以下 16963SE と略す)に従って寿命推定を行った結果を MKM 殿に提出するものである。

以下の項目に関しては、報告書「寿命推定試験報告書-BD-R 三層ディスク」に記載されているため、本報告書では記載しない。

[1] 試験方法
[2] 日程
[3] 試料
[4] 実験機器
[5] 測定結果

[1] 測定データの分析

Annex A “A.2 Data analysis steps for lifetime estimation”に従い、寿命推定計算前の測定データの分析を行う。

1-1 測定データの有効性の判定

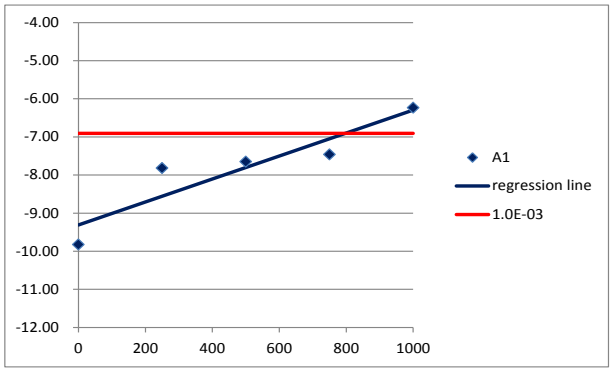
“A.2.1 Judgment of effectiveness of test data and time-to-failure determination”にある、Step 1、Step 2 に従い、測定データの有効性について判定を行う。

1-1-1 Step 1

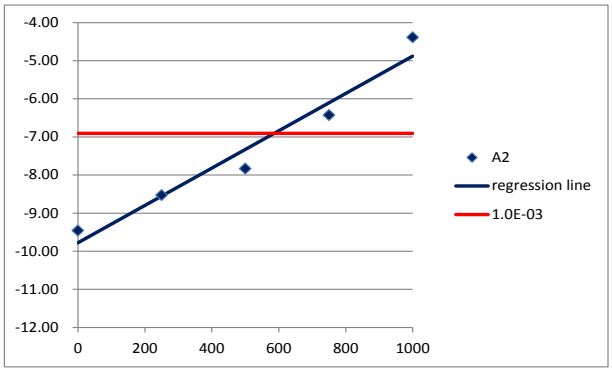
Linear regression か polynomial regression を計算することになるが、前回のデータとの整合性を考慮し、linear regression を計算し各試料のグラフを作成する

1-1-1-1 80℃/80%RH

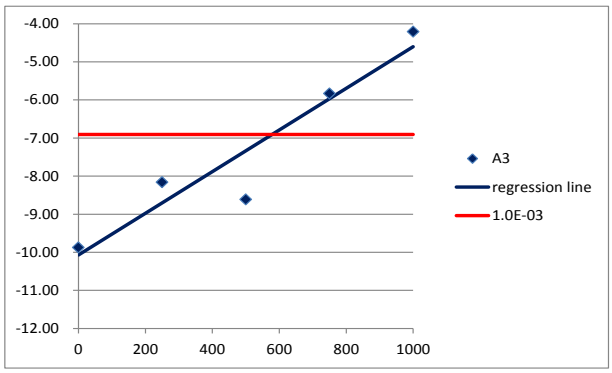
[Figure 1-1-1-1-1]から[Figure 1-1-1-1-20]に各試料のグラフを示す。



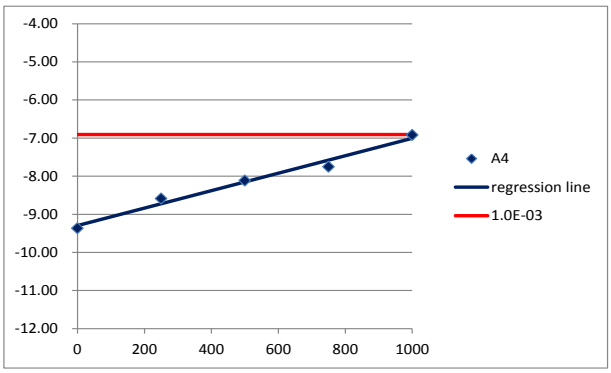
[Figure 1-1-1-1-1] 試料 A1



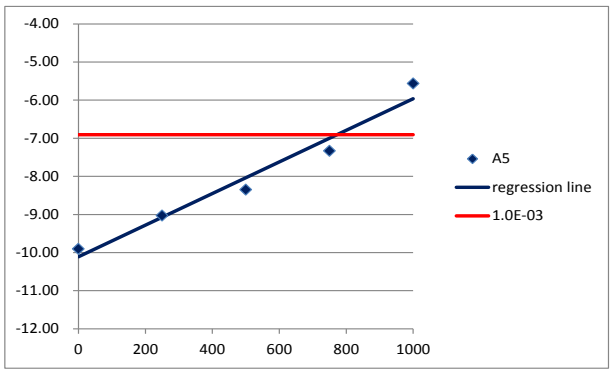
[Figure 1-1-1-1-2] 試料 A2

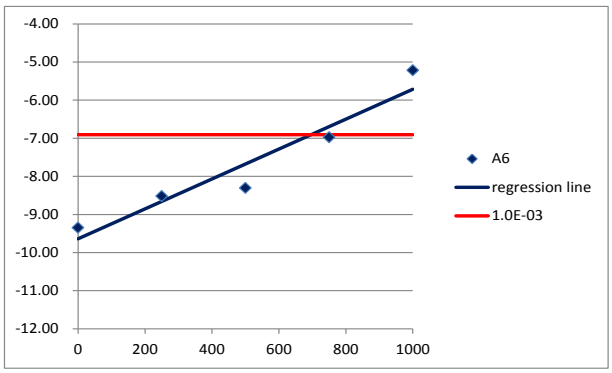


[Figure 1-1-1-1-3] 試料 A3



[Figure 1-1-1-1-4] 試料 A4





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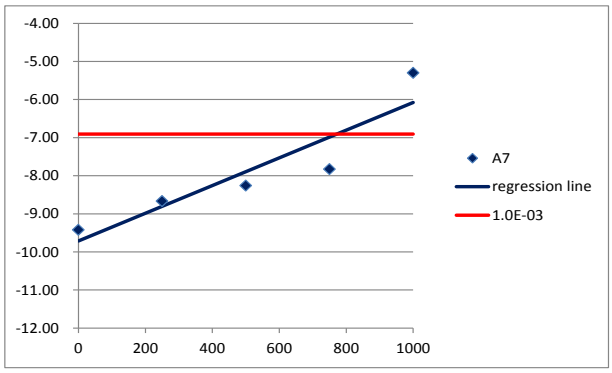
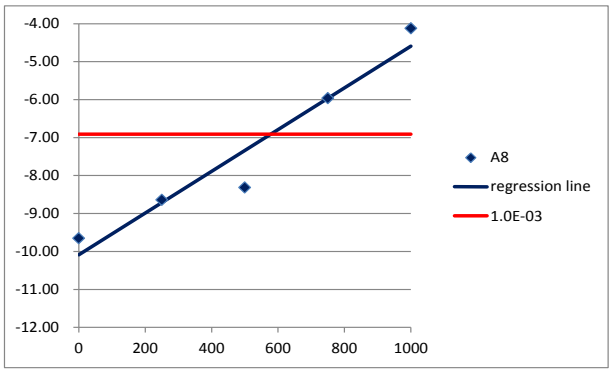


[Figure 1-1-1-1-6] 試料 A6



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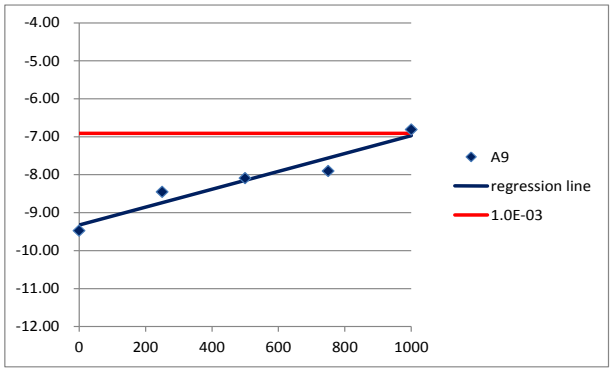
[Figure 1-1-1-1-8] 試料 A8



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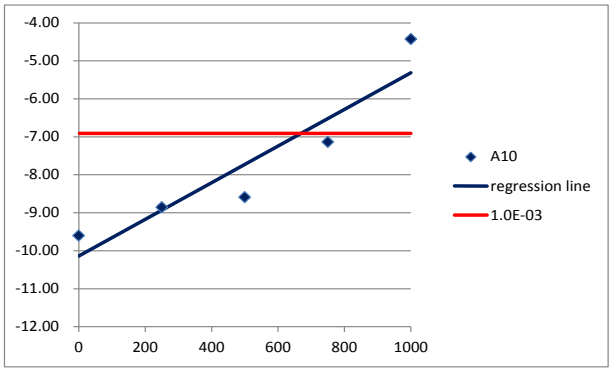

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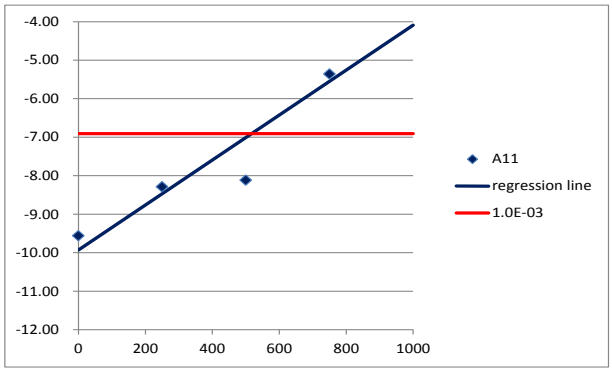
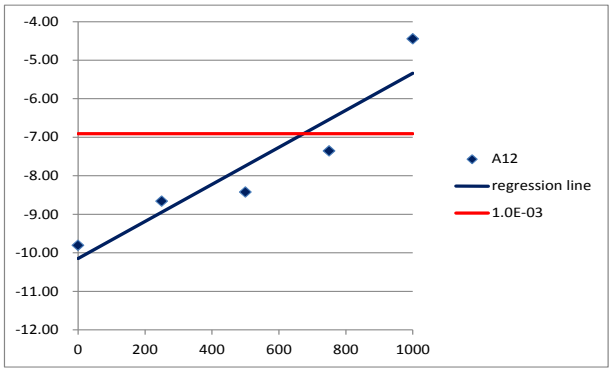
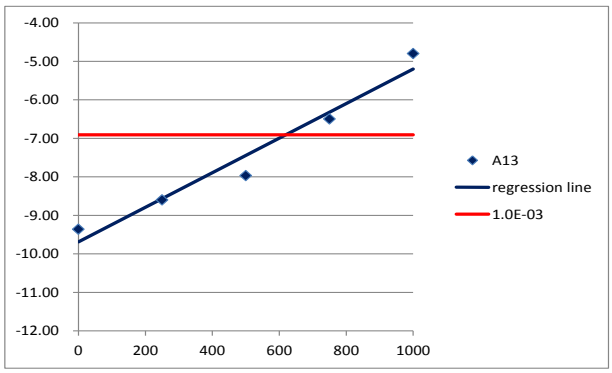


[Figure 1-1-1-1-11] 試料 A11



[Figure 1-1-1-1-12] 試料 A12



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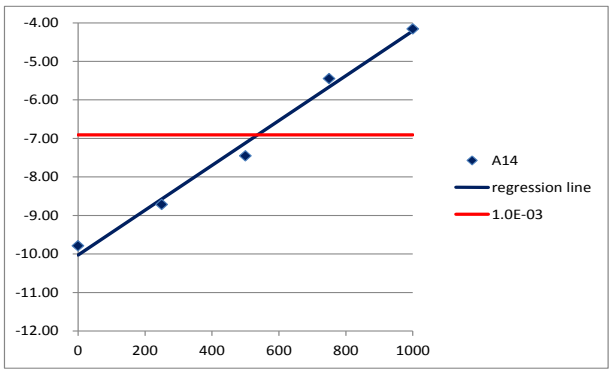

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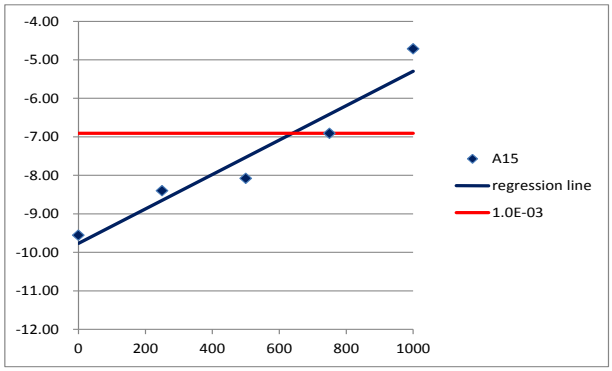

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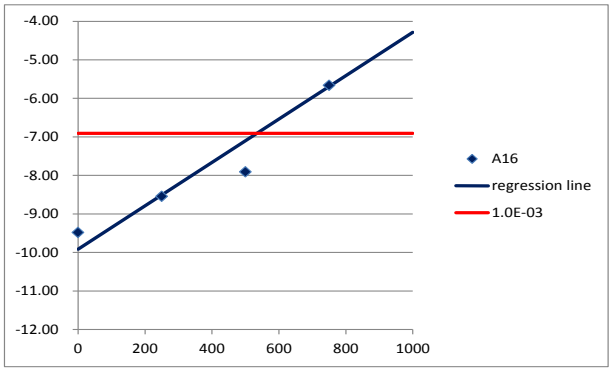

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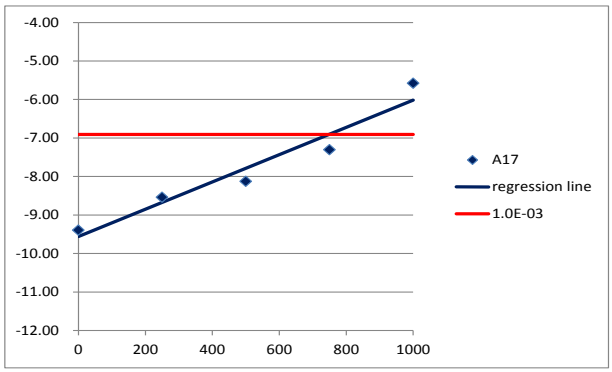

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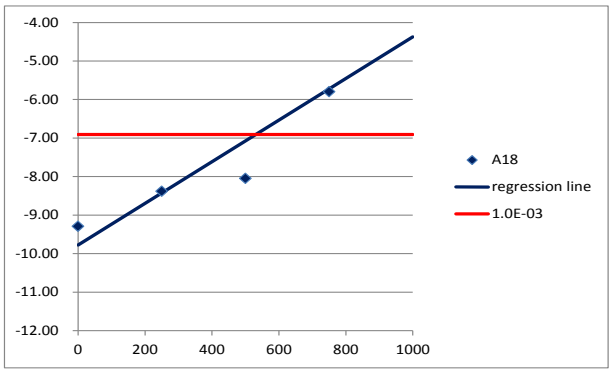

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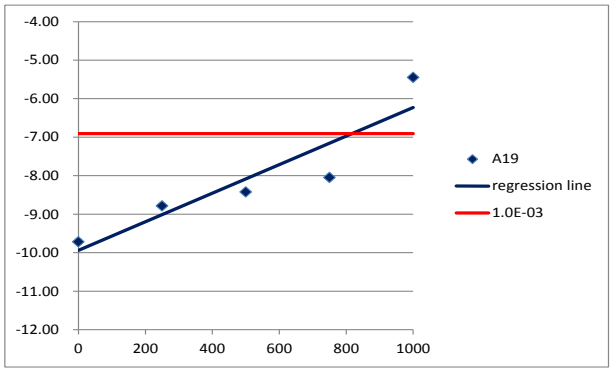
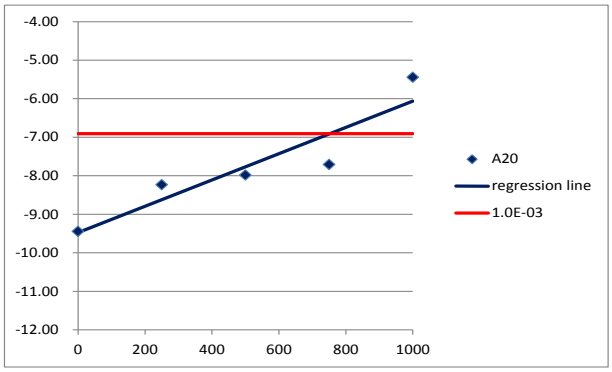


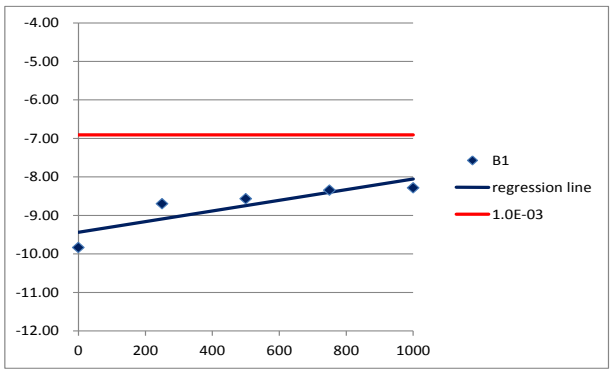
[Figure 1-1-1-1-19] 試料 A19

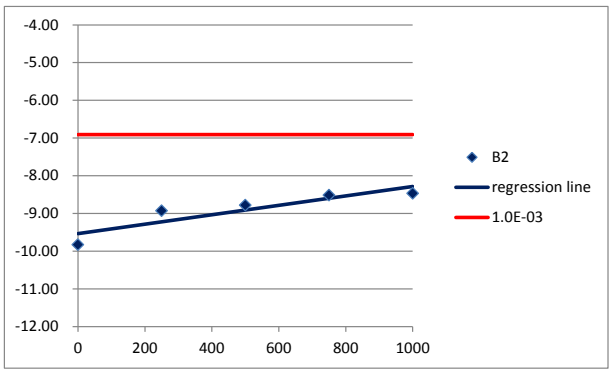


[Figure 1-1-1-1-20] 試料 A20

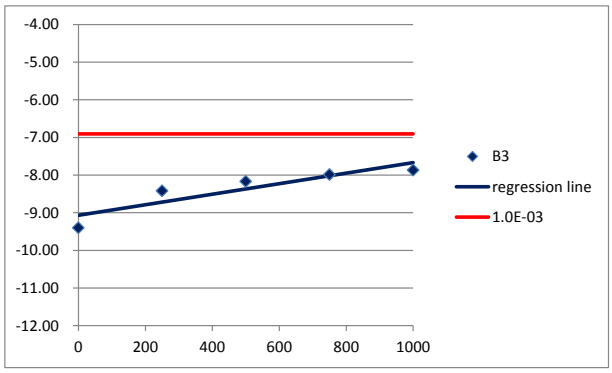
1-1-1-2 80℃/70%RH

[Figure 1-1-1-2-1]から[Figure 1-1-1-2-20]に各試料のグラフを示す。





[Figure 1-1-1-2-1] 試料 B1



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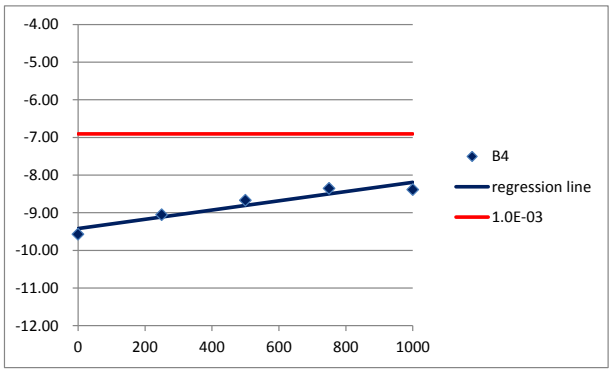

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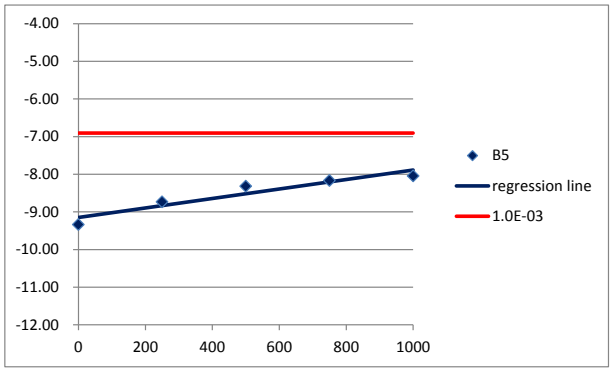

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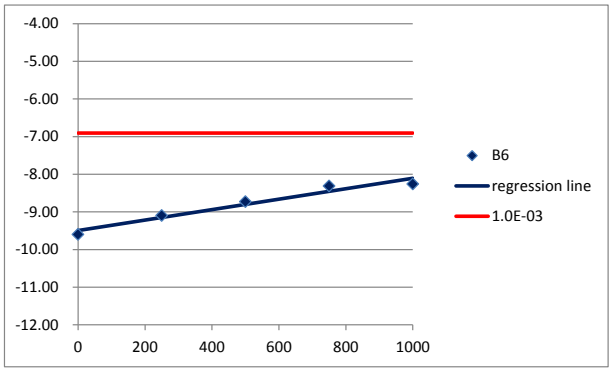
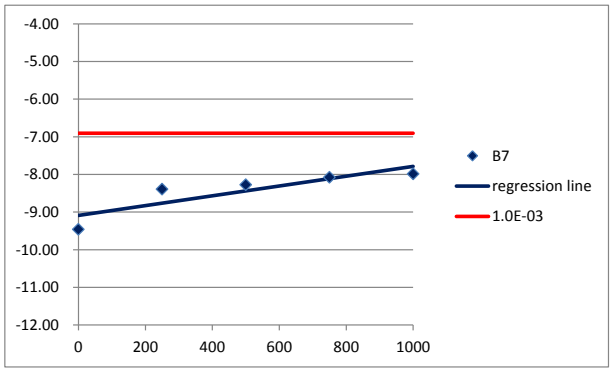
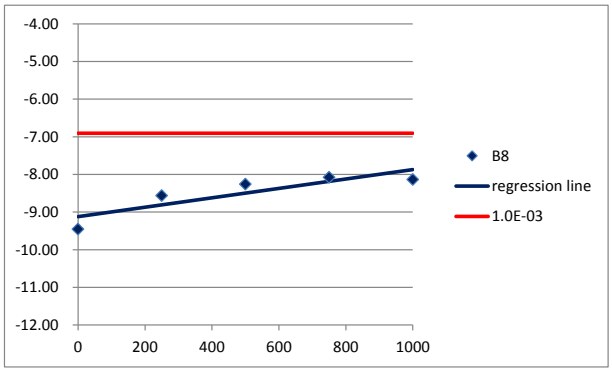


[Figure 1-1-1-2-5] 試料 B5



[Figure 1-1-1-2-6] 試料 B6



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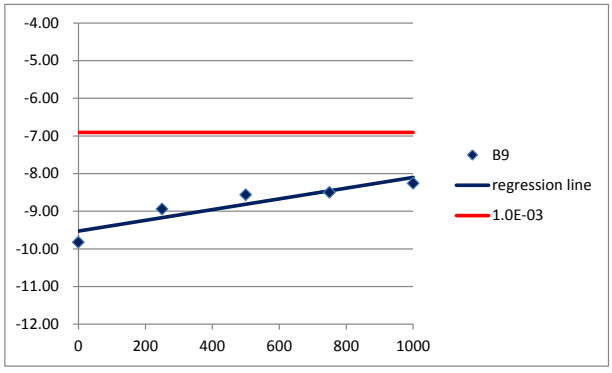

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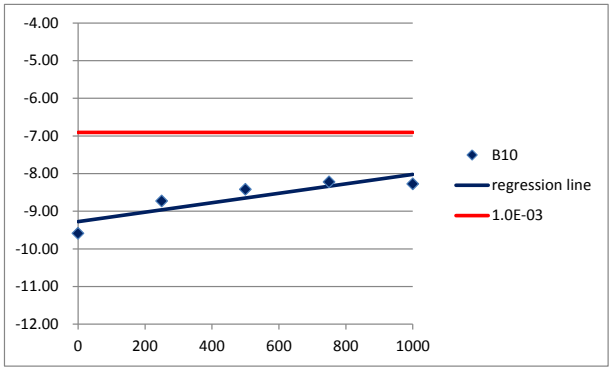
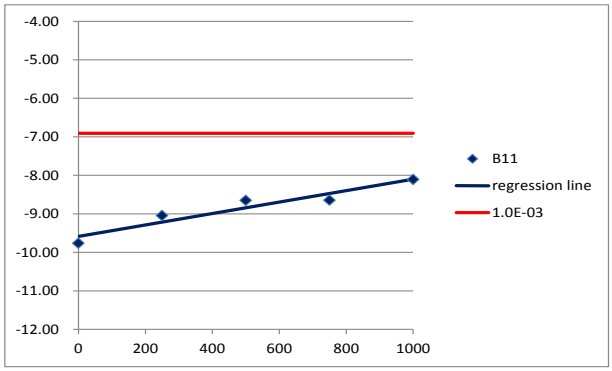
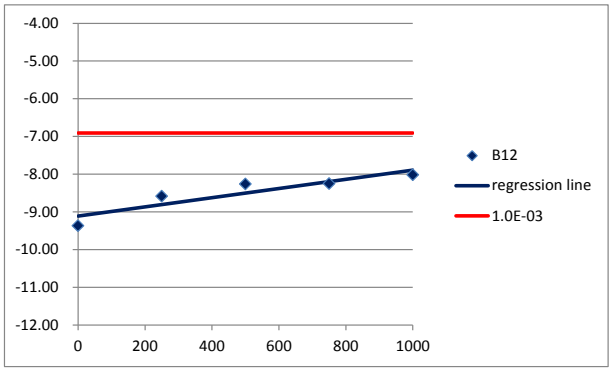


[Figure 1-1-1-2-9] 試料 B9

[Figure 1-1-1-2-10] 試料 B10



[Figure 1-1-1-2-11] 試料 B11



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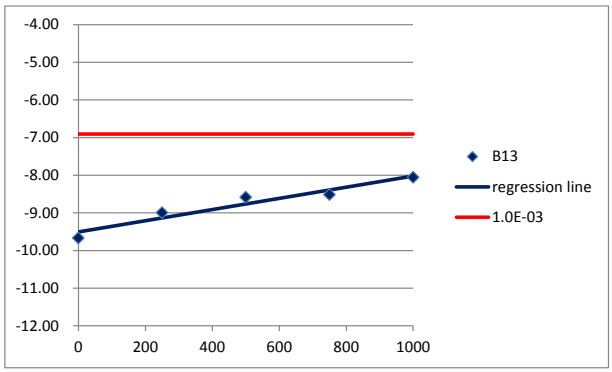

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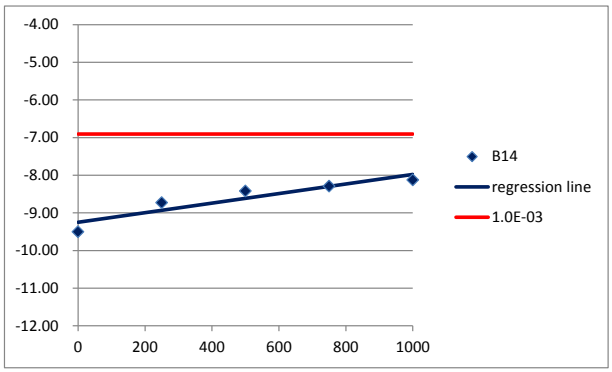

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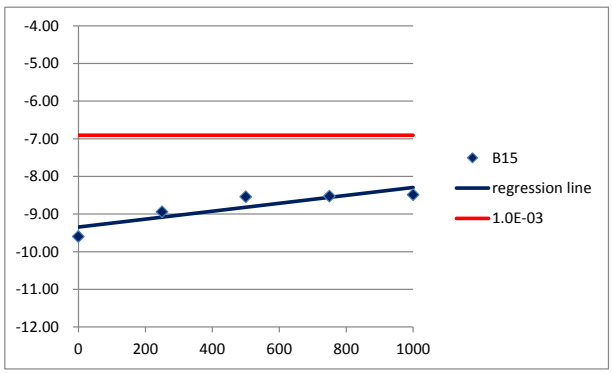

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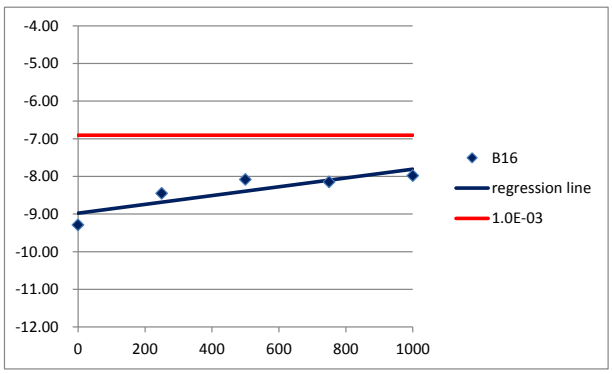

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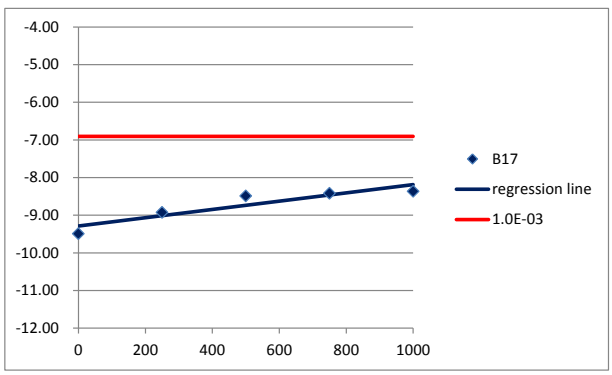

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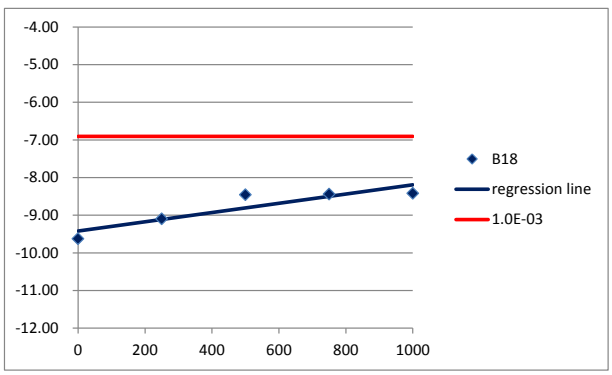
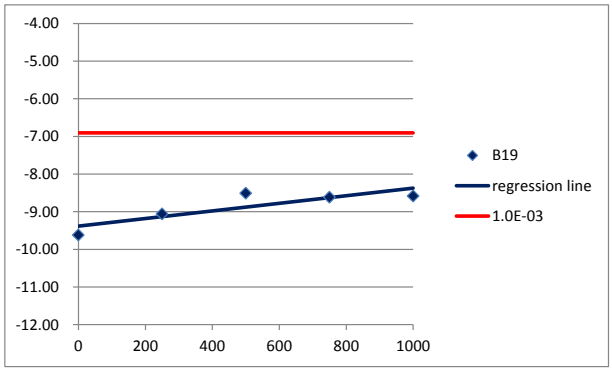
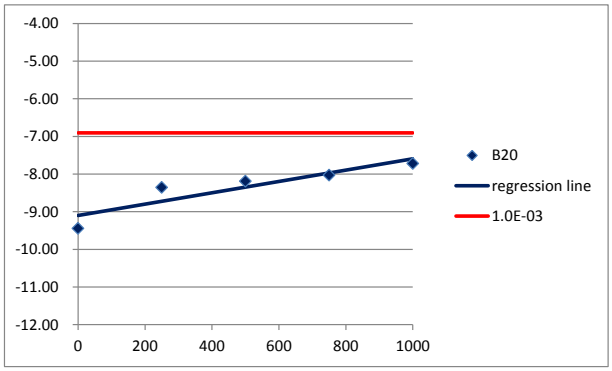


[Figure 1-1-1-2-18] 試料 B18



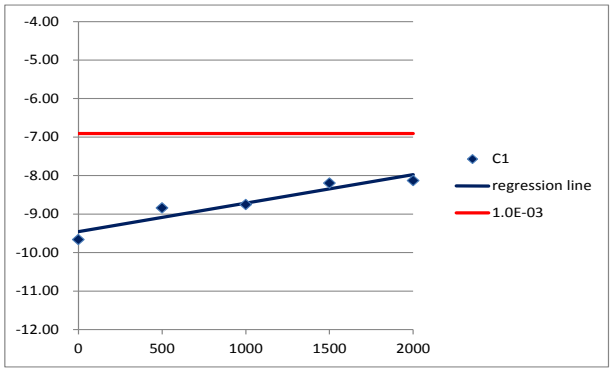
[Figure 1-1-1-2-19] 試料 B19



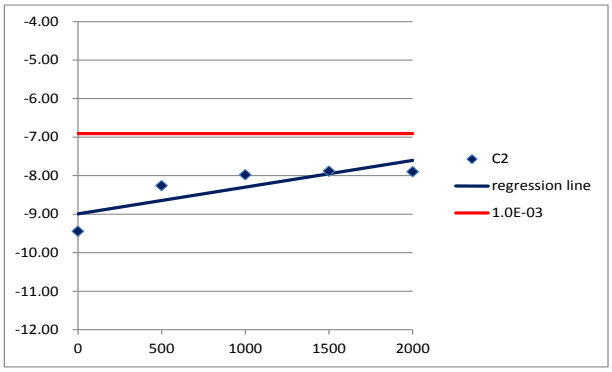
[Figure 1-1-1-2-20] 試料 B20

5-1-1-3 65℃/80%RH

[Figure 1-1-1-3-1]から[Figure 1-1-1-3-20]に各試料のグラフを示す。



[Figure 1-1-1-3-1] 試料 C1



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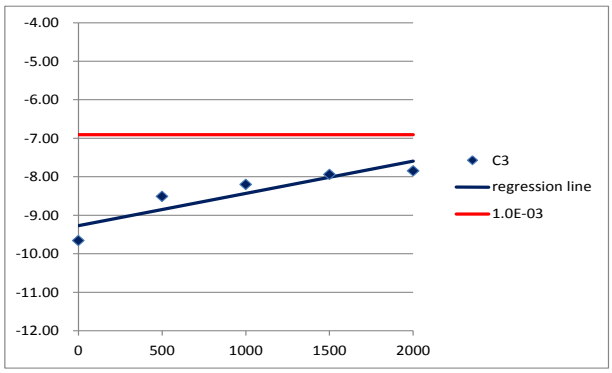

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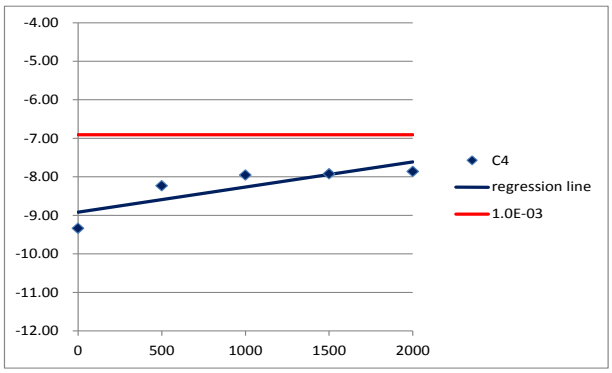

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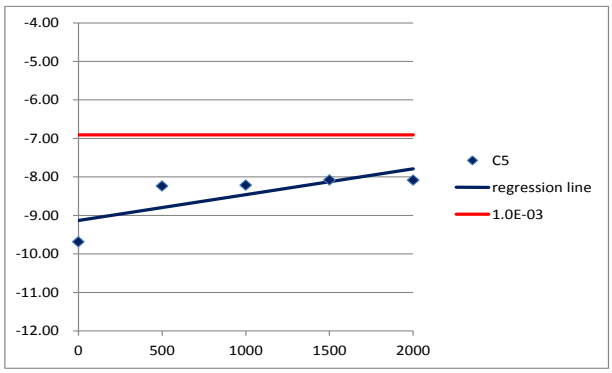
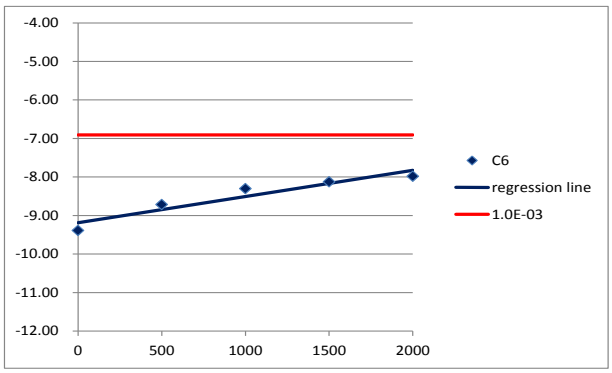
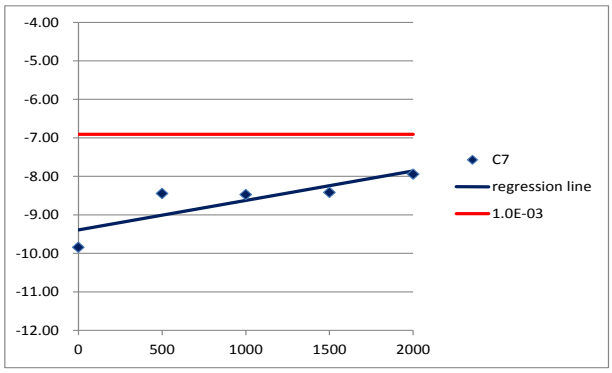
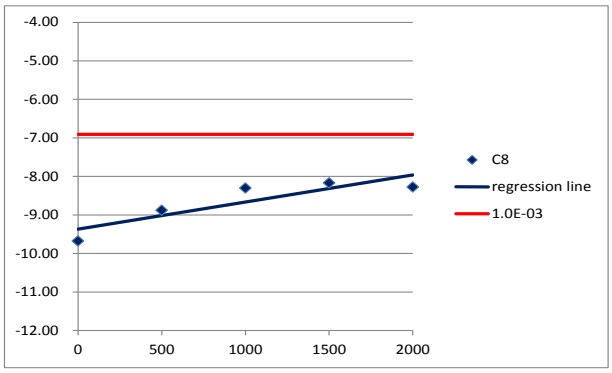




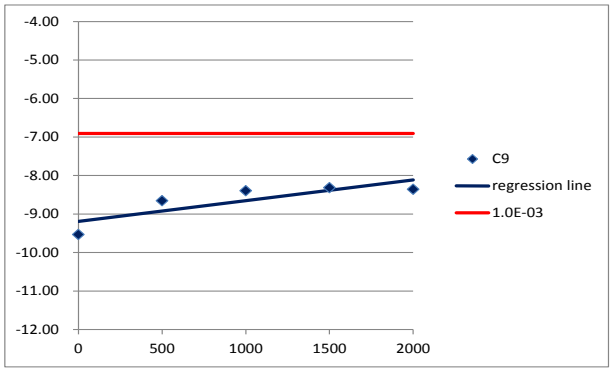
[Figure 1-1-1-3-5] 試料 C5



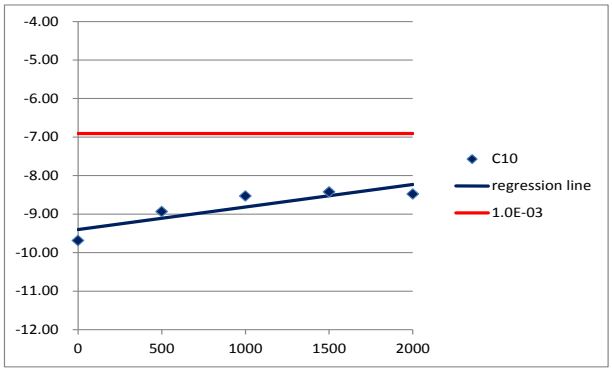
[Figure 1-1-1-3-6] 試料 C6



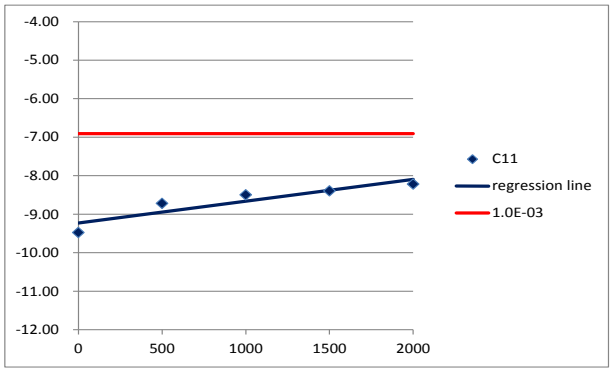
[Figure 1-1-1-3-7] 試料 C7



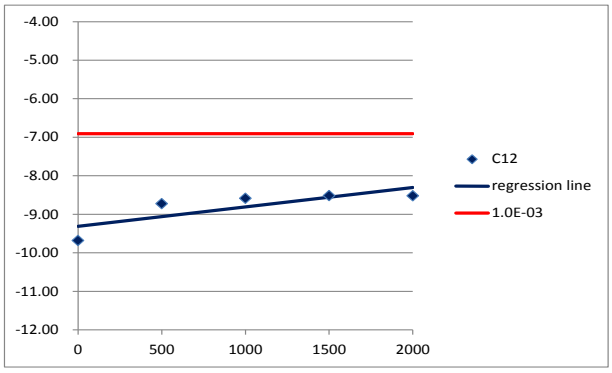
[Figure 1-1-1-3-8] 試料 C8



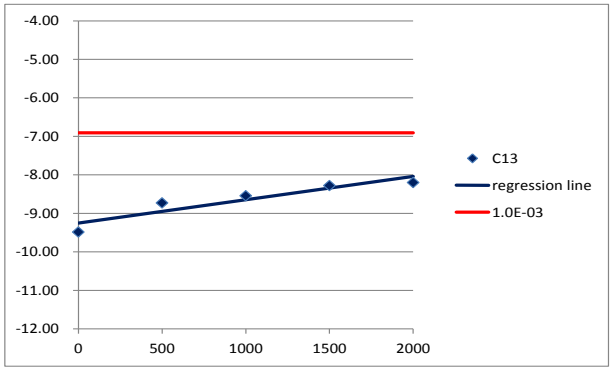
[Figure 1-1-1-3-9] 試料 C9



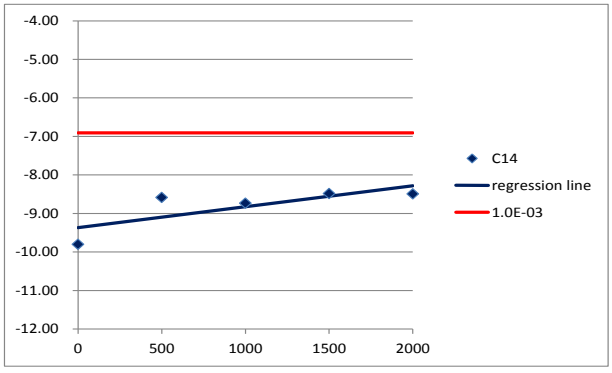
[Figure 1-1-1-3-10] 試料 C10



[Figure 1-1-1-3-11] 試料 C11

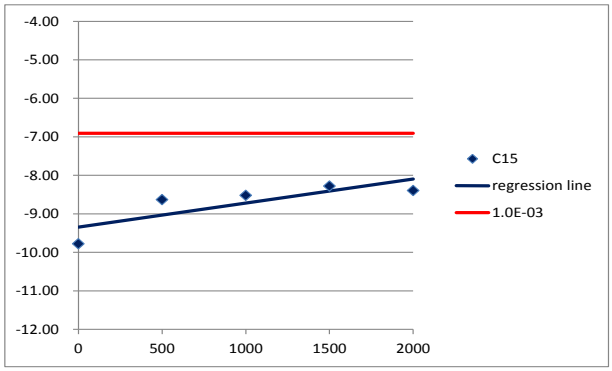


[Figure 1-1-1-3-12] 試料 C12

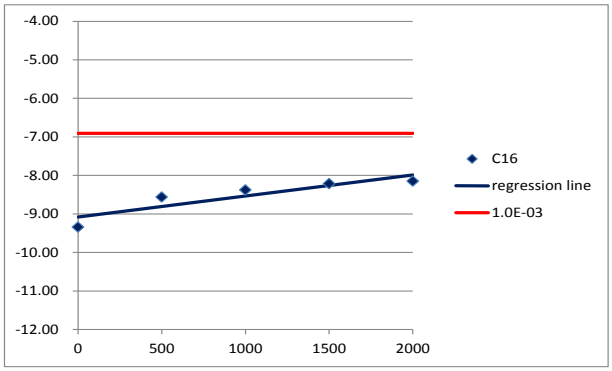


[Figure 1-1-1-3-13] 試料 C13

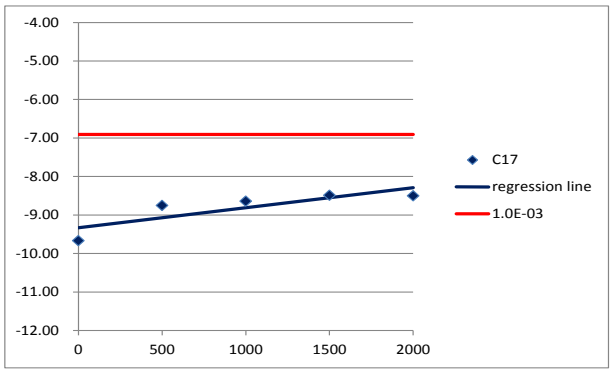
[Figure 1-1-1-3-14] 試料 C14



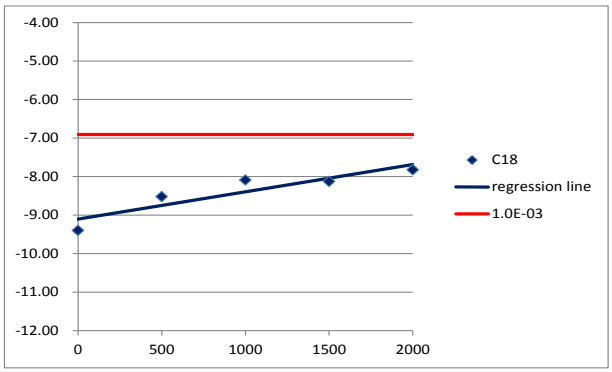
[Figure 1-1-1-3-15] 試料 C15



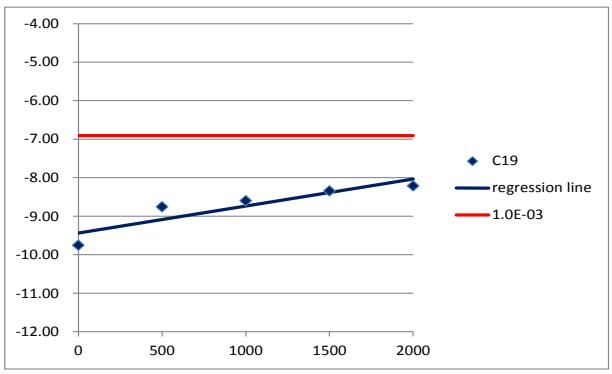
[Figure 1-1-1-3-16] 試料 C16



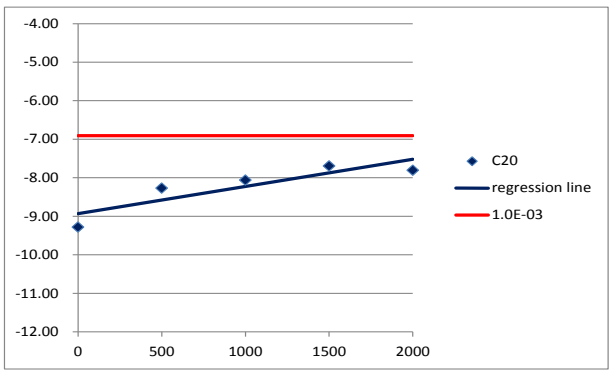
[Figure 1-1-1-3-17] 試料 C17



[Figure 1-1-1-3-18] 試料 C18



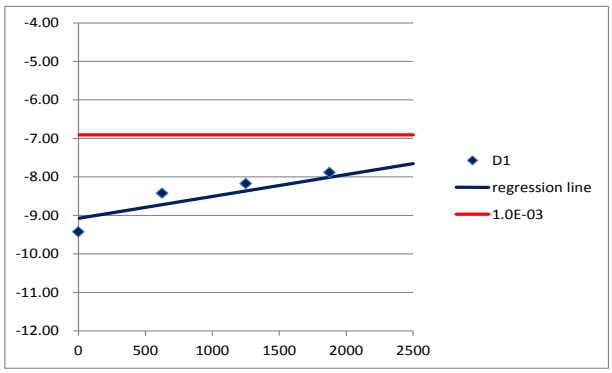
[Figure 1-1-1-3-19] 試料 C19

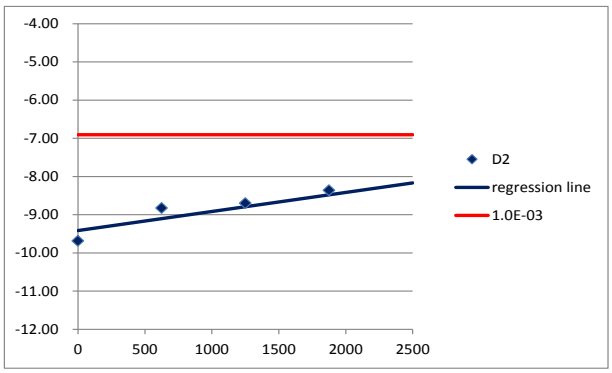


[Figure 1-1-1-3-20] 試料 C20

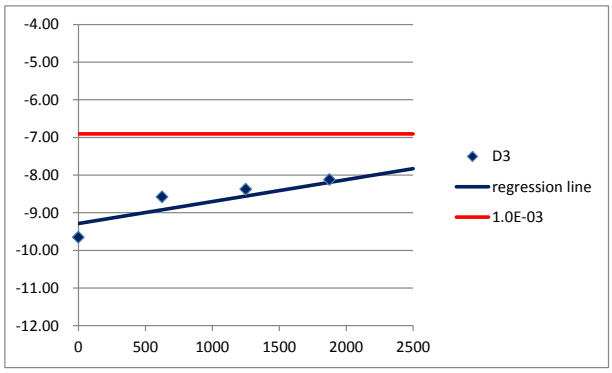
5-1-1-4 70℃/75%RH

[Figure 1-1-1-4-1]から[Figure 1-1-1-4-30]に各試料のグラフを示す。

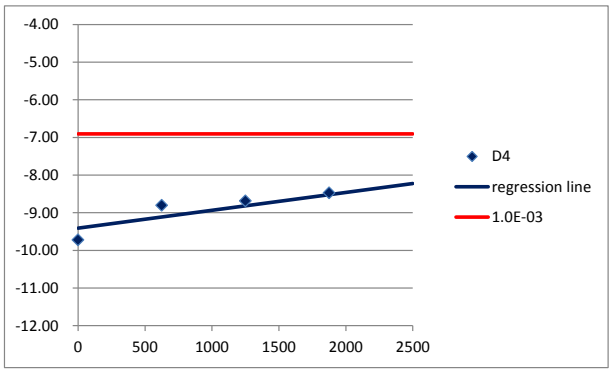




[Figure 1-1-1-4-1] 試料 D1

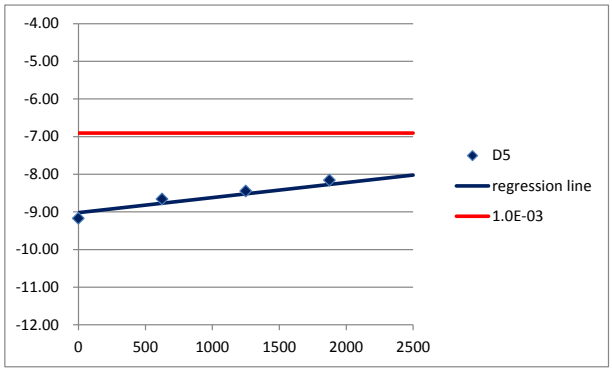


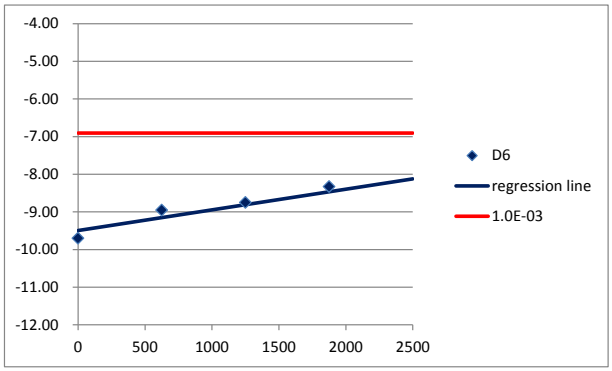
[Figure 1-1-1-4-2] 試料 D2



[Figure 1-1-1-4-3] 試料 D3

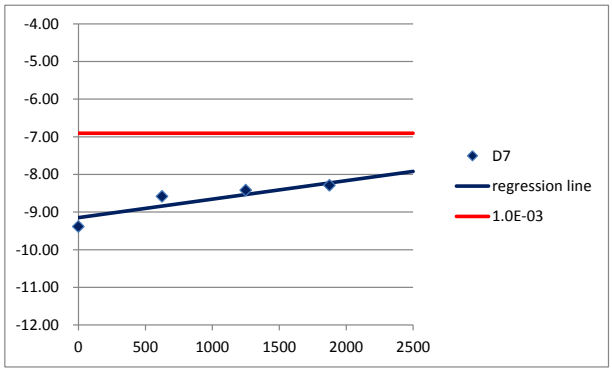
[Figure 1-1-1-4-4] 試料 D4

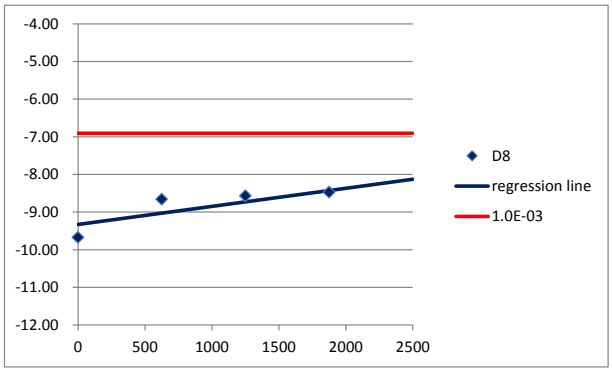




[Figure 1-1-1-4-5] 試料 D5

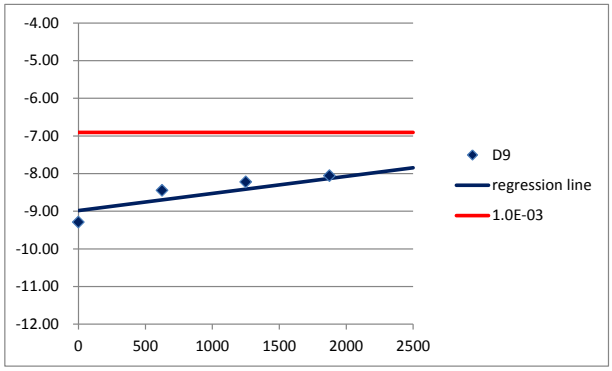
[Figure 1-1-1-4-6] 試料 D6

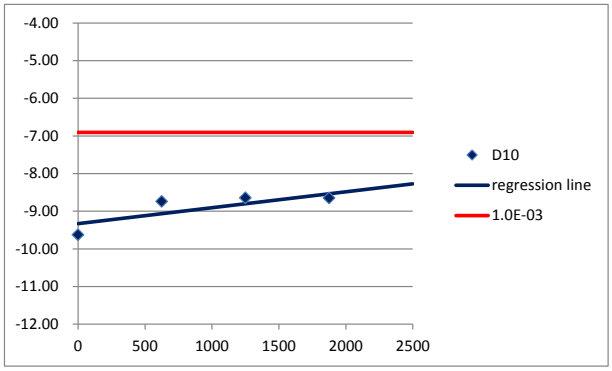




[Figure 1-1-1-4-7] 試料 D7

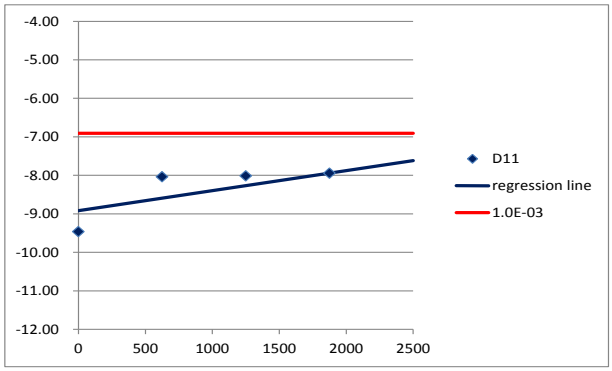
[Figure 1-1-1-4-8] 試料 D8



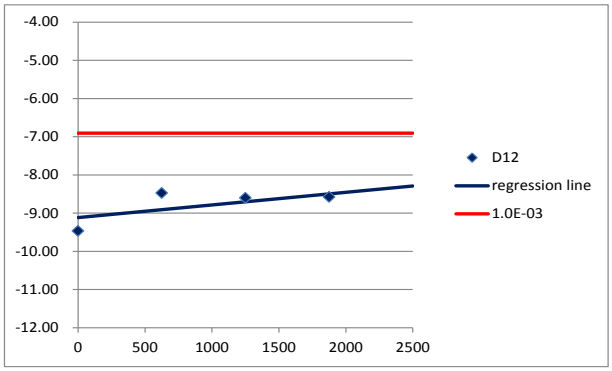


[Figure 1-1-1-4-9] 試料 D9

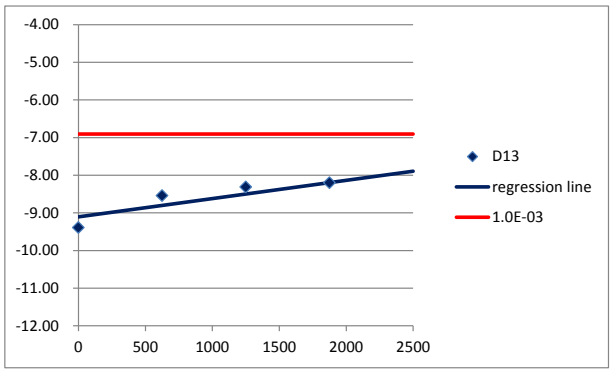
[Figure 1-1-1-4-10] 試料 D10



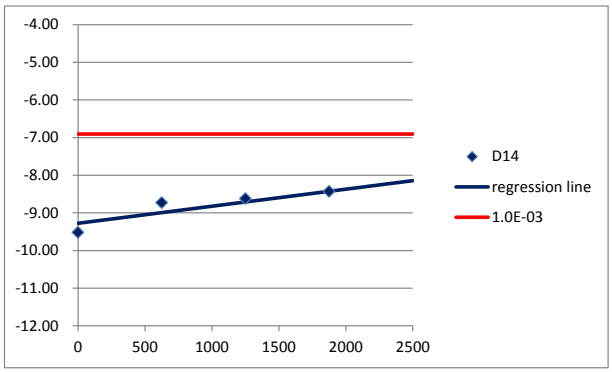
[Figure 1-1-1-4-11] 試料 D11



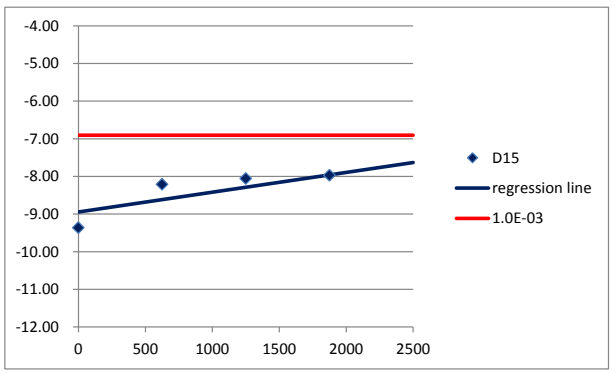
[Figure 1-1-1-4-12] 試料 D12



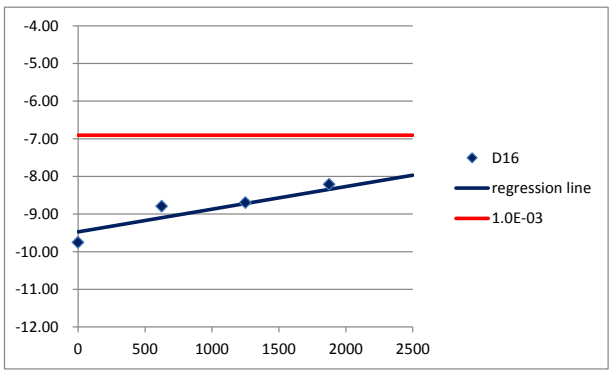
[Figure 1-1-1-4-13] 試料 D13



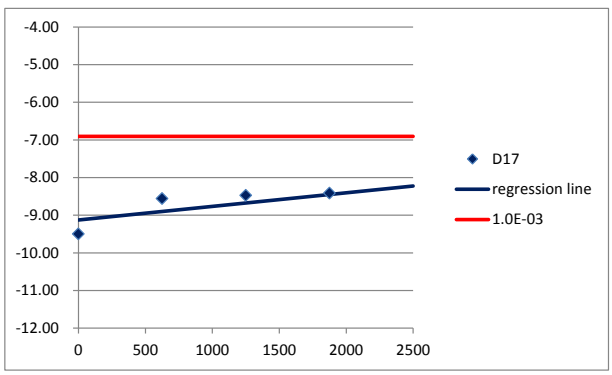
[Figure 1-1-1-4-14] 試料 D14



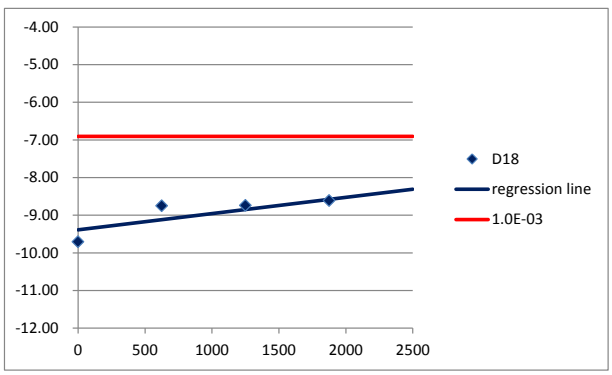
[Figure 1-1-1-4-15] 試料 D15



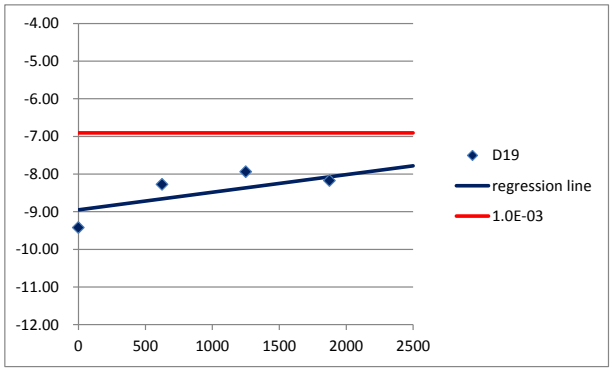
[Figure 1-1-1-4-16] 試料 D16



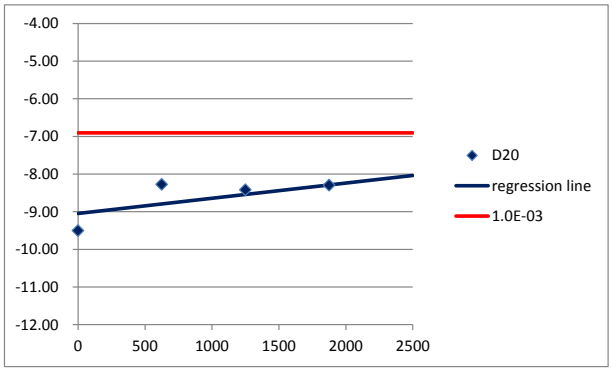
[Figure 1-1-1-4-17] 試料 D17



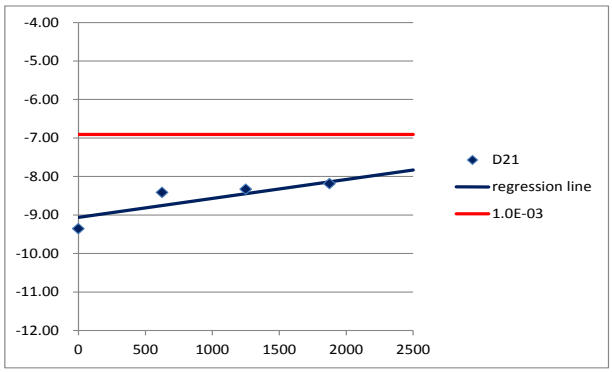
[Figure 1-1-1-4-18] 試料 D18



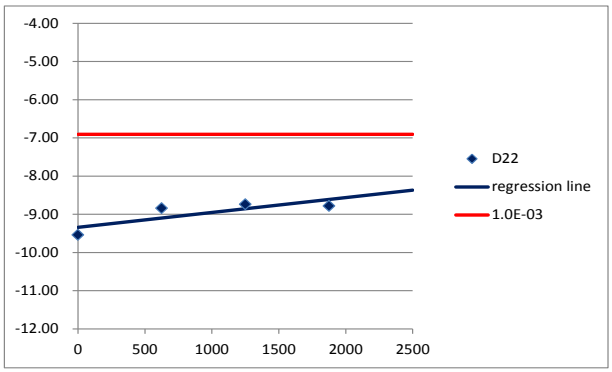
[Figure 1-1-1-4-19] 試料 D19



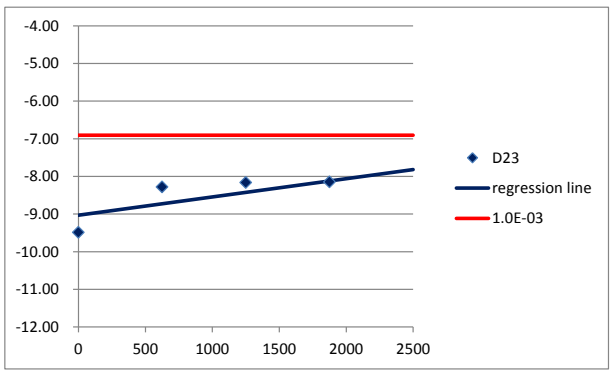
[Figure 1-1-1-4-20] 試料 D20



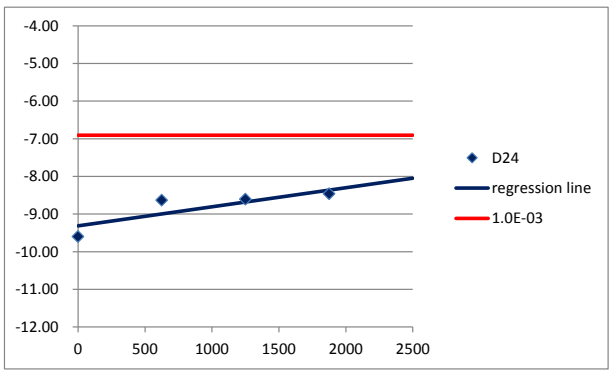
[Figure 1-1-1-4-21] 試料 D21



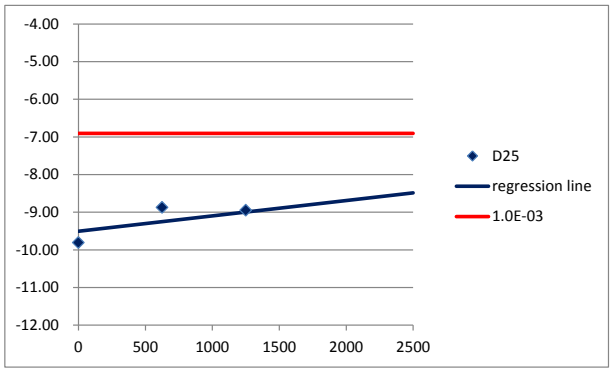
[Figure 1-1-1-4-22] 試料 D22



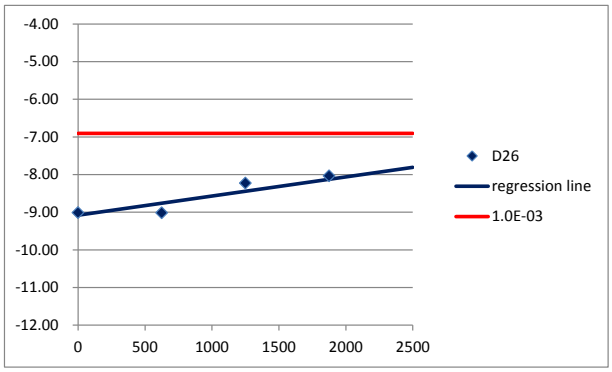
[Figure 1-1-1-4-23] 試料 D23



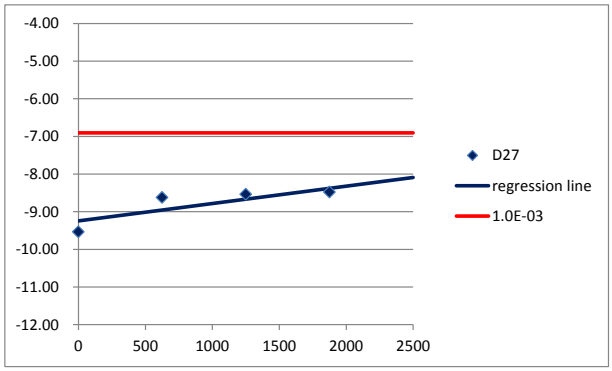
[Figure 1-1-1-4-24] 試料 D24



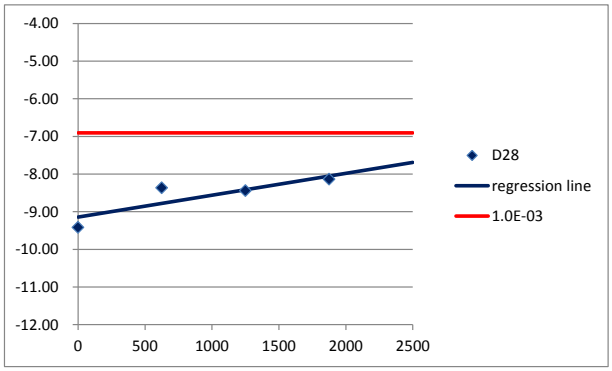
[Figure 1-1-1-4-25] 試料 D25



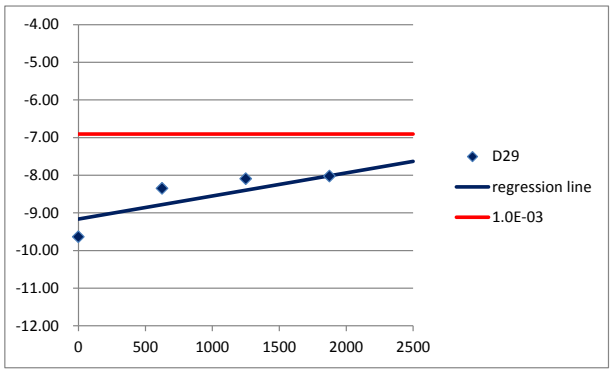
[Figure 1-1-1-4-26] 試料 D26



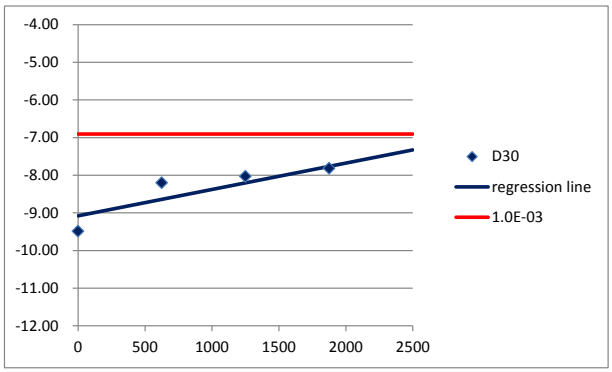
[Figure 1-1-1-4-27] 試料 D27



[Figure 1-1-1-4-28] 試料 D28



[Figure 1-1-1-4-29] 試料 D29



[Figure 1-1-1-4-30] 試料 D30

1-1-2 Step 2

各試料の Step 1 の結果が以下の三条件に適合するか検査を行う。

a) The best-fit line increases monotonously.

b) All ln($Error_t$) are almost on the best-fit line.

c) The best-fit line has on the reasonable increase and is not flat nor having a negative slope.

結果を試験条件ごとにまとめて、[Table 1-1-2-1]～[Table 1-1-2-4]に示す。

[Table 1-1-2-1]

Step 2	Check the tree conditions	reason
A1	OK	
A2	OK	
A3	OK	
A4	OK	
A5	OK	
A6	OK	
A7	OK	
A8	OK	
A9	OK	
A10	OK	
A11	OK	
A12	OK	
A13	OK	
A14	OK	
A15	OK	
A16	OK	
A17	OK	
A18	OK	
A19	OK	
A20	OK	

[Table 1-1-2-2]

Step 2	Check the tree conditions	reason
B1	OK	
B2	OK	
B3	OK	
B4	OK	
B5	OK	
B6	OK	
B7	OK	
B8	OK	
B9	OK	
B10	OK	
B11	OK	
B12	OK	
B13	OK	
B14	OK	
B15	OK	
B16	OK	
B17	OK	
B18	OK	
B19	OK	
B20	OK	

[Table 1-1-2-3]

Step 2	Check the tree conditions	reason
C1	OK	
C2	OK	
C3	OK	
C4	OK	
C5	OK	
C6	OK	
C7	OK	
C8	OK	
C9	OK	
C10	OK	
C11	OK	
C12	OK	
C13	OK	
C14	OK	
C15	OK	
C16	OK	
C17	OK	
C18	OK	
C19	OK	
C20	OK	

[Table 1-1-2-4]

Step 2	Check the tree conditions	reason
D1	OK	
D2	OK	
D3	OK	
D4	OK	
D5	OK	
D6	OK	
D7	OK	
D8	OK	
D9	OK	
D10	OK	
D11	OK	
D12	OK	
D13	OK	
D14	OK	
D15	OK	
D16	OK	
D17	OK	
D18	OK	
D19	OK	
D20	OK	
D21	OK	
D22	OK	
D23	OK	
D24	OK	
D25	OK	
D26	OK	
D27	OK	
D28	OK	
D29	OK	
D30	OK	

1-2 故障時間（time-to-failure）の決定

Step 3 に従い故障時間を決定する。

試験条件ごとに決定した故障時間を、[Table 1-2-1]に示す。

[Table 1-2-1]

Group A		Group B		Group C		Group D	
Disc #	Time -to-failure	Disc #	Time -to-failure	Disc #	Time -to-failure	Disc #	Time -to-failure
A1	797	B1	1829	C1	3442	D1	3817
A2	586	B2	2099	C2	3001	D2	5024
A3	579	B3	1544	C3	2820	D3	4076
A4	1042	B4	2047	C4	3079	D4	5285
A5	772	B5	1781	C5	3314	D5	5296
A6	696	B6	1865	C6	3348	D6	4712
A7	771	B7	1675	C7	3247	D7	4561
A8	578	B8	1772	C8	3502	D8	5042
A9	1027	B9	1837	C9	4250	D9	4553
A10	670	B10	1892	C10	4256	D10	5744
A11	518	B11	1804	C11	4093	D11	3870
A12	673	B12	1815	C12	4777	D12	6686
A13	620	B13	1753	C13	3879	D13	4541
A14	536	B14	1840	C14	4527	D14	5244
A15	640	B15	2313	C15	3905	D15	3878
A16	534	B16	1772	C16	3974	D16	4265
A17	748	B17	2166	C17	4668	D17	6145
A18	531	B18	2045	C18	3098	D18	5769
A19	817	B19	2459	C19	3608	D19	4374
A20	752	B20	1455	C20	2868	D20	5298
						D21	4374
						D22	6256
						D23	4383
						D24	4761
						D25	6355
						D26	4268
						D27	5068
						D28	3848
						D29	3678
						D30	3103

1-3 Complete data の判定

“A.2.2 Judgment of complete data”にある、Step 4、Step 5 及び Step 6 に従い、complete data であるかどうかの判定を行う。

1-3-1 Step 4 及び Step 5

各試料の故障時間に関する median rank を計算しグラフにする。

試験条件ごとに計算して求めた median rank と故障時間の表を[Table 1-3-1-1]～[Table 1-3-1-2]に示す。

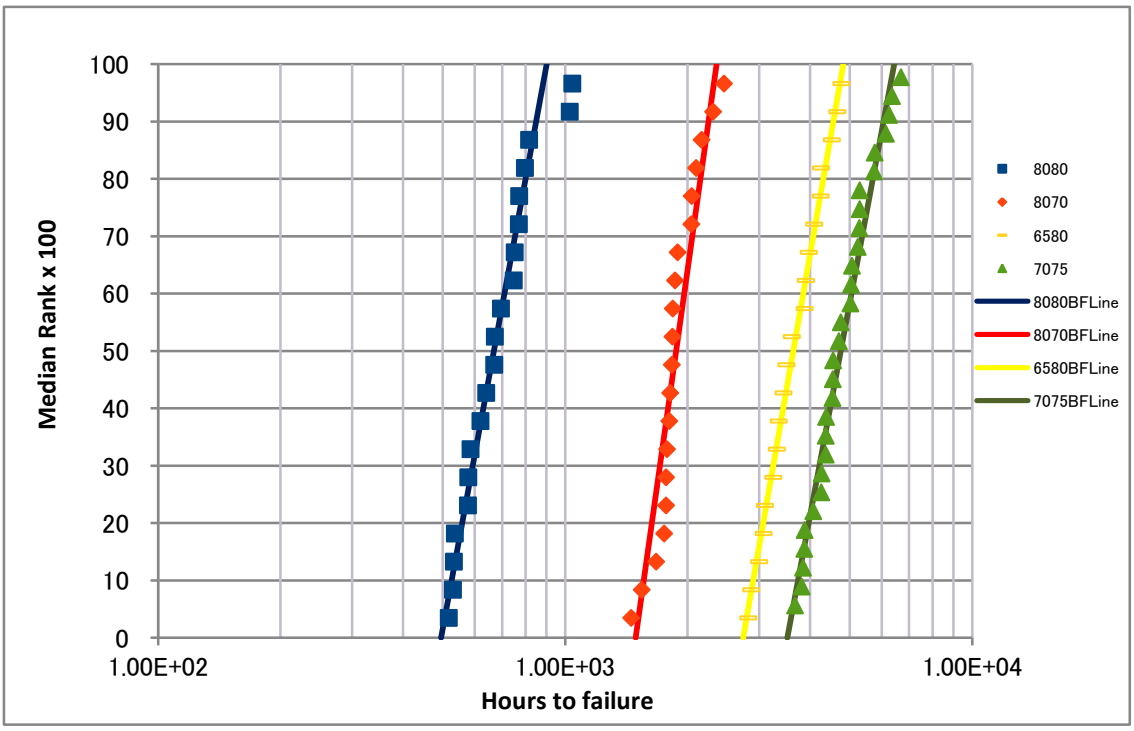
また median rank 対故障時間の対数グラフを、[Figure 1-3-1-1]に示す。

[Table 1-3-1-1]

Order number	Group A 80℃80%RH	Group B 80℃70%RH	Group C 65℃80%RH	Group D 70℃75%RH
1	518	1455	2820	3103
2	531	1544	2868	3678
3	534	1675	3001	3817
4	536	1753	3079	3848
5	578	1772	3098	3870
6	579	1772	3247	3878
7	586	1781	3314	4076
8	620	1804	3348	4265
9	640	1815	3442	4268
10	670	1829	3502	4374
11	673	1837	3608	4374
12	696	1840	3879	4383
13	748	1865	3905	4541
14	752	1892	3974	4553
15	771	2045	4093	4561
16	772	2047	4250	4712
17	797	2099	4256	4761
18	817	2166	4527	5024
19	1027	2313	4668	5042
20	1042	2459	4777	5068
21				5244
22				5285
23				5296
24				5298
25				5744
26				5769
27				6145
28				6256
29				6355
30				6686

[Table 1-3-1-2]

Group A	80℃/80%RH			Group B	80℃/70%RH			Group C	65℃/80%RH			Group D	70℃/75%RH		
Order number	Time-to-failure	ln (H)	Median rank	Order number	Time-to-failure	ln (H)	Median rank	Order number	Time-to-failure	ln (H)	Median rank	Order number	Time-to-failure	ln (H)	Median rank
1	518	6.2500	0.0343	1	1455	7.2828	0.0343	1	2820	7.9445	0.0343	1	3103	8.0401	0.0230
2	531	6.2748	0.0833	2	1544	7.3421	0.0833	2	2868	7.9614	0.0833	2	3678	8.2101	0.0559
3	534	6.2804	0.1324	3	1675	7.4236	0.1324	3	3001	8.0067	0.1324	3	3817	8.2472	0.0888
4	536	6.2841	0.1814	4	1753	7.4691	0.1814	4	3079	8.0324	0.1814	4	3848	8.2553	0.1217
5	578	6.3596	0.2304	5	1772	7.4799	0.2304	5	3098	8.0385	0.2304	5	3870	8.2610	0.1546
6	579	6.3613	0.2794	6	1772	7.4799	0.2794	6	3247	8.0855	0.2794	6	3878	8.2631	0.1875
7	586	6.3733	0.3284	7	1781	7.4849	0.3284	7	3314	8.1059	0.3284	7	4076	8.3129	0.2204
8	620	6.4297	0.3775	8	1804	7.4978	0.3775	8	3348	8.1161	0.3775	8	4265	8.3582	0.2533
9	640	6.4615	0.4265	9	1815	7.5038	0.4265	9	3442	8.1438	0.4265	9	4268	8.3589	0.2862
10	670	6.5073	0.4755	10	1829	7.5115	0.4755	10	3502	8.1611	0.4755	10	4374	8.3834	0.3191
11	673	6.5117	0.5245	11	1837	7.5159	0.5245	11	3608	8.1909	0.5245	11	4374	8.3834	0.3520
12	696	6.5453	0.5735	12	1840	7.5175	0.5735	12	3879	8.2633	0.5735	12	4383	8.3855	0.3849
13	748	6.6174	0.6225	13	1865	7.5310	0.6225	13	3905	8.2700	0.6225	13	4541	8.4209	0.4178
14	752	6.6227	0.6716	14	1892	7.5454	0.6716	14	3974	8.2875	0.6716	14	4553	8.4235	0.4507
15	771	6.6477	0.7206	15	2045	7.6232	0.7206	15	4093	8.3170	0.7206	15	4561	8.4253	0.4836
16	772	6.6490	0.7696	16	2047	7.6241	0.7696	16	4250	8.3547	0.7696	16	4712	8.4579	0.5164
17	797	6.6809	0.8186	17	2099	7.6492	0.8186	17	4256	8.3561	0.8186	17	4761	8.4682	0.5493
18	817	6.7056	0.8676	18	2166	7.6806	0.8676	18	4527	8.4178	0.8676	18	5024	8.5220	0.5822
19	1027	6.9344	0.9167	19	2313	7.7463	0.9167	19	4668	8.4485	0.9167	19	5042	8.5256	0.6151
20	1042	6.9489	0.9657	20	2459	7.8075	0.9657	20	4777	8.4716	0.9657	20	5068	8.5307	0.6480
												21	5244	8.5648	0.6809
												22	5285	8.5726	0.7138
												23	5296	8.5747	0.7467
												24	5298	8.5751	0.7796
												25	5744	8.6559	0.8125
												26	5769	8.6603	0.8454
												27	6145	8.7234	0.8783
												28	6256	8.7413	0.9112
												29	6355	8.7570	0.9441
												30	6686	8.8078	0.9770



[Figure 1-3-1-1] Best-fit lines specimen groups A,B,C,D on lognormal paper

1-3-2 Step 6

各試料の Step 5 の結果が以下の二条件に適合するか検査を行う。

a) All the time-to-failure corresponding to each median rank are almost on the best-fit straight-line of each stress group.

b) The best-fit straight lines of all stress groups are reasonably parallel with each other.

【結論】

① ”1-3-1”(Step 4, 5)及び”1-3-2”(Step 6)の結果より、求められたデータは complete data とは言えない。

② [Figure 1-3-1-1] Best-fit lines specimen groups A,B,C,D on lognormal paper より、best-fit straight line から離れた点がありこれらは missing time-to-failure として取り扱う。

[Table 1-3-1-3] Missing time-to-failure(ハッチ部)

Group A	80℃/80%RH			Group B	80℃/70%RH			Group C	65℃/80%RH			Group D	70℃/75%RH		
Order number	Time-to-failure	ln (H)	Median rank	Order number	Time-to-failure	ln (H)	Median rank	Order number	Time-to-failure	ln (H)	Median rank	Order number	Time-to-failure	ln (H)	Median rank
1	518	6.2500	0.0343	1	1455	7.2828	0.0343	1	2820	7.9445	0.0343	1	3103	8.0401	0.0230
2	531	6.2748	0.0833	2	1544	7.3421	0.0833	2	2868	7.9614	0.0833	2	3678	8.2101	0.0559
3	534	6.2804	0.1324	3	1675	7.4236	0.1324	3	3001	8.0067	0.1324	3	3817	8.2472	0.0888
4	536	6.2841	0.1814	4	1753	7.4691	0.1814	4	3079	8.0324	0.1814	4	3848	8.2553	0.1217
5	578	6.3596	0.2304	5	1772	7.4799	0.2304	5	3098	8.0385	0.2304	5	3870	8.2610	0.1546
6	579	6.3613	0.2794	6	1772	7.4799	0.2794	6	3247	8.0855	0.2794	6	3878	8.2631	0.1875
7	586	6.3733	0.3284	7	1781	7.4849	0.3284	7	3314	8.1059	0.3284	7	4076	8.3129	0.2204
8	620	6.4297	0.3775	8	1804	7.4978	0.3775	8	3348	8.1161	0.3775	8	4265	8.3582	0.2533
9	640	6.4615	0.4265	9	1815	7.5038	0.4265	9	3442	8.1438	0.4265	9	4268	8.3589	0.2862
10	670	6.5073	0.4755	10	1829	7.5115	0.4755	10	3502	8.1611	0.4755	10	4374	8.3834	0.3191
11	673	6.5117	0.5245	11	1837	7.5159	0.5245	11	3608	8.1909	0.5245	11	4374	8.3834	0.3520
12	696	6.5453	0.5735	12	1840	7.5175	0.5735	12	3879	8.2633	0.5735	12	4383	8.3855	0.3849
13	748	6.6174	0.6225	13	1865	7.5310	0.6225	13	3905	8.2700	0.6225	13	4541	8.4209	0.4178
14	752	6.6227	0.6716	14	1892	7.5454	0.6716	14	3974	8.2875	0.6716	14	4553	8.4235	0.4507
15	771	6.6477	0.7206	15	2045	7.6232	0.7206	15	4093	8.3170	0.7206	15	4561	8.4253	0.4836
16	772	6.6490	0.7696	16	2047	7.6241	0.7696	16	4250	8.3547	0.7696	16	4712	8.4579	0.5164
17	797	6.6809	0.8186	17	2099	7.6492	0.8186	17	4256	8.3561	0.8186	17	4761	8.4682	0.5493
18	817	6.7056	0.8676	18	2166	7.6806	0.8676	18	4527	8.4178	0.8676	18	5024	8.5220	0.5822
19	1027	6.9344	0.9167	19	2313	7.7463	0.9167	19	4668	8.4485	0.9167	19	5042	8.5256	0.6151
20	1042	6.9489	0.9657	20	2459	7.8075	0.9657	20	4777	8.4716	0.9657	20	5068	8.5307	0.6480
												21	5244	8.5648	0.6809
												22	5285	8.5726	0.7138
												23	5296	8.5747	0.7467
												24	5298	8.5751	0.7796
												25	5744	8.6559	0.8125
												26	5769	8.6603	0.8454
												27	6145	8.7234	0.8783
												28	6256	8.7413	0.9112
												29	6355	8.7570	0.9441
												30	6686	8.8078	0.9770

1-4 寿命推定の有効性

“A.2.3 Condition for lifetime-estimation effectiveness”にある、Step 7 に従い、以下の三条件に関する検査を行い、故障時間の有効性について判断を行う。

a) The lognormal data plots of each stress group are almost on the best-fit straight-line.

b) Exclude the missing times-to-failure, then check the specimens of each stress group have effective times-to-failure that span over one-half of a median rank point.

c) The best-fit straight lines of all stress groups are reasonably parallel with one another.

【結論】

「1-1-2 Step 2」、「1-3-2 Step 6」及び「1-4 寿命推定の有効性」、の結果より今回得られたデータは、① missing times-to-failure があり、② complete data ではないが、③ このデータを使って寿命推定を行った結果は有効である、と考えられる。

1-5 Missing times-to-failure の取り扱い

「1-4」の結論より、“A.2.4 Lifetime estimation when there are missing times-to-failure(informative)”に記載されている、missing time-to-failure の代替方法を用いて complete data set を用意する。

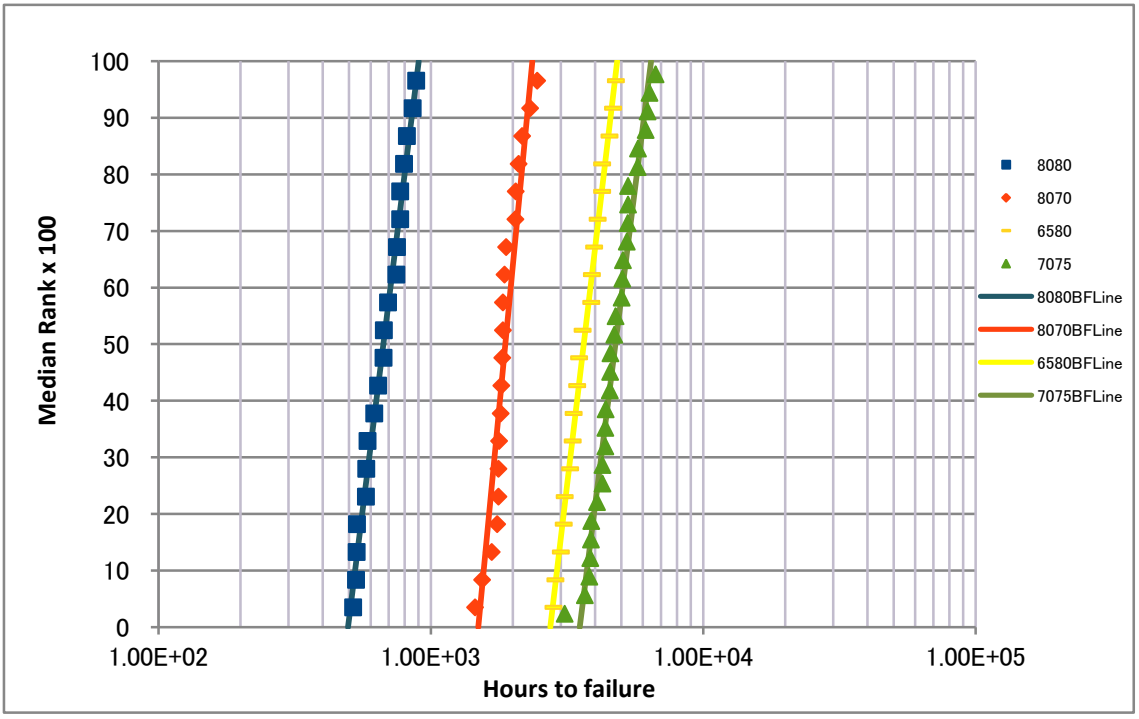
[Table 1-5-1]～[Table 1-5-2]に各試験条件の complete data set を示し、[Figure 1-5-1]にグラフを示す。

[Table 1-5-1]

Order number	Group A 80℃80%RH	Group B 80℃70%RH	Group C 65℃80%RH	Group D 70℃75%RH
1	518	1455	2820	3103
2	531	1544	2868	3678
3	534	1675	3001	3817
4	536	1753	3079	3848
5	578	1772	3098	3870
6	579	1772	3247	3878
7	586	1781	3314	4076
8	620	1804	3348	4265
9	640	1815	3442	4268
10	670	1829	3502	4374
11	673	1837	3608	4374
12	696	1840	3879	4383
13	748	1865	3905	4541
14	752	1892	3974	4553
15	771	2045	4093	4561
16	772	2047	4250	4712
17	797	2099	4256	4761
18	817	2166	4527	5024
19	857	2313	4668	5042
20	883	2459	4777	5068
21				5244
22				5285
23				5296
24				5298
25				5744
26				5769
27				6145
28				6256
29				6355
30				6686

[Table 1-5-2]

Group A	80℃/80%RH			Group B	80℃/70%RH			Group C	65℃/80%RH			Group D	70℃/75%RH		
Order number	Time-to-failure	ln (H)	Median rank	Order number	Time-to-failure	ln (H)	Median rank	Order number	Time-to-failure	ln (H)	Median rank	Order number	Time-to-failure	ln (H)	Median rank
1	518	6.2500	0.034	1	1455	7.2828	0.034	1	2820	7.9445	0.034	1	3103	8.0401	0.023
2	531	6.2748	0.083	2	1544	7.3421	0.083	2	2868	7.9614	0.083	2	3678	8.2101	0.056
3	534	6.2804	0.132	3	1675	7.4236	0.132	3	3001	8.0067	0.132	3	3817	8.2472	0.089
4	536	6.2841	0.181	4	1753	7.4691	0.181	4	3079	8.0324	0.181	4	3848	8.2553	0.122
5	578	6.3596	0.230	5	1772	7.4799	0.230	5	3098	8.0385	0.230	5	3870	8.2610	0.155
6	579	6.3613	0.279	6	1772	7.4799	0.279	6	3247	8.0855	0.279	6	3878	8.2631	0.188
7	586	6.3733	0.328	7	1781	7.4849	0.328	7	3314	8.1059	0.328	7	4076	8.3129	0.220
8	620	6.4297	0.377	8	1804	7.4978	0.377	8	3348	8.1161	0.377	8	4265	8.3582	0.253
9	640	6.4615	0.426	9	1815	7.5038	0.426	9	3442	8.1438	0.426	9	4268	8.3589	0.286
10	670	6.5073	0.475	10	1829	7.5115	0.475	10	3502	8.1611	0.475	10	4374	8.3834	0.319
11	673	6.5117	0.525	11	1837	7.5159	0.525	11	3608	8.1909	0.525	11	4374	8.3834	0.352
12	696	6.5453	0.574	12	1840	7.5175	0.574	12	3879	8.2633	0.574	12	4383	8.3855	0.385
13	748	6.6174	0.623	13	1865	7.5310	0.623	13	3905	8.2700	0.623	13	4541	8.4209	0.418
14	752	6.6227	0.672	14	1892	7.5454	0.672	14	3974	8.2875	0.672	14	4553	8.4235	0.451
15	771	6.6477	0.721	15	2045	7.6232	0.721	15	4093	8.3170	0.721	15	4561	8.4253	0.484
16	772	6.6490	0.770	16	2047	7.6241	0.770	16	4250	8.3547	0.770	16	4712	8.4579	0.516
17	797	6.6809	0.819	17	2099	7.6492	0.819	17	4256	8.3561	0.819	17	4761	8.4682	0.549
18	817	6.7056	0.868	18	2166	7.6806	0.868	18	4527	8.4178	0.868	18	5024	8.5220	0.582
19	857	6.7538	0.917	19	2313	7.7463	0.917	19	4668	8.4485	0.917	19	5042	8.5256	0.615
20	883	6.7830	0.966	20	2459	7.8075	0.966	20	4777	8.4716	0.966	20	5068	8.5307	0.648
												21	5244	8.5648	0.681
												22	5285	8.5726	0.714
												23	5296	8.5747	0.747
												24	5298	8.5751	0.780
												25	5744	8.6559	0.813
												26	5769	8.6603	0.845
												27	6145	8.7234	0.878
												28	6256	8.7413	0.911
												29	6355	8.7570	0.944
												30	6686	8.8078	0.977
Mean	678	6.5190		Mean	1888	7.5434		Mean	3683	8.2114		Mean	4809	8.4783	



[Figure 1-5-1] Best-fit lines specimen groups A,B,C,D on lognormal paper

[2] 寿命推定

Annex B(Normative) “Disk-life estimation for Controlled storage condition (Eyring method)”に従い、寿命推定を行う。

2-1 最小二乗法を用いた最尤法による寿命推定

Controlled storage condition での平均故障時間(ln B_{50})及び標準偏差(σ)を求め、95%信頼区間における 95%残存確率により推定寿命値((B_5 Life)$_L$)を求める。

2-1-1 Step 4

各加速条件の、① 故障時間の自然対数値、② 加速試験条件の絶対温度の逆数、③ 加速試験条件の相対湿度をまとめた、重回帰分析用の表を[Table 2-1-1-1]に示す。

[Table 2-1-1-1]

Number	ln(t)	1/T(Kelvin)	H(%RH)	Number	ln(t)	1/T(Kelvin)	H(%RH)
1	6.249975	0.002832	80	1	7.944492	0.002957	80
2	6.274762	0.002832	80	2	7.961370	0.002957	80
3	6.280396	0.002832	80	3	8.006701	0.002957	80
4	6.284134	0.002832	80	4	8.032360	0.002957	80
5	6.359574	0.002832	80	5	8.038512	0.002957	80
6	6.361302	0.002832	80	6	8.085487	0.002957	80
7	6.373320	0.002832	80	7	8.105911	0.002957	80
8	6.429719	0.002832	80	8	8.116118	0.002957	80
9	6.461468	0.002832	80	9	8.143808	0.002957	80
10	6.507278	0.002832	80	10	8.161090	0.002957	80
11	6.511745	0.002832	80	11	8.190909	0.002957	80
12	6.545350	0.002832	80	12	8.263333	0.002957	80
13	6.617403	0.002832	80	13	8.270013	0.002957	80
14	6.622736	0.002832	80	14	8.287528	0.002957	80
15	6.647688	0.002832	80	15	8.317033	0.002957	80
16	6.648985	0.002832	80	16	8.354674	0.002957	80
17	6.680855	0.002832	80	17	8.356085	0.002957	80
18	6.705639	0.002832	80	18	8.417815	0.002957	80
19	6.753769	0.002832	80	19	8.448486	0.002957	80
20	6.783041	0.002832	80	20	8.471568	0.002957	80
1	7.282761	0.002832	70	1	8.040125	0.002914	75
2	7.342132	0.002832	70	2	8.210124	0.002914	75
3	7.423568	0.002832	70	3	8.247220	0.002914	75
4	7.469084	0.002832	70	4	8.255309	0.002914	75
5	7.479864	0.002832	70	5	8.261010	0.002914	75
6	7.479864	0.002832	70	6	8.263075	0.002914	75
7	7.484930	0.002832	70	7	8.312871	0.002914	75
8	7.497762	0.002832	70	8	8.358197	0.002914	75
9	7.503841	0.002832	70	9	8.358901	0.002914	75
10	7.511525	0.002832	70	10	8.383433	0.002914	75
11	7.515889	0.002832	70	11	8.383433	0.002914	75
12	7.517521	0.002832	70	12	8.385489	0.002914	75
13	7.531016	0.002832	70	13	8.420903	0.002914	75
14	7.545390	0.002832	70	14	8.423542	0.002914	75
15	7.623153	0.002832	70	15	8.425297	0.002914	75
16	7.624131	0.002832	70	16	8.457868	0.002914	75
17	7.649216	0.002832	70	17	8.468213	0.002914	75
18	7.680637	0.002832	70	18	8.521982	0.002914	75
19	7.746301	0.002832	70	19	8.525558	0.002914	75
20	7.807510	0.002832	70	20	8.530702	0.002914	75
				21	8.564840	0.002914	75
				22	8.572628	0.002914	75
				23	8.574707	0.002914	75
				24	8.575085	0.002914	75
				25	8.655911	0.002914	75
				26	8.660254	0.002914	75
				27	8.723394	0.002914	75
				28	8.741296	0.002914	75
				29	8.756997	0.002914	75
				30	8.807771	0.002914	75

重回帰分析結果を[Table 2-1-1-2]に示す。

[Table 2-1-1-2] 解析結果

Estimated regression coefficients			Estimated log standard deviation
$\hat{\beta}_0$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\sigma}_{lsm}$
-26.6065	15037.35	-0.11883	0.21218

Coefficient of determination は 0.92677 と指標である 0.8 を上回っているため、寿命推定計算を進めることにする。

2-1-2 Step 5

[Table 2-1-1-2]の解析結果を用いて、Lifetime distribution の $\ln B_{50}$ 及び $\ln B_5$ を求め、結果を[Table 2-1-2-1]に示す。

[Table 2-1-2-1] $\ln B_{50}$, $\ln B_5$ の計算

$\ln B_{50}$		17.8873
B_{50} Life	Hours	58659119
B_{50} Life	Years	6692
$\ln B_5$		17.5393
B_5 Life	Hours	41420402
B_5 Life	Years	4725

B_5 Life の 95%信頼区間下限値($(B_5 \text{ Life})_L$)を求め、結果を[Table 2-1-2-2]に示す。

[Table 2-1-2-2] 95%lower confidence bound of B_5 Life

$(B_5 \text{ Life})_L$	Hours	24600642
	Years	2806

2-2 加速係数法による寿命推定

2-2-1 Step 4

重回帰分析を行い簡易アイリング式の各係数を求める。

[Table 2-2-1-1]に各加速条件での試験結果である対数平均値を示す。

[Table 2-2-1-1] 各加速試験条件での対数平均値

Group	Log-mean	Temp.	1/T(Kelvin)	Humidity
A	6.5190	80	0.002831658	80
B	7.5434	80	0.002831658	70
C	8.2114	65	0.002957267	80

D	8.4783	70	0.002914177	75

[Table 2-2-1-1]の結果を用いて簡易アイリング係数を計算する。求められた各係数を[Table 2-2-1-2]に示す。

[Table 2-2-1-2] 簡易アイリング式の係数

B	ΔH/k	ln(A)
-0.1153	14746.8749	-26.0425

Coefficient of determination は 0.97118 と高く寿命推定計算を進める。

2-2-2 Step 5

各加速試験条件の加速係数（acceleration factor）を求め、結果を[Table 2-2-2-1]にまとめる。

[Table 2-2-2-1] 各加速試験条件での加速係数

Stress condition		Calculated lifetime		Acceleration factors
℃	%RH	Ln(Lifetime)	Lifetime (hours)	
80	80	6.4916	660	70415
80	70	7.6446	2089	22229
65	80	8.3440	4205	11046
70	75	8.2850	3964	11716
25	50	17.6538	46444136	

2-2-3 Step 6

[Table 2-2-2-1]の加速係数より、25℃/50%RH での正規化された故障時間を求め[Table 2-2-3-1]に示す。

[Table 2-2-3-1] Composite data

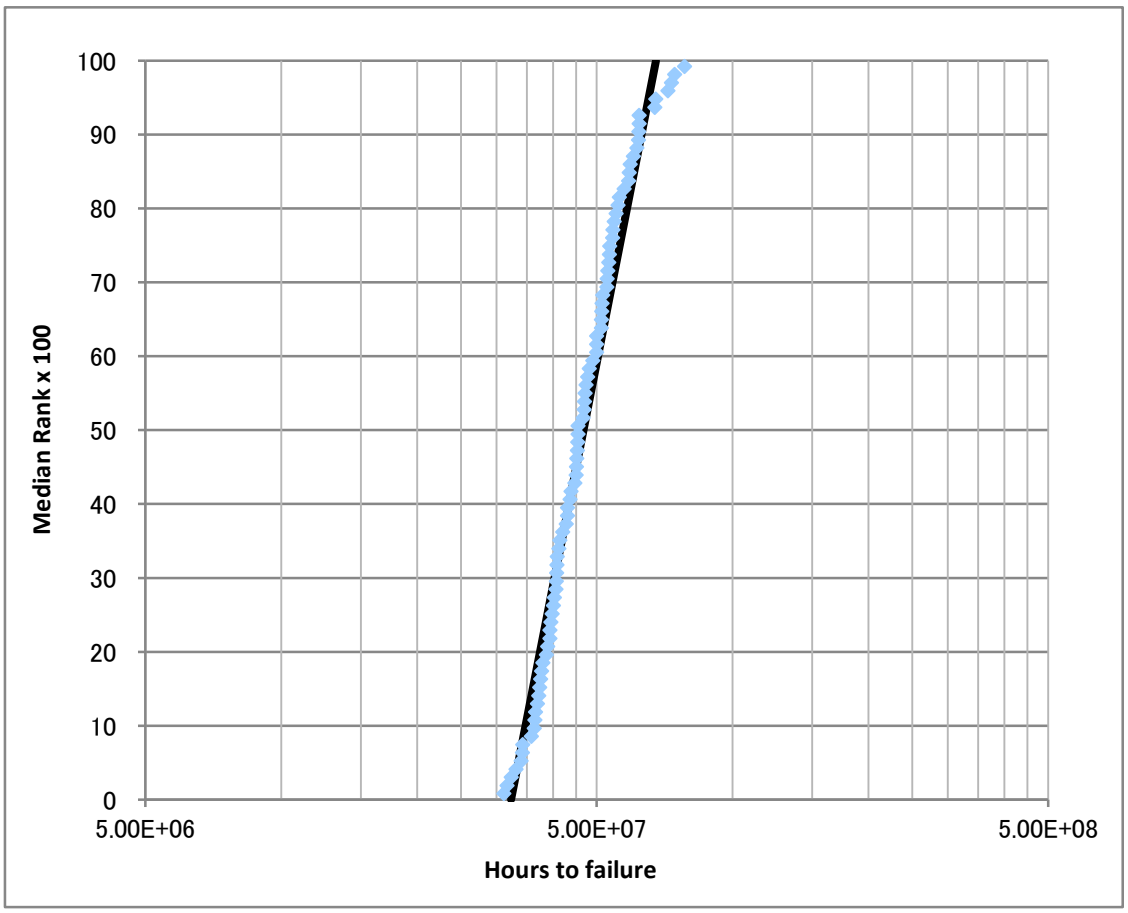
Time-to-failure	Group #	Normalized to 25℃50%RH	Ln	Group #	Normalized to 25℃50%RH	Order	Media rank
518	A	36474821	17.41	C	31149211	1	0.0077
531	A	37390212	17.44	C	31679410	2	0.0188
534	A	37601457	17.44	B	32343332	3	0.0299
536	A	37742286	17.45	C	33148504	4	0.0409
578	A	40699704	17.52	C	34010078	5	0.0520
579	A	40770119	17.52	C	34219949	6	0.0631
586	A	41263022	17.54	B	34321722	7	0.0741
620	A	43657122	17.59	C	35865776	8	0.0852
640	A	45065416	17.62	D	36356153	9	0.0962
670	A	47177857	17.67	A	36474821	10	0.1073
673	A	47389102	17.67	C	36605846	11	0.1184

696	A	49008640	17.71	C	36981404	12	0.1294
748	A	52670205	17.78	B	37233733	13	0.1405
752	A	52951864	17.78	A	37390212	14	0.1515
771	A	54289743	17.81	A	37601457	15	0.1626
772	A	54360158	17.81	A	37742286	16	0.1737
797	A	56120526	17.84	C	38019711	17	0.1847
817	A	57528820	17.87	C	38682460	18	0.1958
857	A	60365418	17.92	B	38967603	19	0.2069
883	A	62158554	17.95	B	39389955	20	0.2179
1455	B	32343332	17.29	B	39389955	21	0.2290
1544	B	34321722	17.35	B	39590017	22	0.2400
1675	B	37233733	17.43	C	39853317	23	0.2511
1753	B	38967603	17.48	B	40101286	24	0.2622
1772	B	39389955	17.49	B	40345806	25	0.2732
1772	B	39389955	17.49	B	40657014	26	0.2843
1781	B	39590017	17.49	A	40699704	27	0.2954
1804	B	40101286	17.51	A	40770119	28	0.3064
1815	B	40345806	17.51	B	40834846	29	0.3175
1829	B	40657014	17.52	B	40901534	30	0.3285
1837	B	40834846	17.53	A	41263022	31	0.3396
1840	B	40901534	17.53	B	41457261	32	0.3507
1865	B	41457261	17.54	B	42057447	33	0.3617
1892	B	42057447	17.55	C	42846734	34	0.3728
2045	B	45458498	17.63	D	43093113	35	0.3838
2047	B	45502956	17.63	C	43133925	36	0.3949
2099	B	46658869	17.66	A	43657122	37	0.4060
2166	B	48148219	17.69	C	43896086	38	0.4170
2313	B	51415895	17.76	D	44721700	39	0.4281
2459	B	54661343	17.82	A	45065416	40	0.4392
2820	C	31149211	17.25	D	45084910	41	0.4502
2868	C	31679410	17.27	C	45210539	42	0.4613
3001	C	33148504	17.32	D	45342672	43	0.4723
3079	C	34010078	17.34	D	45436404	44	0.4834
3098	C	34219949	17.35	B	45458498	45	0.4945
3247	C	35865776	17.40	B	45502956	46	0.5055
3314	C	36605846	17.42	B	46658869	47	0.5166
3348	C	36981404	17.43	C	46944733	48	0.5277
3442	C	38019711	17.45	C	47011008	49	0.5387
3502	C	38682460	17.47	A	47177857	50	0.5498

3608	C	39853317	17.50	A	47389102	51	0.5608
3879	C	42846734	17.57	D	47756262	52	0.5719
3905	C	43133925	17.58	B	48148219	53	0.5830
3974	C	43896086	17.60	A	49008640	54	0.5940
4093	C	45210539	17.63	D	49970671	55	0.6051
4250	C	46944733	17.66	C	50004425	56	0.6162
4256	C	47011008	17.67	D	50005821	57	0.6272
4527	C	50004425	17.73	D	51247765	58	0.6383
4668	C	51561885	17.76	D	51247765	59	0.6493
4777	C	52765880	17.78	D	51353213	60	0.6604
3103	D	36356153	17.41	B	51415895	61	0.6715
3678	D	43093113	17.58	C	51561885	62	0.6825
3817	D	44721700	17.62	A	52670205	63	0.6936
3848	D	45084910	17.62	C	52765880	64	0.7046
3870	D	45342672	17.63	A	52951864	65	0.7157
3878	D	45436404	17.63	D	53204412	66	0.7268
4076	D	47756262	17.68	D	53345010	67	0.7378
4265	D	49970671	17.73	D	53438741	68	0.7489
4268	D	50005821	17.73	A	54289743	69	0.7600
4374	D	51247765	17.75	A	54360158	70	0.7710
4374	D	51247765	17.75	B	54661343	71	0.7821
4383	D	51353213	17.75	D	55207926	72	0.7931
4541	D	53204412	17.79	D	55782032	73	0.8042
4553	D	53345010	17.79	A	56120526	74	0.8153
4561	D	53438741	17.79	A	57528820	75	0.8263
4712	D	55207926	17.83	D	58863459	76	0.8374
4761	D	55782032	17.84	D	59074355	77	0.8485
5024	D	58863459	17.89	D	59378983	78	0.8595
5042	D	59074355	17.89	A	60365418	79	0.8706
5068	D	59378983	17.90	D	61441079	80	0.8816
5244	D	61441079	17.93	D	61921453	81	0.8927
5285	D	61921453	17.94	D	62050334	82	0.9038
5296	D	62050334	17.94	D	62073767	83	0.9148
5298	D	62073767	17.94	A	62158554	84	0.9259
5744	D	67299305	18.02	D	67299305	85	0.9369
5769	D	67592216	18.03	D	67592216	86	0.9480
6145	D	71997603	18.09	D	71997603	87	0.9591
6256	D	73298129	18.11	D	73298129	88	0.9701
6355	D	74458058	18.13	D	74458058	89	0.9812

6686	D	78336204	18.18	D	78336204	90	0.9923
		Mean	17.66		Total	90	
		Deviation	0.20923				

Composite data をプロットし[Figure 2-2-3-1]に示す。



[Figure 2-2-3-1] 25℃/50%RH での正規化データ

2-2-4 Step 7

Controlled storage condition での B_{50} Life、B_5 Life 及び B_{5V} Life を求め、[Table 2-2-4-1]に示す。

[Table 2-2-4-1]

B_{50} Life	Hours	46703456
	Years	5328
B_5 Life	Hours	33137793
	Years	3780
B_{5V} Life	Hours	23512464
	Years	2682

[3] 寿命推定計算結果

最小二乗法を用いた最尤法(MLE with LSM)及び加速係数法(AFM)により求めた、寿命推定値をまとめて[Table 3-1]に示す。

[Table 3-1] まとめ

MLE with LSM	AFM
2806 years	2682 years

[4] Result of estimated disk life

1) Number of title of this standard.
   ISO/IEC 16963:2014(E)
   “Information technology – Digitally recorded media for information interchange and storage – Test method for the estimation of lifetime of optical disks for long-term data storage”

2) Ambient storage condition for the lifetime estimation:
   Controlled storage condition: 25℃/50%RH

3) Stress and testing condition:
   Alternative Basic stress-conditions for use with Eyring method.

4) The recording speed used for testing shall be reported.
   調査して報告。

5) Time-to-failure data
   Data with the substitutes of missing times-to-failure.

6) Sample information

Test cell number	Stress condition		Number of specimens
	Temp. (℃)	%RH	-
A	80	80	20
B	80	70	20
C	65	80	20
D	70	75	30

7) Estimation method and the estimated data
   Maximum-likelihood method with least squares method (MLE with LSM) and acceleration-factor method (AFM).

	Log standard deviation
MLE with LSM	0.21218
AFM	0.20923

8) B_{50} Life, B_5 Life and 95% lower confidence bound of B_5 Life (= $(B_5\ \text{Life})_L$) for the maximum-likelihood method with least squares method.

B_{50} Life	Hours	58659119
	Years	6692

B_5 Life	Hours	41420402
	Years	4725
$(B_5 \text{ Life})_L$	Hours	24600642
	Years	2806

B_{50} Life, B_5 Life and the point estimates of the 5% with variation (= B_{5V} Life) for the acceleration-factor method.

B_{50} Life	Hours	46703456
	Years	5328
B_5 Life	Hours	33137793
	Years	3780
B_{5V} Life	Hours	23512464
	Years	2682

[5] 結論

[Table 3-1]より本ディスクは Archival grade disc として認めることができる。

参考規格

ISO/IEC 16963:2011, Information technology – Digitally recorded media for information interchange and storage – Test method for the estimation of lifetime of optical media for long-term data storage

ISO/IEC 30190:2013, Information technology – Digitally recorded media for information interchange and storage – 120mm Single Layer (25.0 Gbytes per disk) and Dual Layer (50.0 Gbytes per disk) BD Recordable disk

ISO/IEC 30191:2013, Information technology – Digitally recorded media for information interchange and storage – 120mm Triple Layer (100.0 Gbytes per disk) and Quadruple Layer (50.0 Gbytes per disk) BD Recordable disk