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　二層ディスク

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 二層ディスク」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 二層ディスク」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

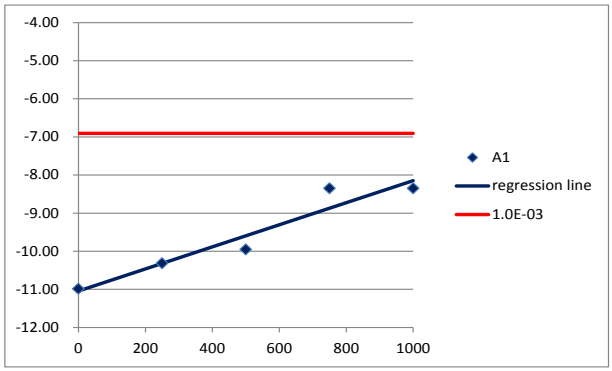
“A.2.1 Judgment of effectiveness of test data and time-to-failure determination”にある、Step 1、Step 2 に従い、測定データの有効性について判定を行う。

1-1-1 Step 1

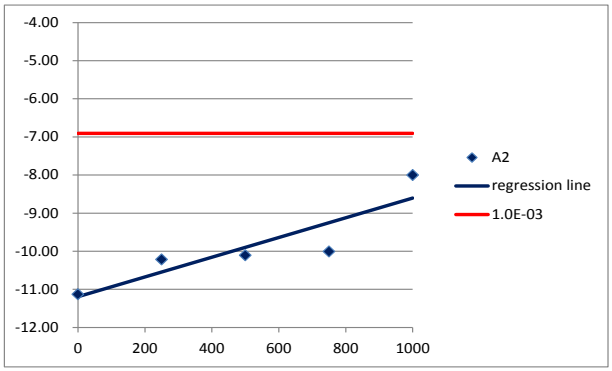
Linear regression か polynomial regression を計算することになるが、前回のデータとの整合性を考慮し、linear regression を計算し各試料のグラフを作成する

1-1-1-1 80℃/80%RH

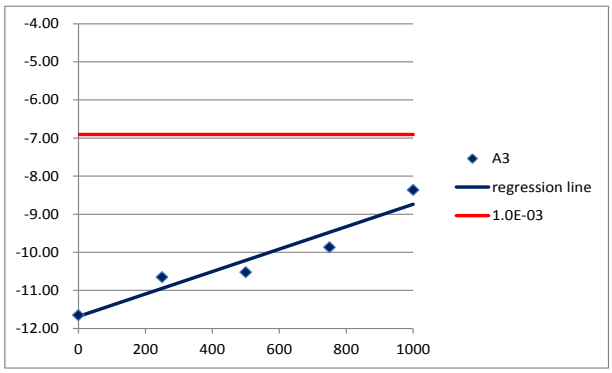
[Figure 1-1-1-1-1]から[Figure 1-1-1-1-20]に各試料のグラフを示す。



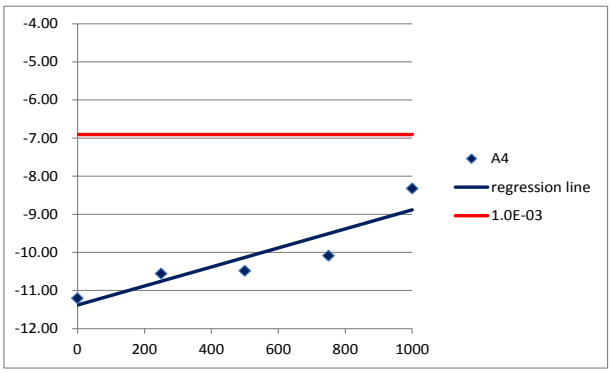
[Figure 1-1-1-1-1] 試料 A1



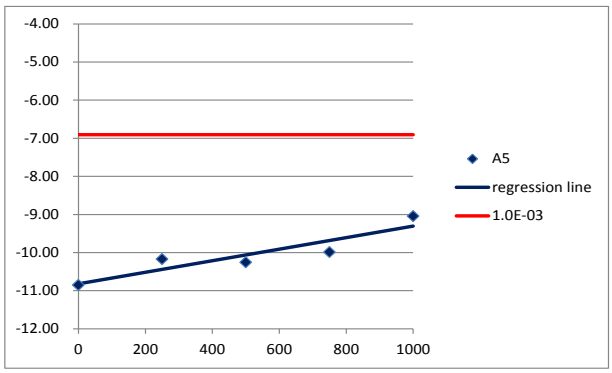
[Figure 1-1-1-1-2] 試料 A2

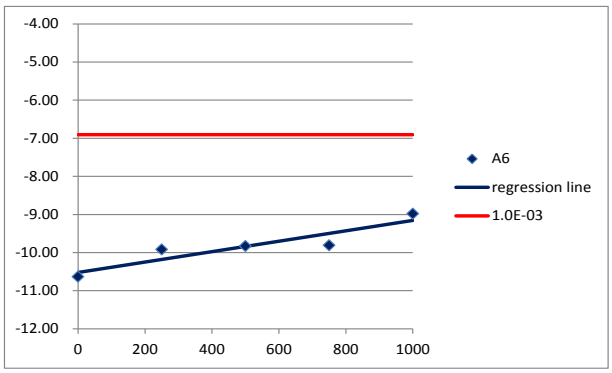


[Figure 1-1-1-1-3] 試料 A3

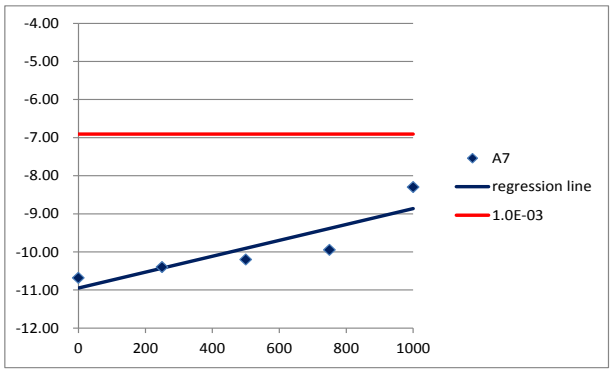


[Figure 1-1-1-1-4] 試料 A4

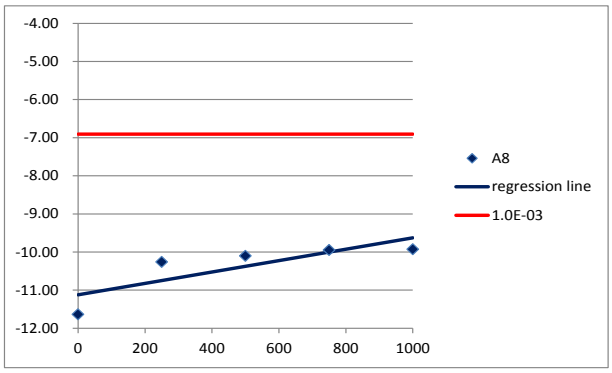




[Figure 1-1-1-1-5] 試料 A5



[Figure 1-1-1-1-6] 試料 A6



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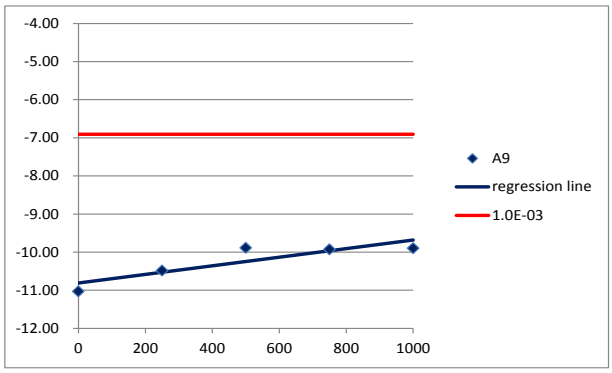
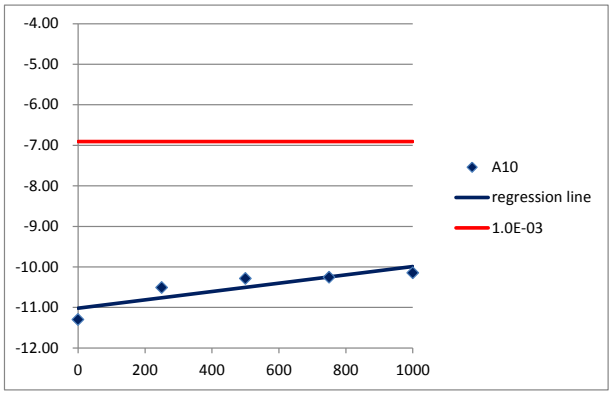
[Figure 1-1-1-1-8] 試料 A8



[Figure 1-1-1-1-9] 試料 A9



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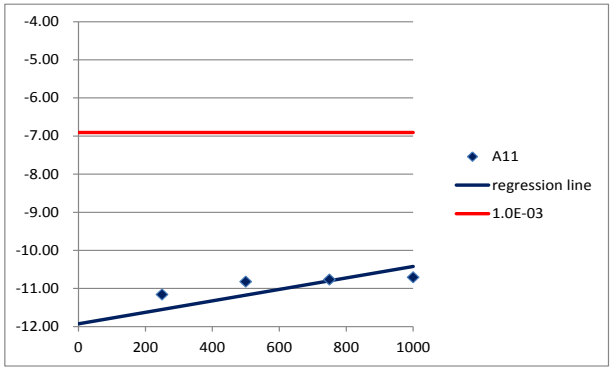

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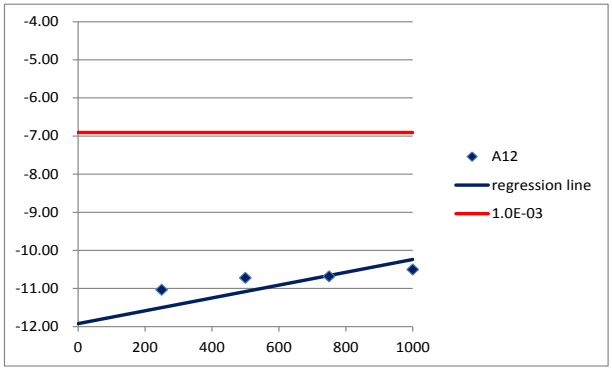
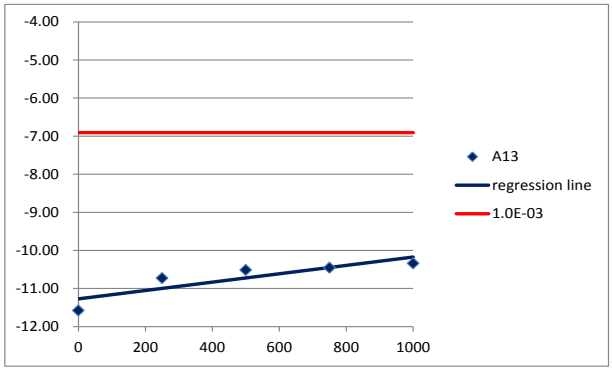


[Figure 1-1-1-1-12] 試料 A12



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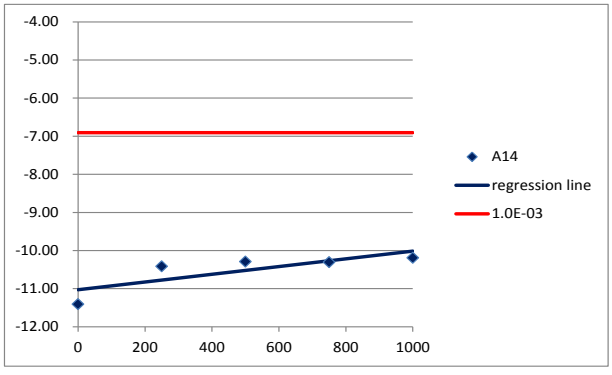

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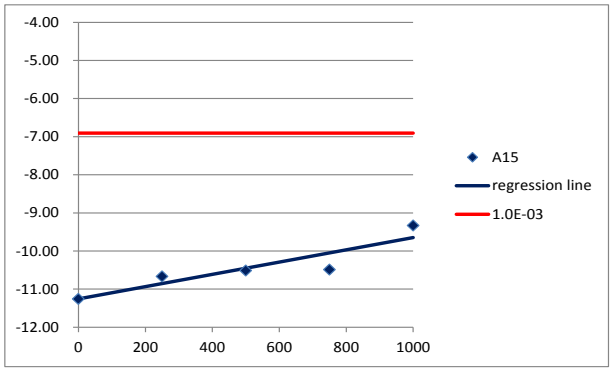

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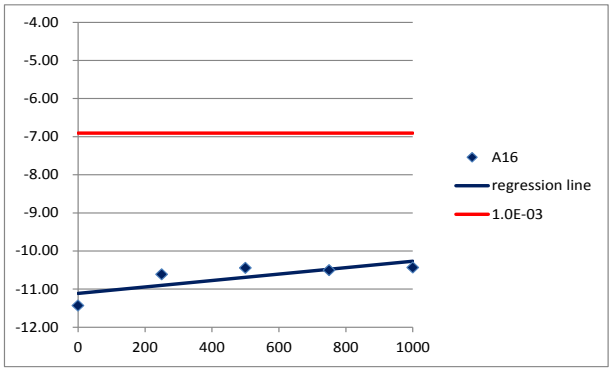

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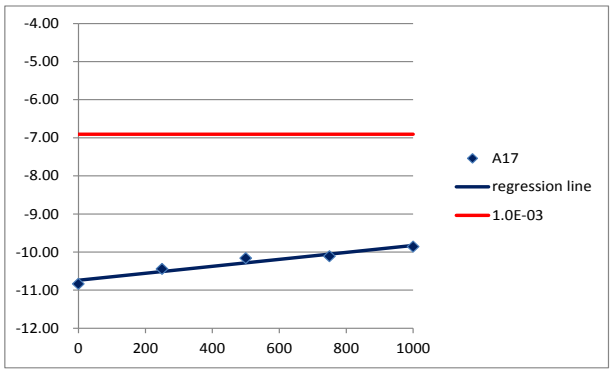

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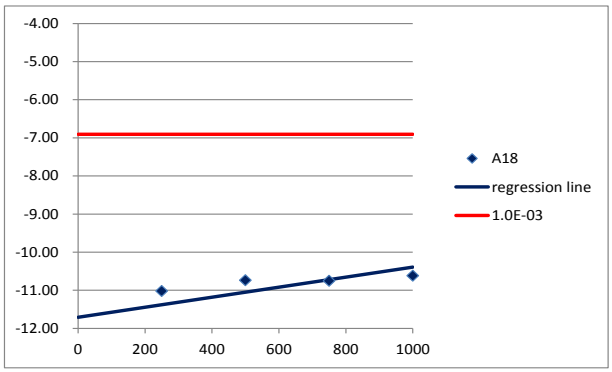

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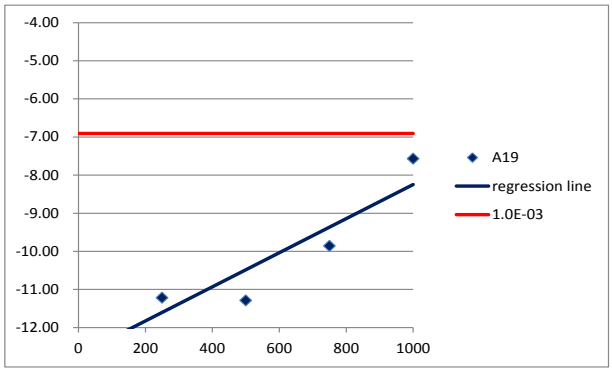

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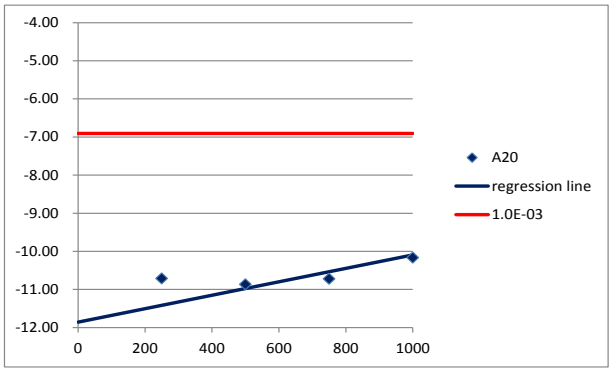
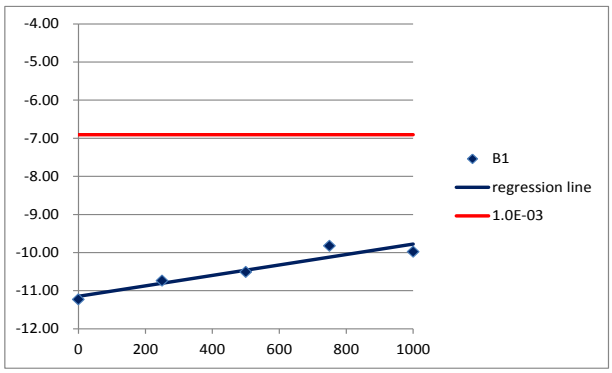
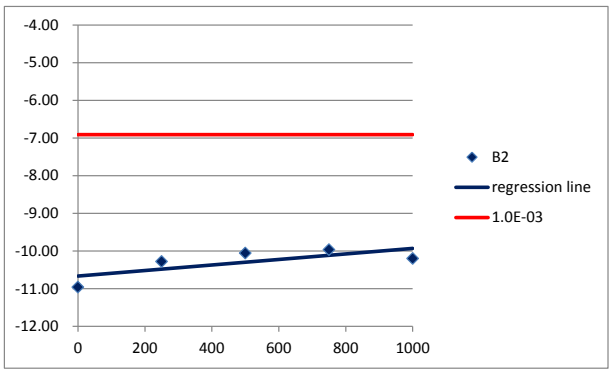


[Figure 1-1-1-1-20] 試料 A20

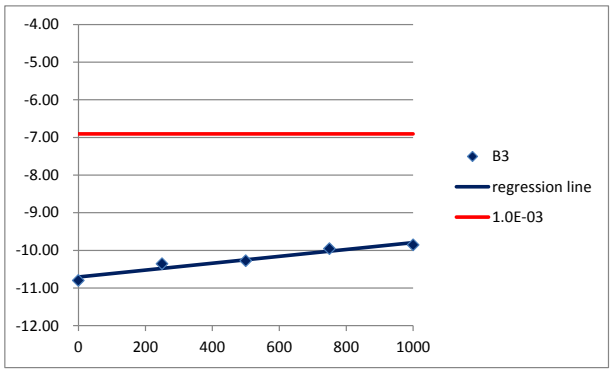
1-1-1-2 80℃/70%RH

[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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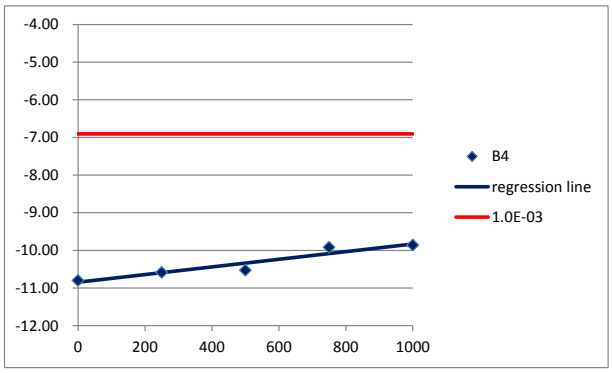

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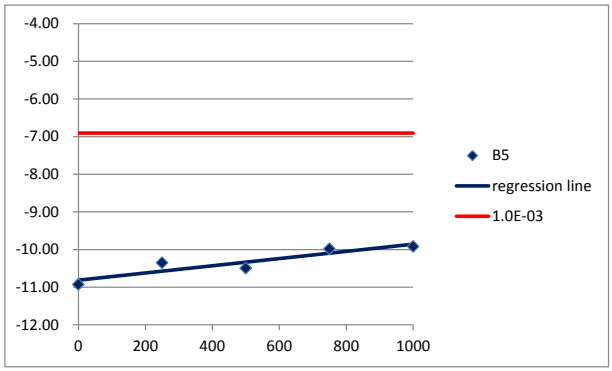

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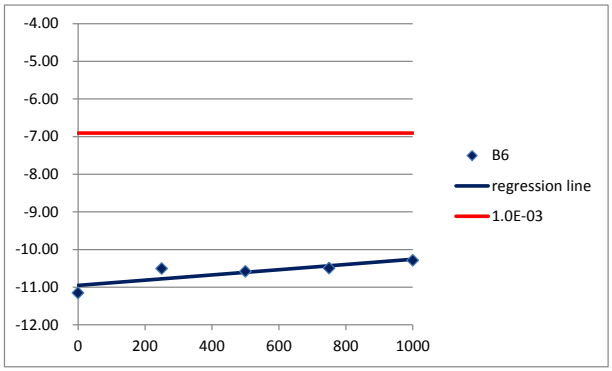
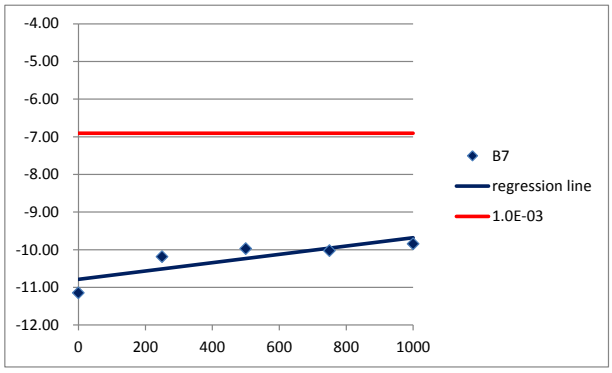
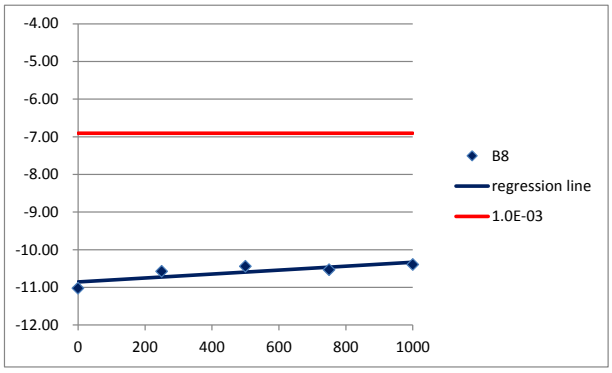


[Figure 1-1-1-2-5] 試料 B5



[Figure 1-1-1-2-6] 試料 B6



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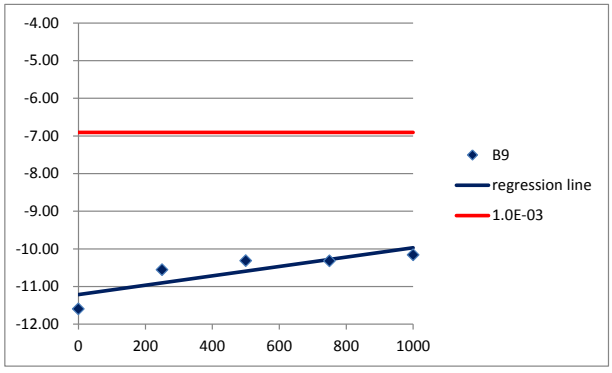

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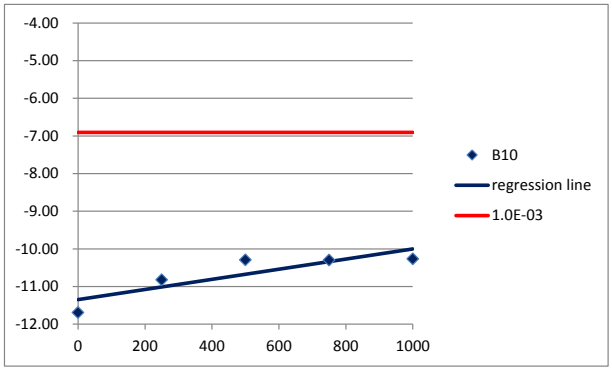
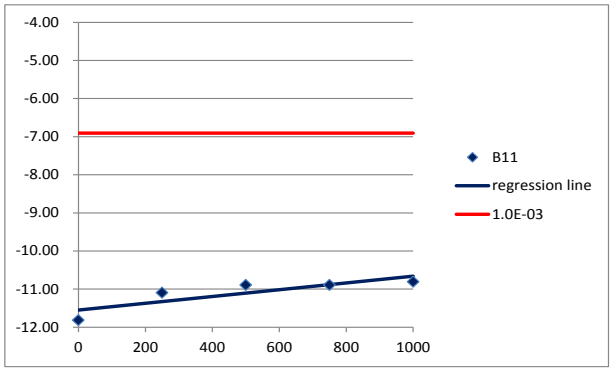
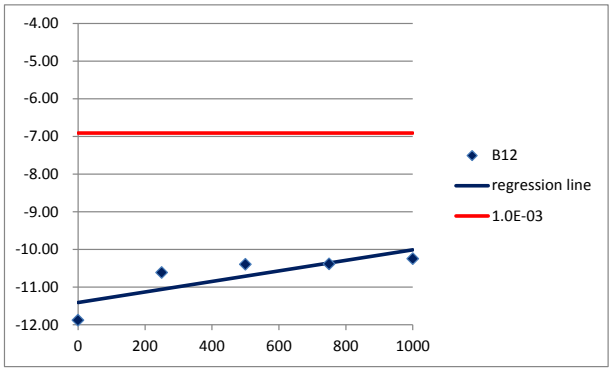


[Figure 1-1-1-2-9] 試料 B9

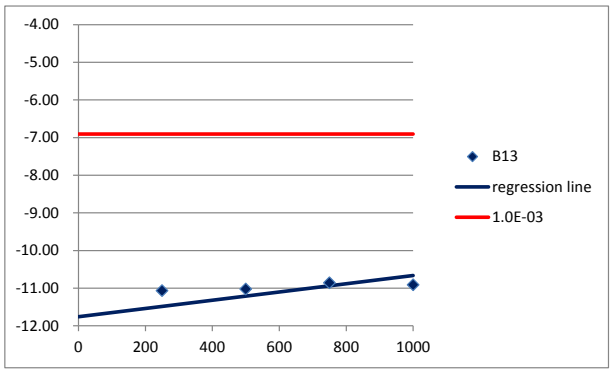
[Figure 1-1-1-2-10] 試料 B10



[Figure 1-1-1-2-11] 試料 B11



[Figure 1-1-1-2-12] 試料 B12



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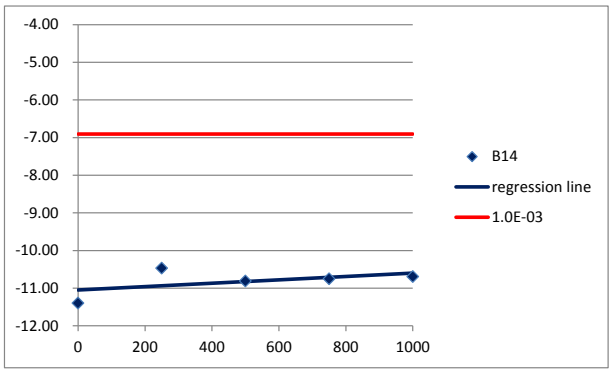
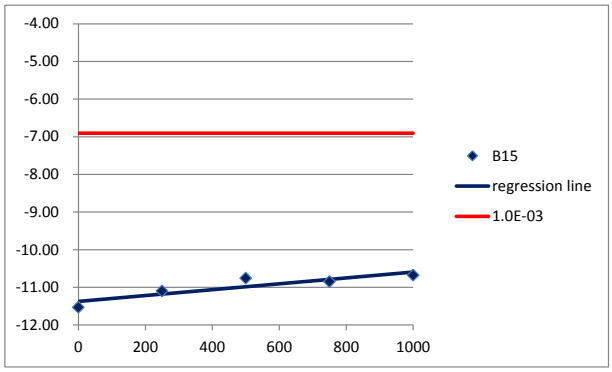


[Figure 1-1-1-2-14] 試料 B14



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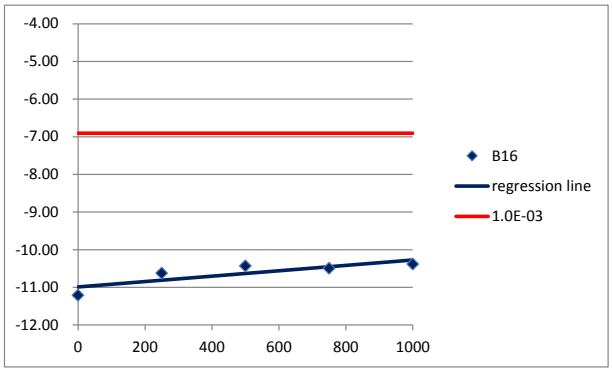

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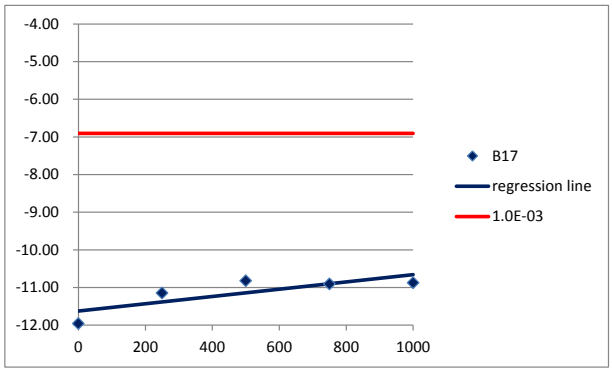

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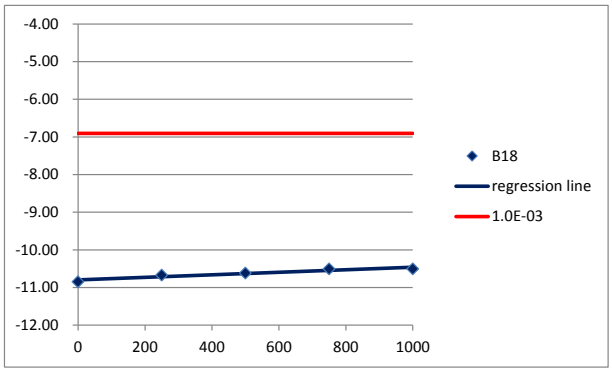

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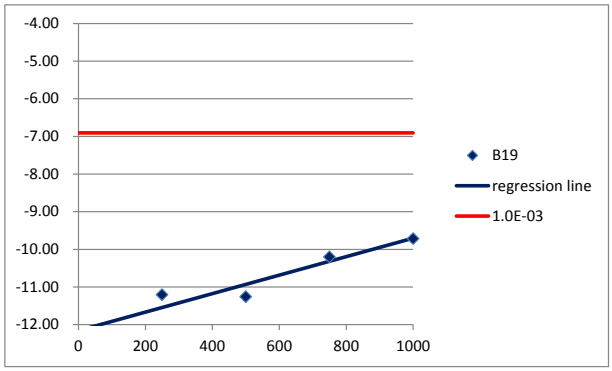
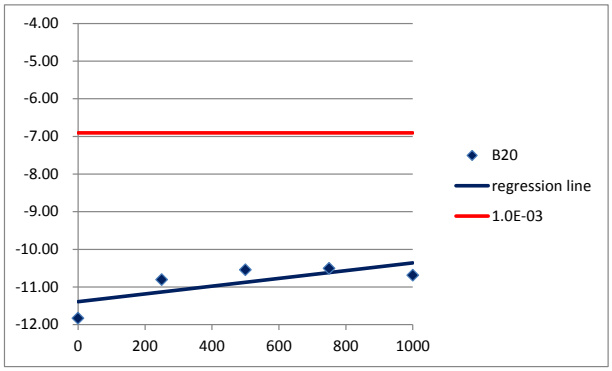


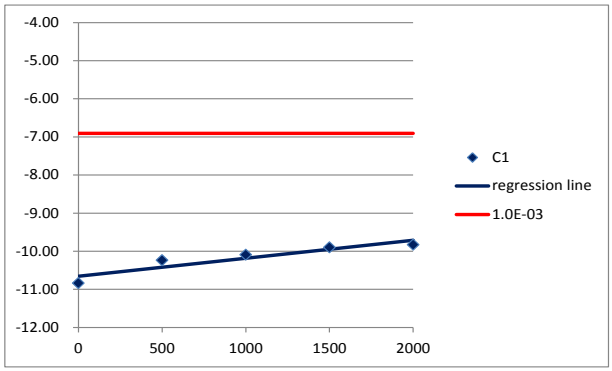
[Figure 1-1-1-2-19] 試料 B19



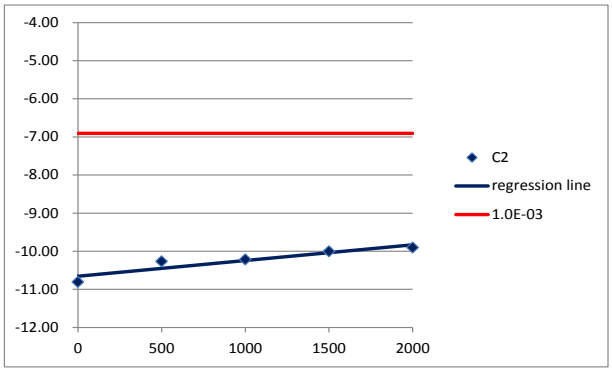
[Figure 1-1-1-2-20] 試料 B20

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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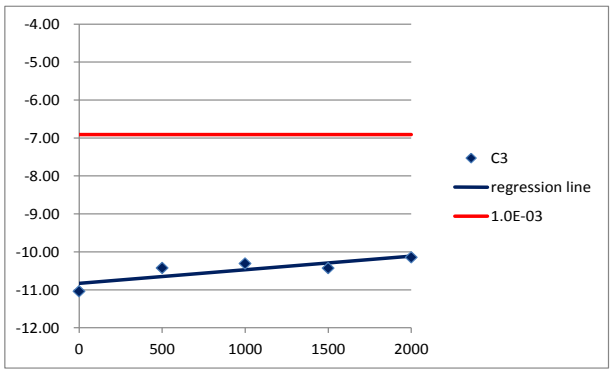

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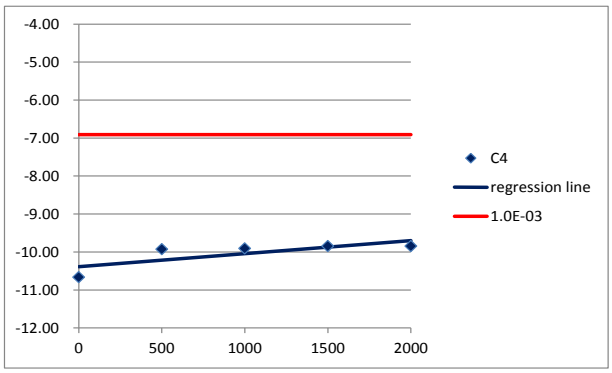

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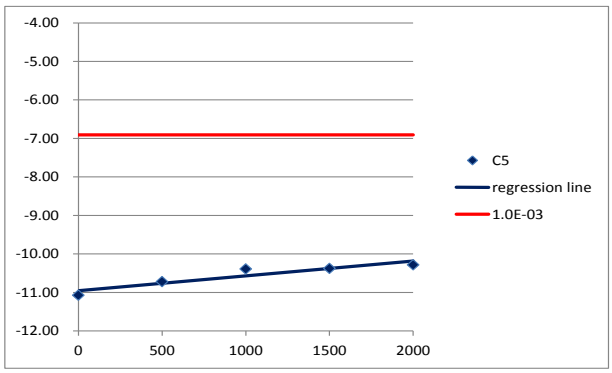
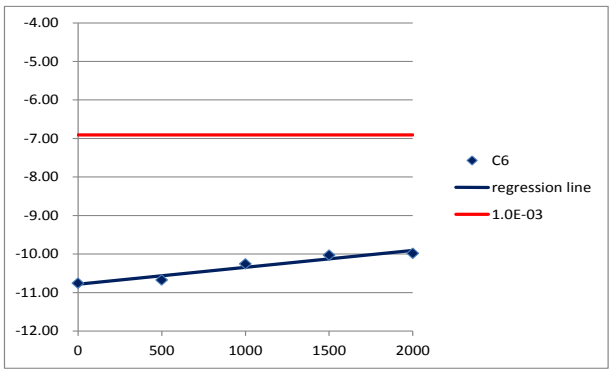
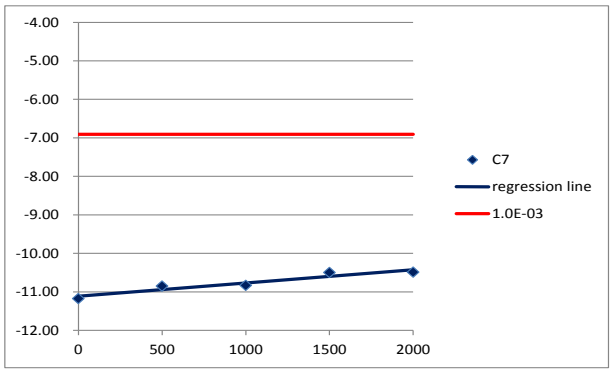
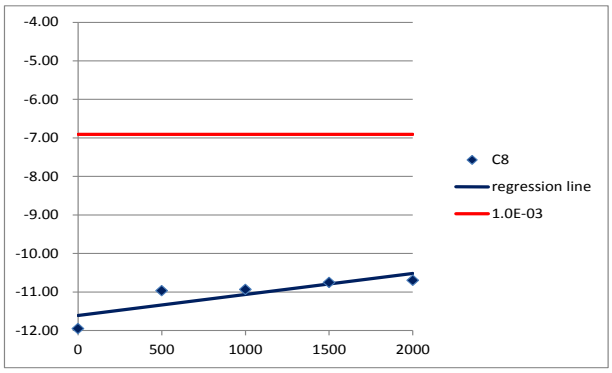




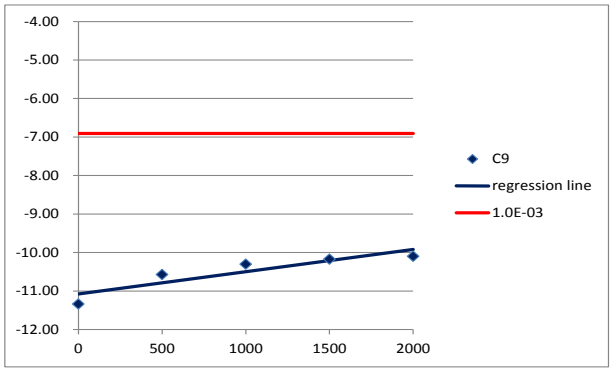
[Figure 1-1-1-3-5] 試料 C5



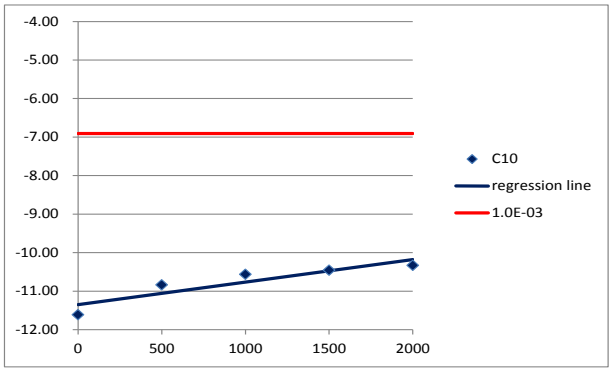
[Figure 1-1-1-3-6] 試料 C6



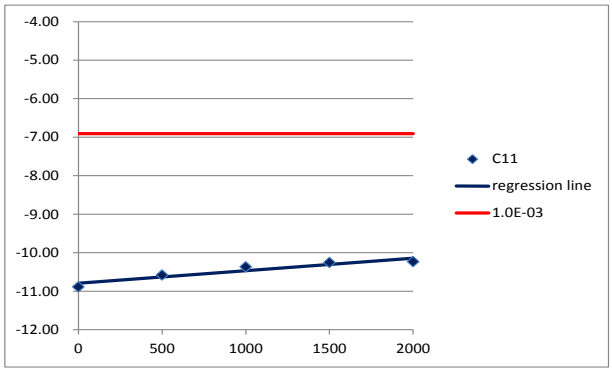
[Figure 1-1-1-3-7] 試料 C7



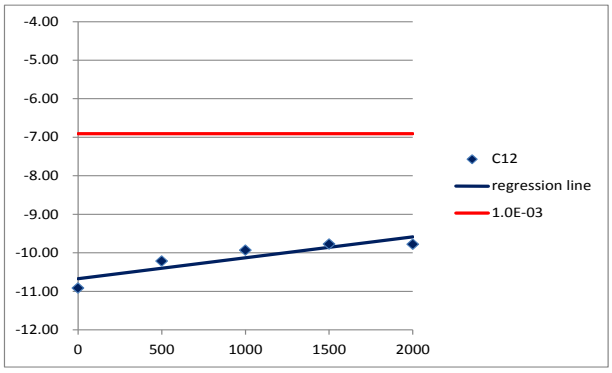
[Figure 1-1-1-3-8] 試料 C8



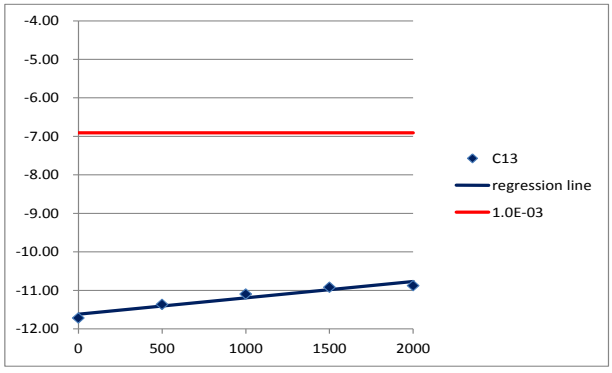
[Figure 1-1-1-3-9] 試料 C9



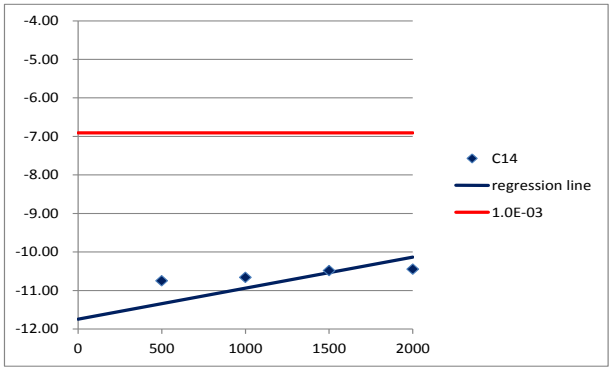
[Figure 1-1-1-3-10] 試料 C10



[Figure 1-1-1-3-11] 試料 C11

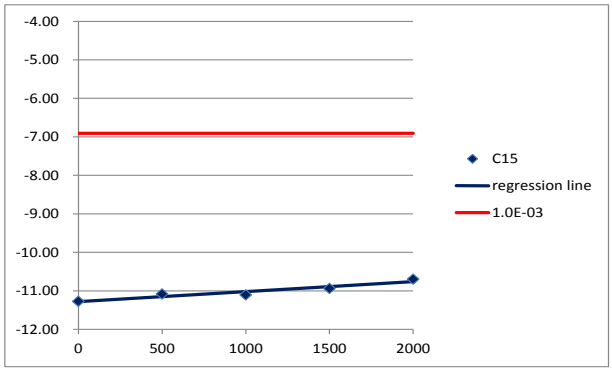


[Figure 1-1-1-3-12] 試料 C12

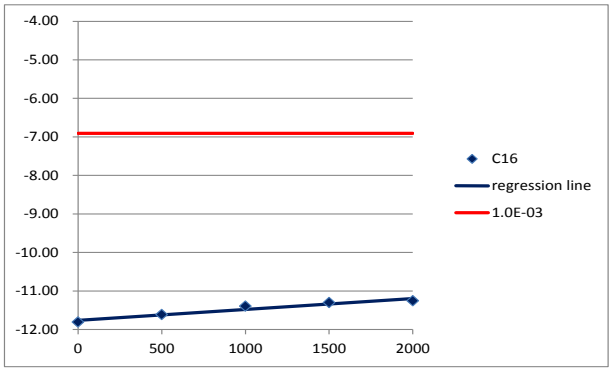


[Figure 1-1-1-3-13] 試料 C13

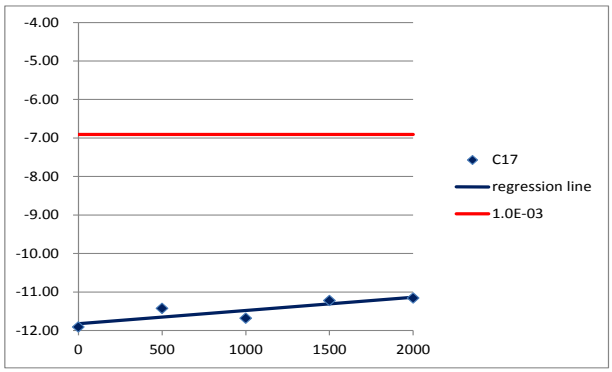
[Figure 1-1-1-3-14] 試料 C14



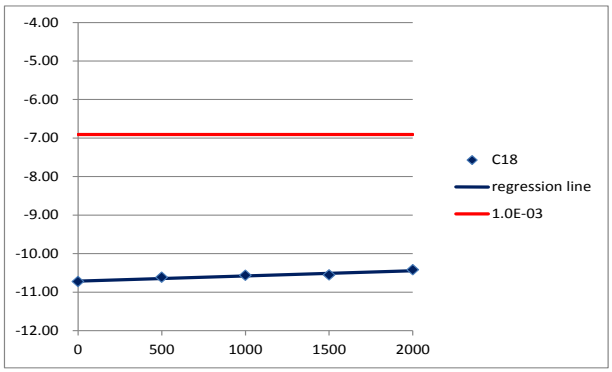
[Figure 1-1-1-3-15] 試料 C15



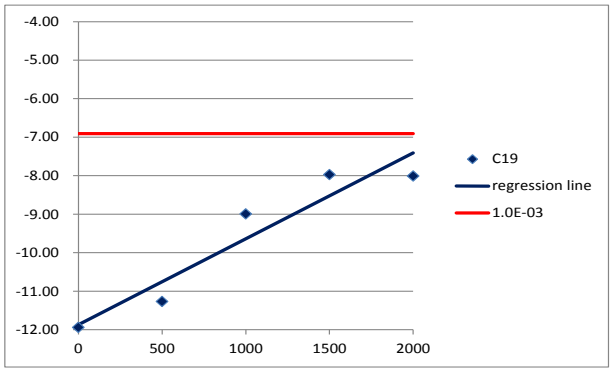
[Figure 1-1-1-3-16] 試料 C16



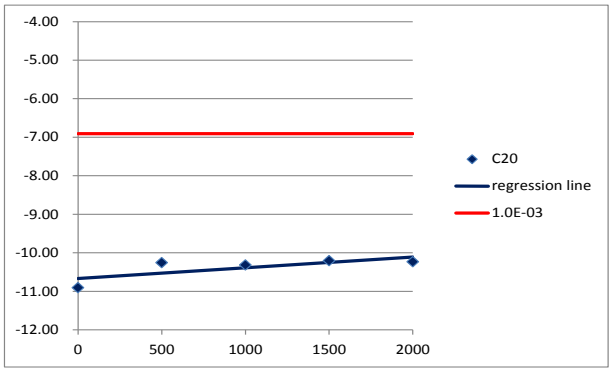
[Figure 1-1-1-3-17] 試料 C17



[Figure 1-1-1-3-18] 試料 C18



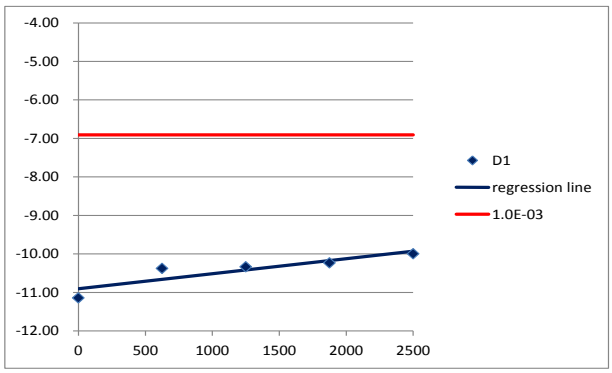
[Figure 1-1-1-3-19] 試料 C19

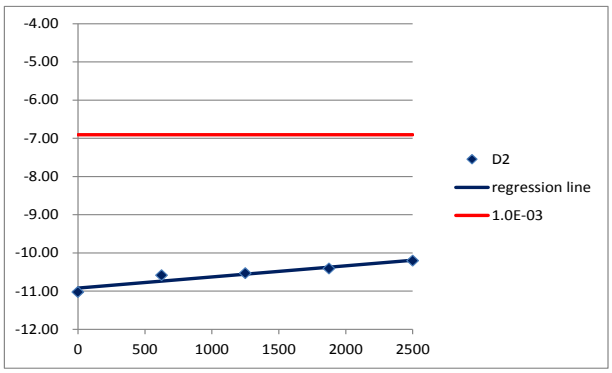


[Figure 1-1-1-3-20] 試料 C20

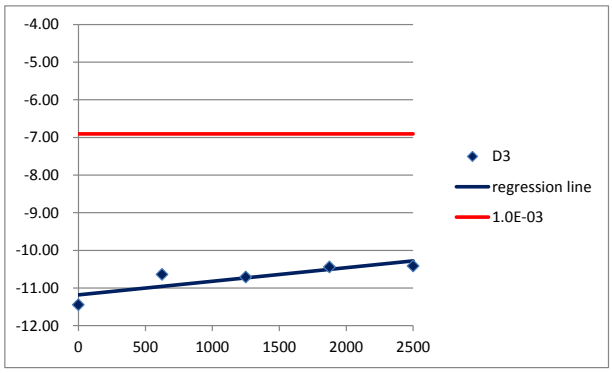
5-1-1-4 70℃/75%RH

[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。

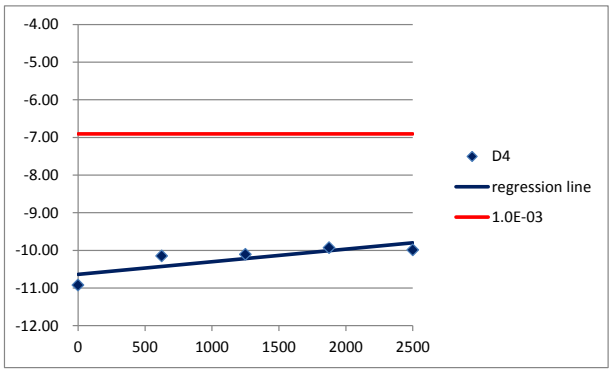




[Figure 1-1-1-4-1] 試料 D1

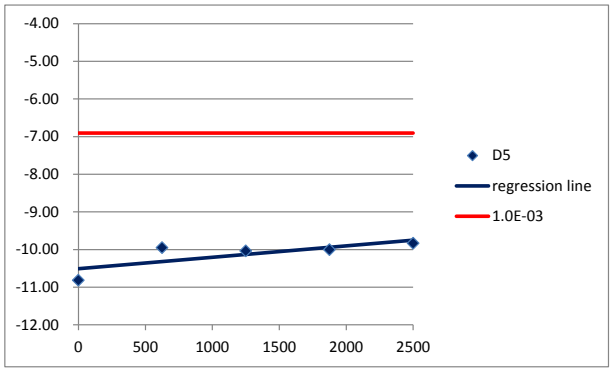


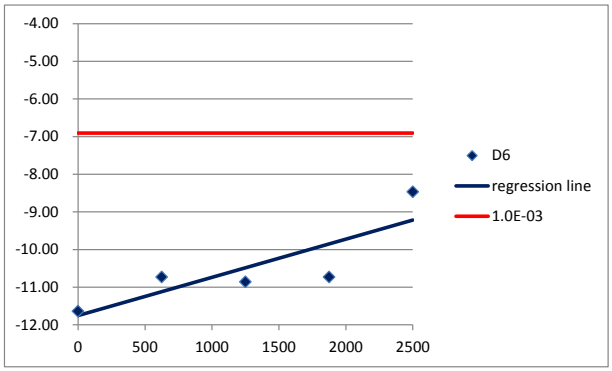
[Figure 1-1-1-4-2] 試料 D2



[Figure 1-1-1-4-3] 試料 D3

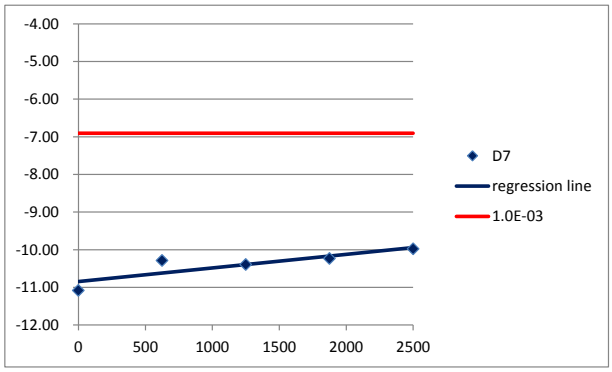
[Figure 1-1-1-4-4] 試料 D4

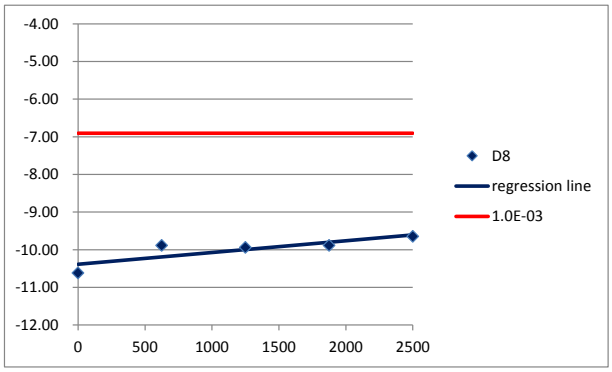




[Figure 1-1-1-4-5] 試料 D5

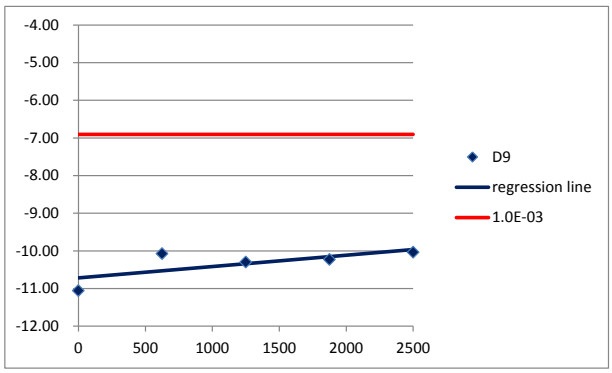
[Figure 1-1-1-4-6] 試料 D6

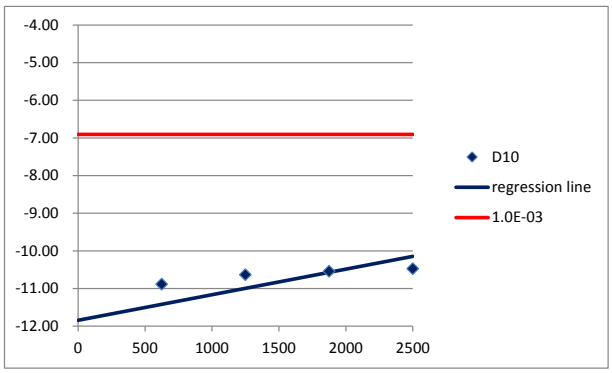




[Figure 1-1-1-4-7] 試料 D7

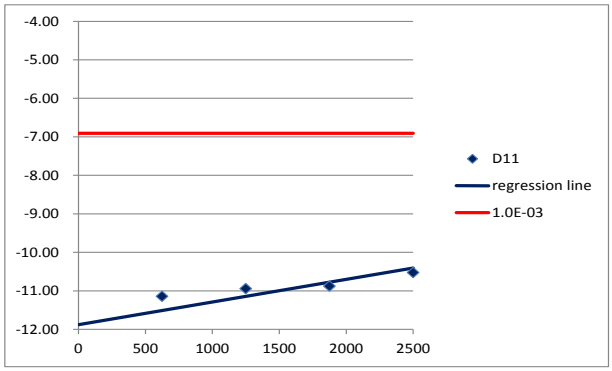
[Figure 1-1-1-4-8] 試料 D8



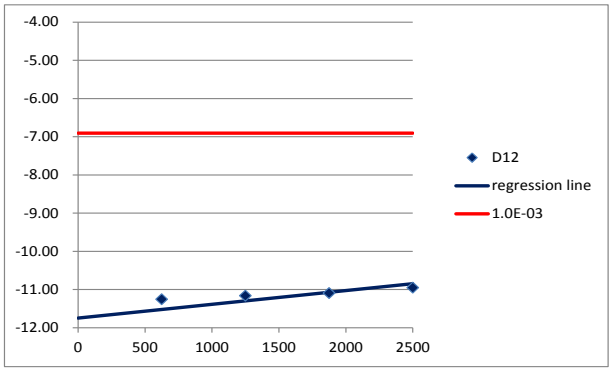


[Figure 1-1-1-4-9] 試料 D9

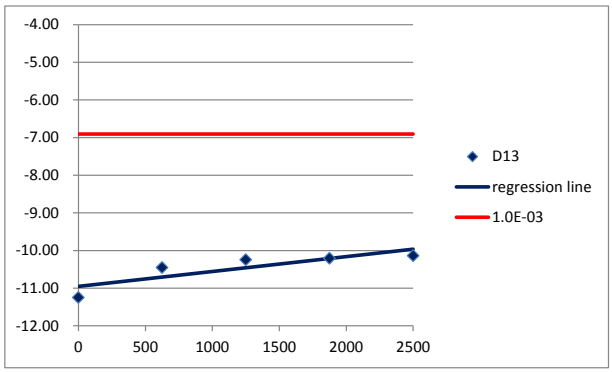
[Figure 1-1-1-4-10] 試料 D10



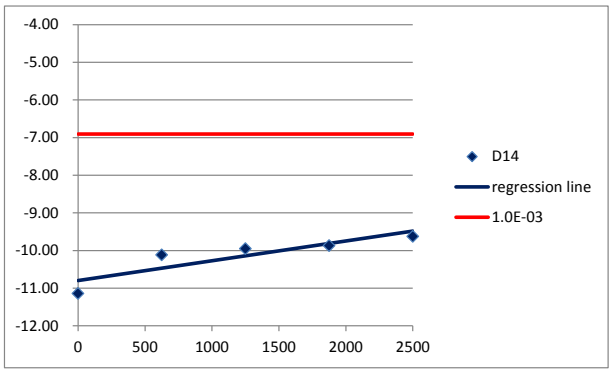
[Figure 1-1-1-4-11] 試料 D11



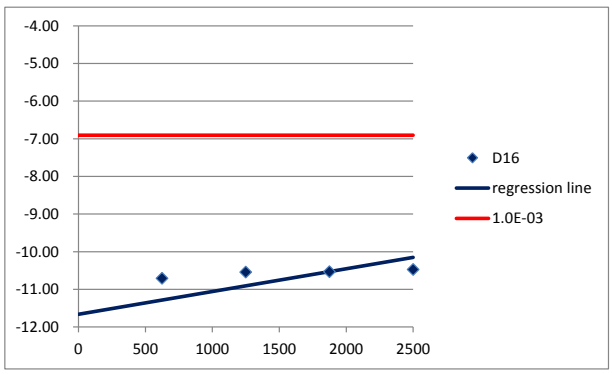
[Figure 1-1-1-4-12] 試料 D12



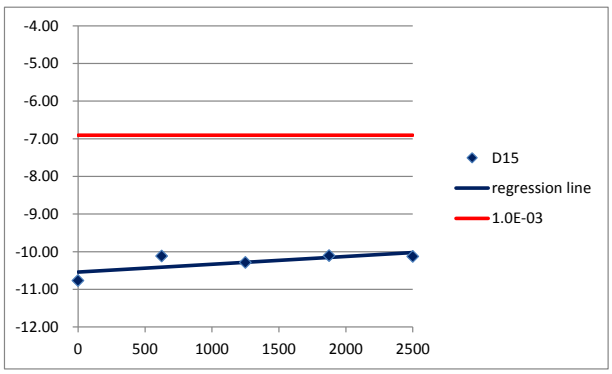
[Figure 1-1-1-4-13] 試料 D13



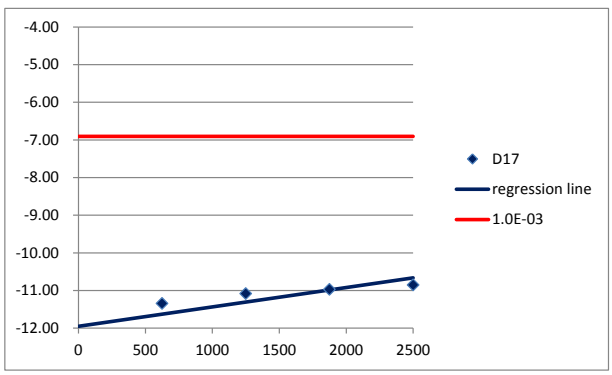
[Figure 1-1-1-4-14] 試料 D14



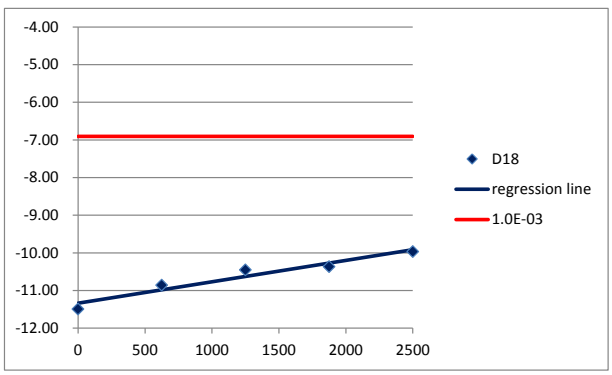
[Figure 1-1-1-4-15] 試料 D15



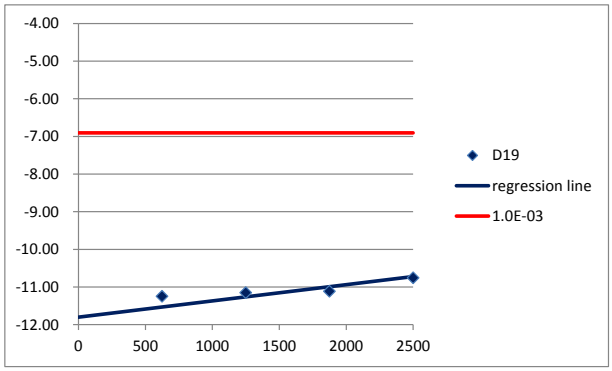
[Figure 1-1-1-4-16] 試料 D16



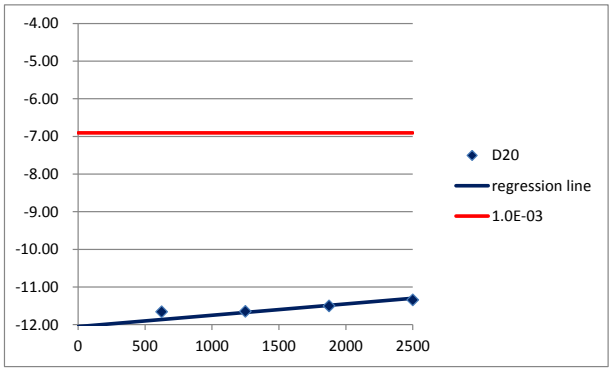
[Figure 1-1-1-4-17] 試料 D17



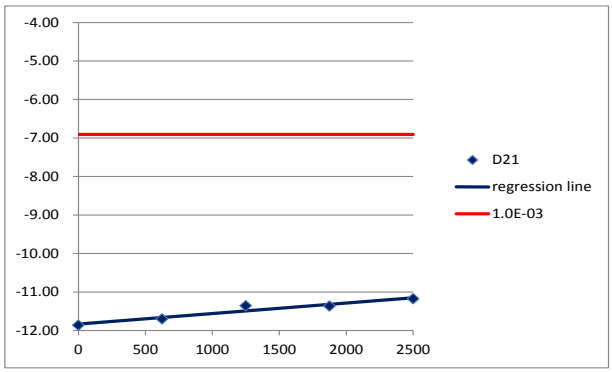
[Figure 1-1-1-4-18] 試料 D18



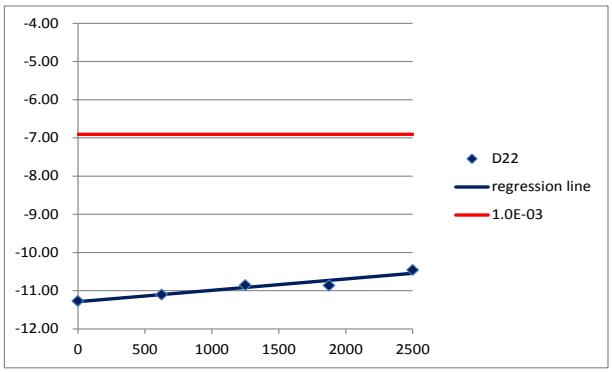
[Figure 1-1-1-4-19] 試料 D19



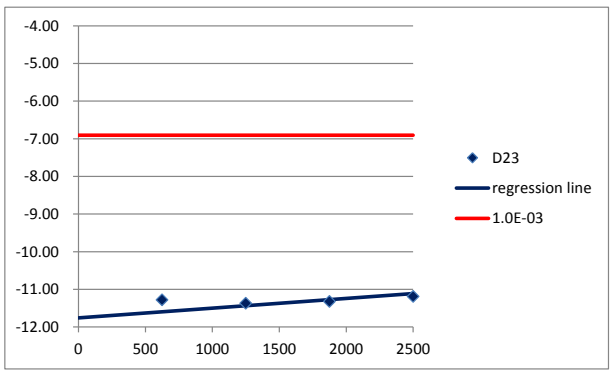
[Figure 1-1-1-4-20] 試料 D20



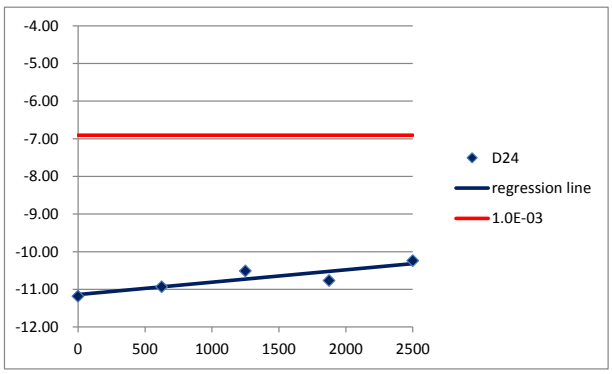
[Figure 1-1-1-4-21] 試料 D21



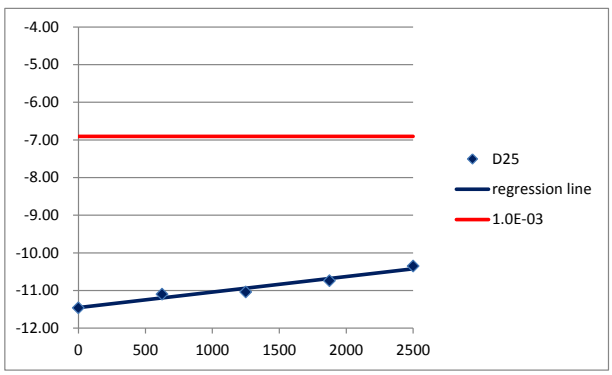
[Figure 1-1-1-4-22] 試料 D22



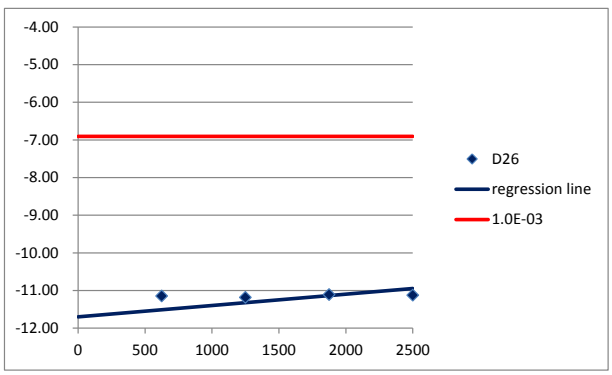
[Figure 1-1-1-4-23] 試料 D23



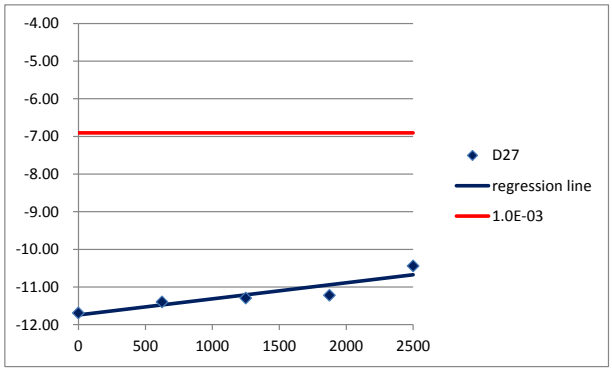
[Figure 1-1-1-4-24] 試料 D24



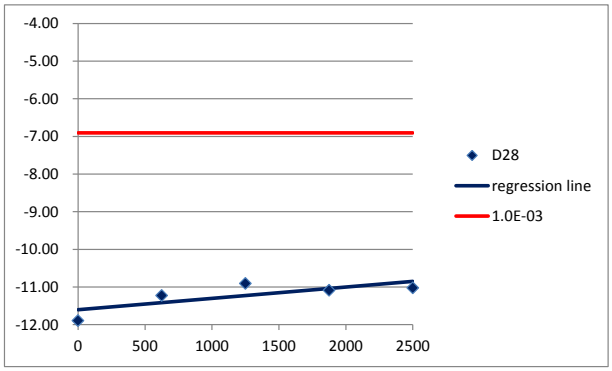
[Figure 1-1-1-4-25] 試料 D25



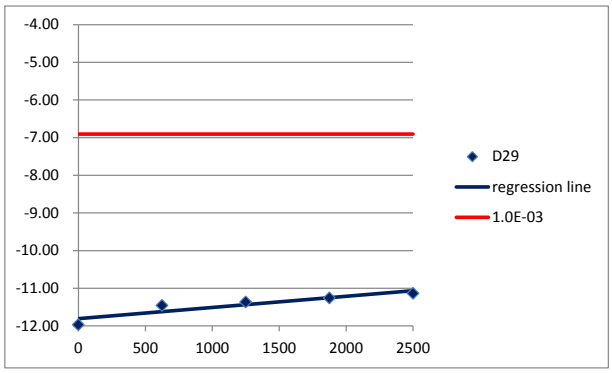
[Figure 1-1-1-4-26] 試料 D26



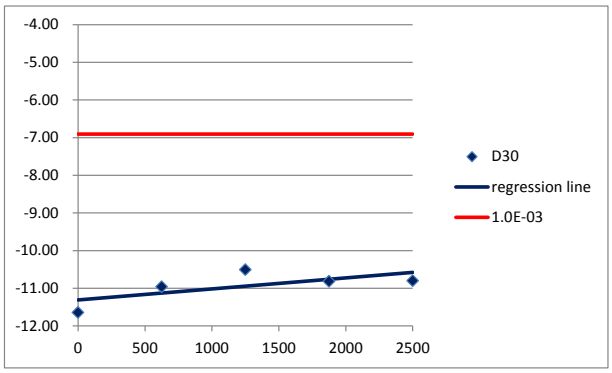
[Figure 1-1-1-4-27] 試料 D27



[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	NG	violation b)
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	NG	violation b)
C15	OK	
C16	OK	
C17	OK	
C18	OK	
C19	NG	violation b)
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	NG	violation b)
D7	OK	
D8	OK	
D9	OK	
D10	NG	violation b)
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	1429	B1	3097	C1	7970	D1	10258
A2	1657	B2	5105	C2	9086	D2	13770
A3	1623	B3	4158	C3	10949	D3	11812
A4	1792	B4	3876	C4	10149	D4	11145
A5	2577	B5	4080	C5	10527	D5	11826
A6	2649	B6	5792	C6	8844	D6	
A7	1935	B7	3506	C7	12195	D7	10886
A8	2826	B8	7559	C8	8652	D8	11191
A9	3457	B9	3465	C9	7222	D9	12667
A10	4004	B10	3294	C10	7578	D10	
A11	3330	B11	5227	C11	11928	D11	8460
A12	2983	B12	3220	C12	6927	D12	13478
A13	3975	B13	4430	C13	11076	D13	10236
A14	4058	B14	9167	C14		D14	7414
A15	2703	B15	5724	C15	16844	D15	17553
A16	4986	B16	5707	C16	17130	D16	7884
A17	4195	B17	4896	C17	14333	D17	9801
A18	3654	B18	11454	C18	28173	D18	7799
A19		B19	2141	C19		D19	11330
A20	2807	B20	4341	C20	13495	D20	17072
						D21	18073
						D22	14715
						D23	18810
						D24	12889
						D25	11018
						D26	15850
						D27	11317
						D28	15637
						D29	16453
						D30	15033

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。

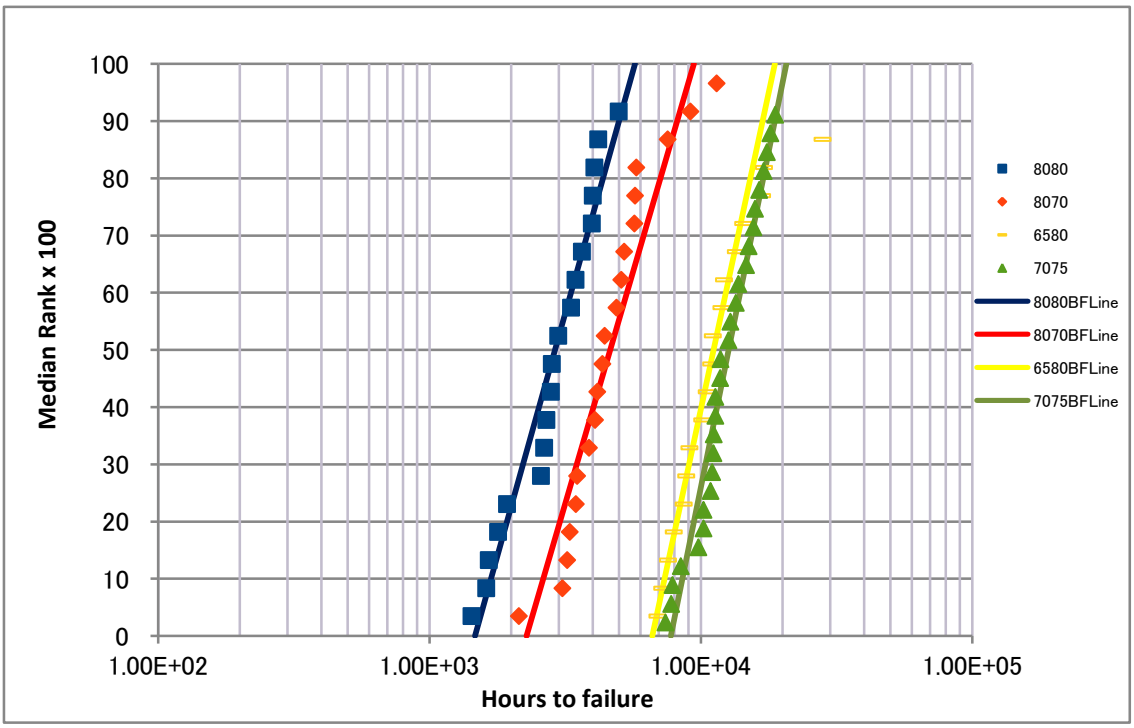
また median rank 対故障時間の対数グラフを、[Figure 1-3-1-1]に示す。

[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	1429	2141	6927	7414
2	1623	3097	7222	7799
3	1657	3220	7578	7884
4	1792	3294	7970	8460
5	1935	3465	8652	9801
6	2577	3506	8844	10236
7	2649	3876	9086	10258
8	2703	4080	10149	10886
9	2807	4158	10527	11018
10	2826	4341	10949	11145
11	2983	4430	11076	11191
12	3330	4896	11928	11317
13	3457	5105	12195	11330
14	3654	5227	13495	11812
15	3975	5707	14333	11826
16	4004	5724	16844	12667
17	4058	5792	17130	12889
18	4195	7559	28173	13478
19	4986	9167		13770
20		11454		14715
21				15033
22				15637
23				15850
24				16453
25				17072
26				17553
27				18073
28				18810
29				
30				

[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	1429	7.2647	0.0343	1	2141	7.6690	0.0343	1	6927	8.8432	0.0343	1	7414	8.9111	0.0230
2	1623	7.3920	0.0833	2	3097	8.0382	0.0833	2	7222	8.8849	0.0833	2	7799	8.9618	0.0559
3	1657	7.4128	0.1324	3	3220	8.0771	0.1324	3	7578	8.9330	0.1324	3	7884	8.9726	0.0888
4	1792	7.4911	0.1814	4	3294	8.0999	0.1814	4	7970	8.9834	0.1814	4	8460	9.0431	0.1217
5	1935	7.5679	0.2304	5	3465	8.1505	0.2304	5	8652	9.0655	0.2304	5	9801	9.1902	0.1546
6	2577	7.8544	0.2794	6	3506	8.1622	0.2794	6	8844	9.0875	0.2794	6	10236	9.2337	0.1875
7	2649	7.8819	0.3284	7	3876	8.2626	0.3284	7	9086	9.1145	0.3284	7	10258	9.2358	0.2204
8	2703	7.9021	0.3775	8	4080	8.3139	0.3775	8	10149	9.2251	0.3775	8	10886	9.2952	0.2533
9	2807	7.9399	0.4265	9	4158	8.3328	0.4265	9	10527	9.2617	0.4265	9	11018	9.3073	0.2862
10	2826	7.9466	0.4755	10	4341	8.3759	0.4755	10	10949	9.3010	0.4755	10	11145	9.3187	0.3191
11	2983	8.0007	0.5245	11	4430	8.3962	0.5245	11	11076	9.3125	0.5245	11	11191	9.3229	0.3520
12	3330	8.1107	0.5735	12	4896	8.4962	0.5735	12	11928	9.3866	0.5735	12	11317	9.3341	0.3849
13	3457	8.1482	0.6225	13	5105	8.5380	0.6225	13	12195	9.4088	0.6225	13	11330	9.3352	0.4178
14	3654	8.2036	0.6716	14	5227	8.5616	0.6716	14	13495	9.5101	0.6716	14	11812	9.3769	0.4507
15	3975	8.2878	0.7206	15	5707	8.6494	0.7206	15	14333	9.5703	0.7206	15	11826	9.3781	0.4836
16	4004	8.2950	0.7696	16	5724	8.6524	0.7696	16	16844	9.7317	0.7696	16	12667	9.4468	0.5164
17	4058	8.3084	0.8186	17	5792	8.6642	0.8186	17	17130	9.7486	0.8186	17	12889	9.4641	0.5493
18	4195	8.3416	0.8676	18	7559	8.9305	0.8676	18	28173	10.2461	0.8676	18	13478	9.5088	0.5822
19	4986	8.5144	0.9167	19	9167	9.1234	0.9167	19				19	13770	9.5302	0.6151
20				20	11454	9.3461	0.9657	20				20	14715	9.5966	0.6480
												21	15033	9.6180	0.6809
												22	15637	9.6574	0.7138
												23	15850	9.6709	0.7467
												24	16453	9.7083	0.7796
												25	17072	9.7452	0.8125
												26	17553	9.7730	0.8454
												27	18073	9.8022	0.8783
												28	18810	9.8421	0.9112
												29			
												30			



[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	1429	7.2647	0.0343	1	2141	7.6690	0.0343	1	6927	8.8432	0.0343	1	7414	8.9111	0.0230
2	1623	7.3920	0.0833	2	3097	8.0382	0.0833	2	7222	8.8849	0.0833	2	7799	8.9618	0.0559
3	1657	7.4128	0.1324	3	3220	8.0771	0.1324	3	7578	8.9330	0.1324	3	7884	8.9726	0.0888
4	1792	7.4911	0.1814	4	3294	8.0999	0.1814	4	7970	8.9834	0.1814	4	8460	9.0431	0.1217
5	1935	7.5679	0.2304	5	3465	8.1505	0.2304	5	8652	9.0655	0.2304	5	9801	9.1902	0.1546
6	2577	7.8544	0.2794	6	3506	8.1622	0.2794	6	8844	9.0875	0.2794	6	10236	9.2337	0.1875
7	2649	7.8819	0.3284	7	3876	8.2626	0.3284	7	9086	9.1145	0.3284	7	10258	9.2358	0.2204
8	2703	7.9021	0.3775	8	4080	8.3139	0.3775	8	10149	9.2251	0.3775	8	10886	9.2952	0.2533
9	2807	7.9399	0.4265	9	4158	8.3328	0.4265	9	10527	9.2617	0.4265	9	11018	9.3073	0.2862
10	2826	7.9466	0.4755	10	4341	8.3759	0.4755	10	10949	9.3010	0.4755	10	11145	9.3187	0.3191
11	2983	8.0007	0.5245	11	4430	8.3962	0.5245	11	11076	9.3125	0.5245	11	11191	9.3229	0.3520
12	3330	8.1107	0.5735	12	4896	8.4962	0.5735	12	11928	9.3866	0.5735	12	11317	9.3341	0.3849
13	3457	8.1482	0.6225	13	5105	8.5380	0.6225	13	12195	9.4088	0.6225	13	11330	9.3352	0.4178
14	3654	8.2036	0.6716	14	5227	8.5616	0.6716	14	13495	9.5101	0.6716	14	11812	9.3769	0.4507
15	3975	8.2878	0.7206	15	5707	8.6494	0.7206	15	14333	9.5703	0.7206	15	11826	9.3781	0.4836
16	4004	8.2950	0.7696	16	5724	8.6524	0.7696	16	16844	9.7317	0.7696	16	12667	9.4468	0.5164
17	4058	8.3084	0.8186	17	5792	8.6642	0.8186	17	17130	9.7486	0.8186	17	12889	9.4641	0.5493
18	4195	8.3416	0.8676	18	7559	8.9305	0.8676	18	28173	10.2461	0.8676	18	13478	9.5088	0.5822
19	4986	8.5144	0.9167	19	9167	9.1234	0.9167	19				19	13770	9.5302	0.6151
20				20	11454	9.3461	0.9657	20				20	14715	9.5966	0.6480
												21	15033	9.6180	0.6809
												22	15637	9.6574	0.7138
												23	15850	9.6709	0.7467
												24	16453	9.7083	0.7796
												25	17072	9.7452	0.8125
												26	17553	9.7730	0.8454
												27	18073	9.8022	0.8783
												28	18810	9.8421	0.9112
												29			
												30			

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。

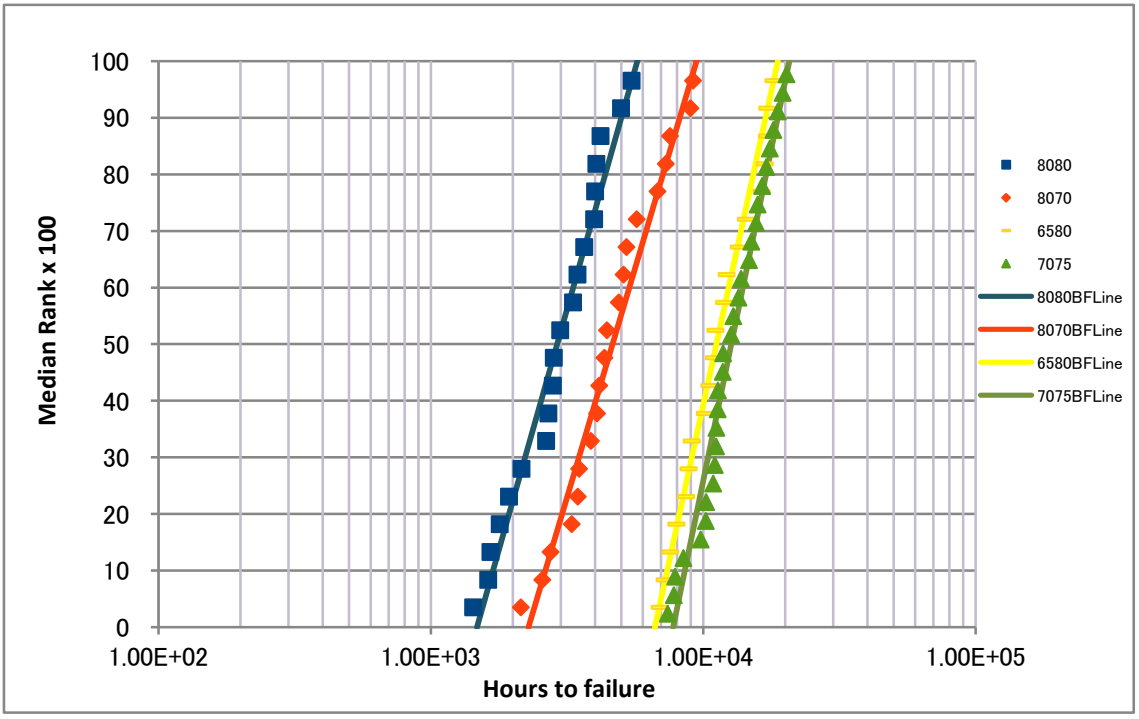
[Table 1-5-1]～[Table 1-5-2]に各試験条件の complete data set を示し、[Figure 1-5-1]にグラフを示す。

[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	1429	2141	6927	7414
2	1623	2568	7222	7799
3	1657	2753	7578	7884
4	1792	3294	7970	8460
5	1935	3465	8652	9801
6	2153	3506	8844	10236
7	2649	3876	9086	10258
8	2703	4080	10149	10886
9	2807	4158	10527	11018
10	2826	4341	10949	11145
11	2983	4430	11076	11191
12	3330	4896	11928	11317
13	3457	5105	12195	11330
14	3654	5227	13495	11812
15	3975	5707	14333	11826
16	4004	6799	16353	12667
17	4058	7289	16844	12889
18	4195	7559	17130	13478
19	4986	8981	17208	13770
20	5457	9167	18108	14715
21				15033
22				15637
23				15850
24				16453
25				17072
26				17553
27				18073
28				18810
29				19569
30				20211

[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	1429	7.2647	0.034	1	2141	7.6690	0.034	1	6927	8.8432	0.034	1	7414	8.9111	0.023
2	1623	7.3920	0.083	2	2568	7.8507	0.083	2	7222	8.8849	0.083	2	7799	8.9618	0.056
3	1657	7.4128	0.132	3	2753	7.9203	0.132	3	7578	8.9330	0.132	3	7884	8.9726	0.089
4	1792	7.4911	0.181	4	3294	8.0999	0.181	4	7970	8.9834	0.181	4	8460	9.0431	0.122
5	1935	7.5679	0.230	5	3465	8.1505	0.230	5	8652	9.0655	0.230	5	9801	9.1902	0.155
6	2153	7.6744	0.279	6	3506	8.1622	0.279	6	8844	9.0875	0.279	6	10236	9.2337	0.188
7	2649	7.8819	0.328	7	3876	8.2626	0.328	7	9086	9.1145	0.328	7	10258	9.2358	0.220
8	2703	7.9021	0.377	8	4080	8.3139	0.377	8	10149	9.2251	0.377	8	10886	9.2952	0.253
9	2807	7.9399	0.426	9	4158	8.3328	0.426	9	10527	9.2617	0.426	9	11018	9.3073	0.286
10	2826	7.9466	0.475	10	4341	8.3759	0.475	10	10949	9.3010	0.475	10	11145	9.3187	0.319
11	2983	8.0007	0.525	11	4430	8.3962	0.525	11	11076	9.3125	0.525	11	11191	9.3229	0.352
12	3330	8.1107	0.574	12	4896	8.4962	0.574	12	11928	9.3866	0.574	12	11317	9.3341	0.385
13	3457	8.1482	0.623	13	5105	8.5380	0.623	13	12195	9.4088	0.623	13	11330	9.3352	0.418
14	3654	8.2036	0.672	14	5227	8.5616	0.672	14	13495	9.5101	0.672	14	11812	9.3769	0.451
15	3975	8.2878	0.721	15	5707	8.6494	0.721	15	14333	9.5703	0.721	15	11826	9.3781	0.484
16	4004	8.2950	0.770	16	6799	8.8246	0.770	16	16353	9.7022	0.770	16	12667	9.4468	0.516
17	4058	8.3084	0.819	17	7289	8.8942	0.819	17	16844	9.7317	0.819	17	12889	9.4641	0.549
18	4195	8.3416	0.868	18	7559	8.9305	0.868	18	17130	9.7486	0.868	18	13478	9.5088	0.582
19	4986	8.5144	0.917	19	8981	9.1028	0.917	19	17208	9.7531	0.917	19	13770	9.5302	0.615
20	5457	8.6047	0.966	20	9167	9.1234	0.966	20	18108	9.8041	0.966	20	14715	9.5966	0.648
												21	15033	9.6180	0.681
												22	15637	9.6574	0.714
												23	15850	9.6709	0.747
												24	16453	9.7083	0.780
												25	17072	9.7452	0.813
												26	17553	9.7730	0.845
												27	18073	9.8022	0.878
												28	18810	9.8421	0.911
												29	19569	9.8817	0.944
												30	20211	9.9140	0.977
Mean	3084	8.0339		Mean	4967	8.5106		Mean	11829	9.3783		Mean	13139	9.4833	



[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	7.264730	0.002832	80	1	8.843182	0.002957	80
2	7.392032	0.002832	80	2	8.884887	0.002957	80
3	7.412764	0.002832	80	3	8.933005	0.002957	80
4	7.491088	0.002832	80	4	8.983440	0.002957	80
5	7.567863	0.002832	80	5	9.065546	0.002957	80
6	7.674416	0.002832	80	6	9.087495	0.002957	80
7	7.881937	0.002832	80	7	9.114490	0.002957	80
8	7.902118	0.002832	80	8	9.225130	0.002957	80
9	7.939872	0.002832	80	9	9.261699	0.002957	80
10	7.946618	0.002832	80	10	9.301003	0.002957	80
11	8.000685	0.002832	80	11	9.312536	0.002957	80
12	8.110728	0.002832	80	12	9.386644	0.002957	80
13	8.148156	0.002832	80	13	9.408781	0.002957	80
14	8.203578	0.002832	80	14	9.510075	0.002957	80
15	8.287780	0.002832	80	15	9.570320	0.002957	80
16	8.295049	0.002832	80	16	9.702181	0.002957	80
17	8.308446	0.002832	80	17	9.731750	0.002957	80
18	8.341649	0.002832	80	18	9.748587	0.002957	80
19	8.514389	0.002832	80	19	9.753145	0.002957	80
20	8.604670	0.002832	80	20	9.804108	0.002957	80
1	7.669028	0.002832	70	1	8.911125	0.002914	75
2	7.850710	0.002832	70	2	8.961751	0.002914	75
3	7.920273	0.002832	70	3	8.972591	0.002914	75
4	8.099858	0.002832	70	4	9.043104	0.002914	75
5	8.150468	0.002832	70	5	9.190240	0.002914	75
6	8.162231	0.002832	70	6	9.233666	0.002914	75
7	8.262559	0.002832	70	7	9.235813	0.002914	75
8	8.313852	0.002832	70	8	9.295233	0.002914	75
9	8.332789	0.002832	70	9	9.307286	0.002914	75
10	8.375860	0.002832	70	10	9.318746	0.002914	75
11	8.396155	0.002832	70	11	9.322865	0.002914	75
12	8.496174	0.002832	70	12	9.334061	0.002914	75
13	8.537976	0.002832	70	13	9.335209	0.002914	75
14	8.561593	0.002832	70	14	9.376871	0.002914	75
15	8.649449	0.002832	70	15	9.378056	0.002914	75
16	8.824593	0.002832	70	16	9.446755	0.002914	75
17	8.894156	0.002832	70	17	9.464130	0.002914	75
18	8.930494	0.002832	70	18	9.508814	0.002914	75
19	9.102846	0.002832	70	19	9.530248	0.002914	75
20	9.123365	0.002832	70	20	9.596623	0.002914	75
				21	9.618003	0.002914	75
				22	9.657395	0.002914	75
				23	9.670925	0.002914	75
				24	9.708263	0.002914	75
				25	9.745195	0.002914	75
				26	9.772980	0.002914	75
				27	9.802174	0.002914	75
				28	9.842144	0.002914	75
				29	9.881687	0.002914	75
				30	9.913970	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
$\hat{\beta}_0$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\sigma}_{lsm}$
-22.4759	12531.08	-0.06354	0.37093

Coefficient of determination は 0.73175 と指標である 0.8 より下回っているが、大きく下回っている状態でもないため、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

$\ln B_{50}$		16.3765
B_{50} Life	Hours	12948257
B_{50} Life	Years	1477
$\ln B_5$		15.7681
B_5 Life	Hours	7047240
B_5 Life	Years	804

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	2834356
	Years	323

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	8.0339	80	0.002831658	80
B	8.5106	80	0.002831658	70

C	9.3783	65	0.002957267	80
D	9.4833	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)
-0.0603	11948.2816	-21.0061

Coefficient of determination は 0.95689 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	8.0033	2991	3135
80	70	8.6063	5466	1715
65	80	9.5042	13415	699
70	75	9.2908	10838	865
25	50	16.0536	9375710	

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

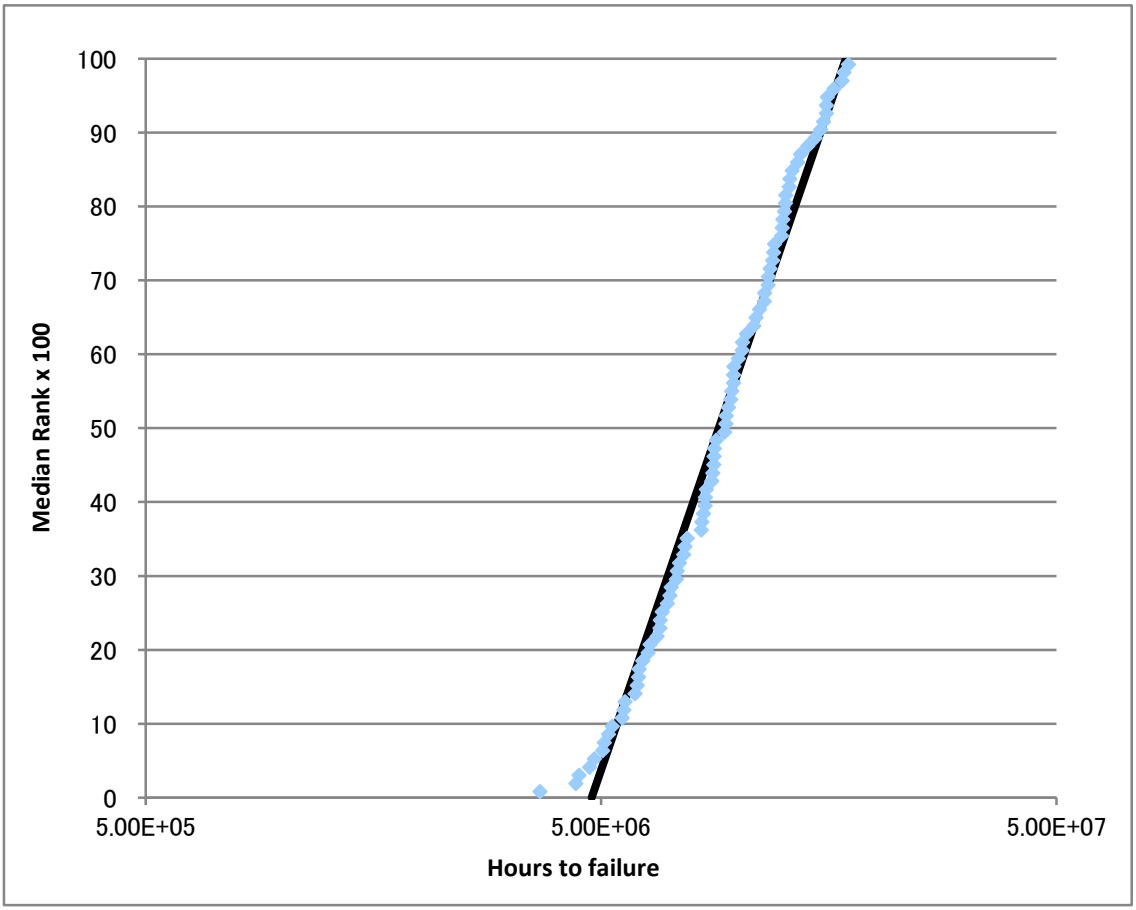
Time-to-failure	Group #	Normalized to 25℃50%RH	Ln	Group #	Normalized to 25℃50%RH	Order	Media rank
1429	A	4479476.25	15.32	B	3672249	1	0.0077
1623	A	5087606.69	15.44	B	4403881	2	0.0188
1657	A	5194186.25	15.46	A	4479476	3	0.0299
1792	A	5617369.80	15.54	B	4721135	4	0.0409
1935	A	6065630.89	15.62	C	4841090	5	0.0520
2153	A	6747637.38	15.72	C	5047257	6	0.0631
2649	A	8303801.67	15.93	A	5087607	7	0.0741
2703	A	8473075.09	15.95	A	5194186	8	0.0852
2807	A	8799083.16	15.99	C	5296056	9	0.0962
2826	A	8858642.33	16.00	C	5570014	10	0.1073

2983	A	9350789.12	16.05	A	5617370	11	0.1184
3330	A	10438527.58	16.16	B	5649878	12	0.1294
3457	A	10836633.59	16.20	B	5943178	13	0.1405
3654	A	11454168.10	16.25	B	6013501	14	0.1515
3975	A	12460404.54	16.34	C	6046645	15	0.1626
4004	A	12551310.64	16.35	A	6065631	16	0.1737
4058	A	12720584.06	16.36	C	6180828	17	0.1847
4195	A	13150037.00	16.39	C	6349955	18	0.1958
4986	A	15629579.13	16.56	D	6413690	19	0.2069
5457	A	17106284.45	16.65	B	6648126	20	0.2179
2141	B	3672249.11	15.12	D	6746746	21	0.2290
2568	B	4403880.54	15.30	A	6747637	22	0.2400
2753	B	4721134.77	15.37	D	6820277	23	0.2511
3294	B	5649877.89	15.55	B	6998027	24	0.2622
3465	B	5943177.56	15.60	C	7092857	25	0.2732
3506	B	6013500.87	15.61	B	7131813	26	0.2843
3876	B	6648125.89	15.71	D	7318562	27	0.2954
4080	B	6998027.26	15.76	C	7357031	28	0.3064
4158	B	7131813.07	15.78	B	7445695	29	0.3175
4341	B	7445695.18	15.82	B	7598348	30	0.3285
4430	B	7598348.22	15.84	C	7651955	31	0.3396
4896	B	8397632.71	15.94	C	7740712	32	0.3507
5105	B	8756110.09	15.99	A	8303802	33	0.3617
5227	B	8965364.82	16.01	C	8336151	34	0.3728
5707	B	9788662.15	16.10	B	8397633	35	0.3838
6799	B	11662393.39	16.27	A	8473075	36	0.3949
7289	B	12502548.70	16.34	D	8478632	37	0.4060
7559	B	12965217.66	16.38	C	8522750	38	0.4170
8981	B	15403916.65	16.55	B	8756110	39	0.4281
9167	B	15723263.69	16.57	A	8799083	40	0.4392
6927	C	4841089.75	15.39	D	8854941	41	0.4502
7222	C	5047257.13	15.43	A	8858642	42	0.4613
7578	C	5296055.74	15.48	D	8873973	43	0.4723
7970	C	5570013.76	15.53	B	8965365	44	0.4834
8652	C	6046644.79	15.62	A	9350789	45	0.4945
8844	C	6180828.31	15.64	D	9417242	46	0.5055
9086	C	6349955.46	15.66	C	9431284	47	0.5166
10149	C	7092856.91	15.77	D	9531433	48	0.5277
10527	C	7357030.72	15.81	D	9641298	49	0.5387

10949	C	7651954.91	15.85	D	9681091	50	0.5498
11076	C	7740711.71	15.86	B	9788662	51	0.5608
11928	C	8336151.08	15.94	D	9790091	52	0.5719
12195	C	8522750.03	15.96	D	9801337	53	0.5830
13495	C	9431284.27	16.06	C	10016939	54	0.5940
14333	C	10016939.42	16.12	D	10218305	55	0.6051
16353	C	11428830.07	16.25	D	10230416	56	0.6162
16844	C	11771808.24	16.28	A	10438528	57	0.6272
17130	C	11971685.78	16.30	A	10836634	58	0.6383
17208	C	12026377.62	16.30	D	10957947	59	0.6493
18108	C	12655167.49	16.35	D	11149994	60	0.6604
7414	D	6413690.49	15.67	C	11428830	61	0.6715
7799	D	6746745.64	15.72	A	11454168	62	0.6825
7884	D	6820277.29	15.74	D	11659525	63	0.6936
8460	D	7318562.39	15.81	B	11662393	64	0.7046
9801	D	8478632.39	15.95	C	11771808	65	0.7157
10236	D	8854941.45	16.00	D	11912128	66	0.7268
10258	D	8873973.17	16.00	C	11971686	67	0.7378
10886	D	9417242.34	16.06	C	12026378	68	0.7489
11018	D	9531432.67	16.07	A	12460405	69	0.7600
11145	D	9641297.62	16.08	B	12502549	70	0.7710
11191	D	9681091.22	16.09	A	12551311	71	0.7821
11317	D	9790091.08	16.10	C	12655167	72	0.7931
11330	D	9801337.10	16.10	A	12720584	73	0.8042
11812	D	10218304.84	16.14	D	12729627	74	0.8153
11826	D	10230415.94	16.14	B	12965218	75	0.8263
12667	D	10957946.79	16.21	D	13004722	76	0.8374
12889	D	11149994.17	16.23	A	13150037	77	0.8485
13478	D	11659525.28	16.27	D	13527229	78	0.8595
13770	D	11912128.15	16.29	D	13711491	79	0.8706
14715	D	12729627.14	16.36	D	14233133	80	0.8816
15033	D	13004722.04	16.38	D	14768617	81	0.8927
15637	D	13527229.33	16.42	D	15184719	82	0.9038
15850	D	13711491.00	16.43	B	15403917	83	0.9148
16453	D	14233133.22	16.47	A	15629579	84	0.9259
17072	D	14768616.68	16.51	D	15634560	85	0.9369
17553	D	15184719.34	16.54	B	15723264	86	0.9480
18073	D	15634560.06	16.56	D	16272123	87	0.9591
18810	D	16272122.76	16.60	D	16928465	88	0.9701

19569	D	16928464.80	16.64	A	17106284	89	0.9812
20211	D	17483886.62	16.67679	D	17483886.62	90	0.992257
		Mean	16.02		Total	90	
		Deviation	0.36577				

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	9062837
	Years	1034
B_5 Life	Hours	4974457
	Years	567
B_{5V} Life	Hours	2730405
	Years	311

[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
323 years	311 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 (MLH with LSM) and acceleration-factor method (AFM).

	Log standard deviation
MLE with LSM	0.37093
AFM	0.36577

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	12948257
	Years	1477

B_5 Life	Hours	7047240
	Years	804
$(B_5 \text{ Life})_L$	Hours	2834356
	Years	323

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	9062837
	Years	1034
B_5 Life	Hours	4974457
	Years	567
B_{5V} Life	Hours	2730405
	Years	311

[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