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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

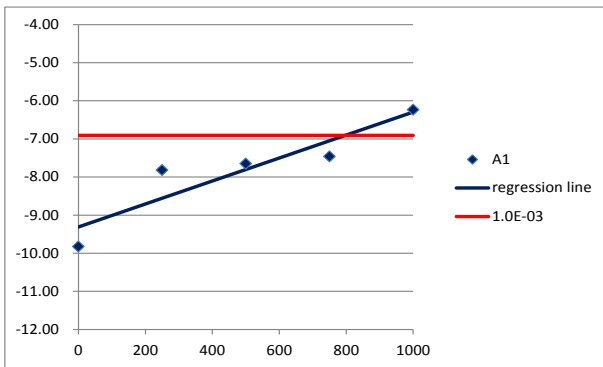
“A.2.1 Judgment of effectiveness of test data and time-to-failure determination”にある、Step 1、Step 2に従い、測定データの有効性について判定を行う。

#### 1-1-1 Step 1

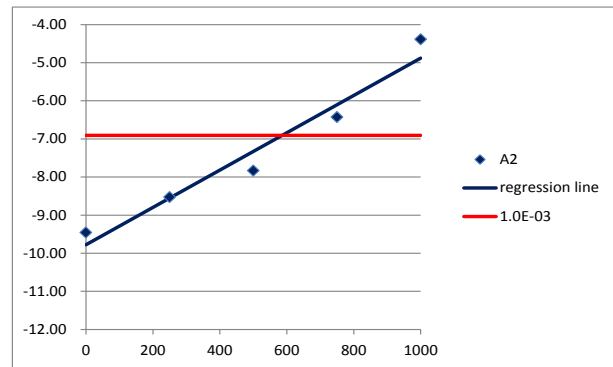
Linear regression か polynomial regression を計算することになるが、前回のデータとの整合性を考慮し、linear regression を計算し各試料のグラフを作成する

##### 1-1-1-1 80°C/80%RH

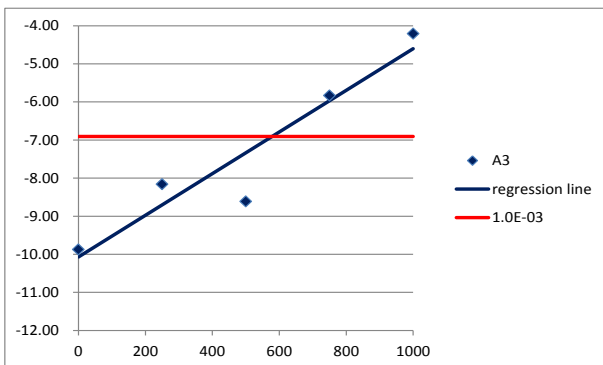
[Figure 1-1-1-1]から[Figure 1-1-1-20]に各試料のグラフを示す。



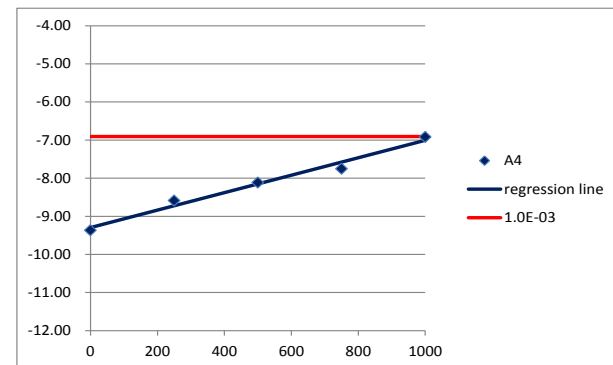
[Figure 1-1-1-1] 試料 A1



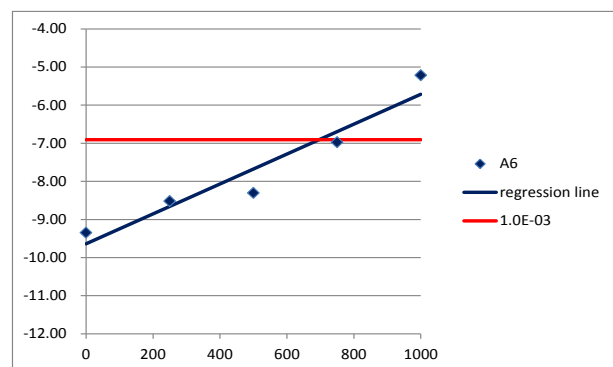
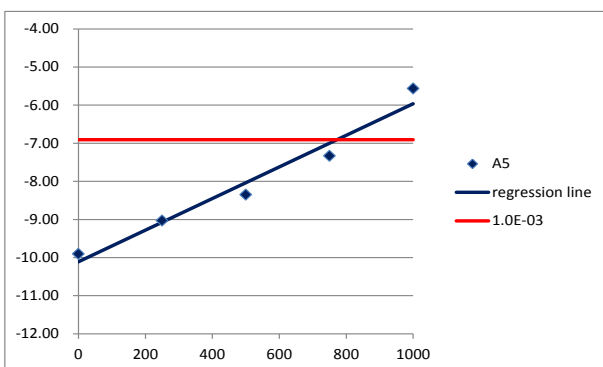
[Figure 1-1-1-2] 試料 A2



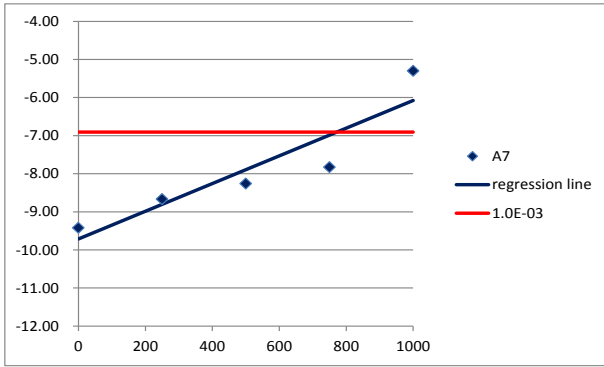
[Figure 1-1-1-3] 試料 A3



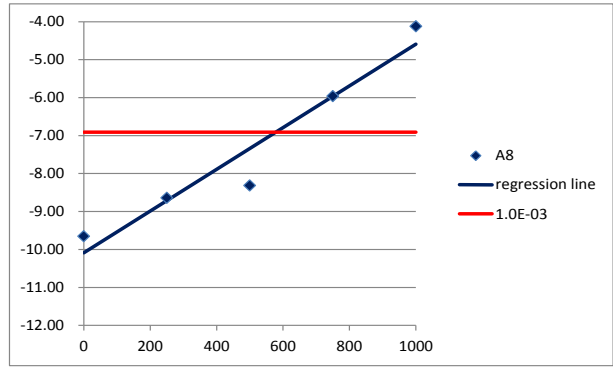
[Figure 1-1-1-4] 試料 A4



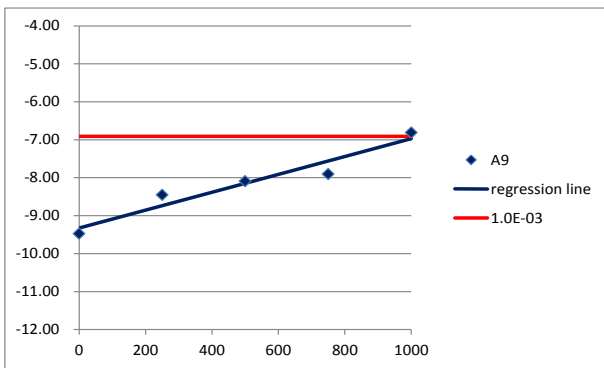
[Figure 1-1-1-5] 試料 A5



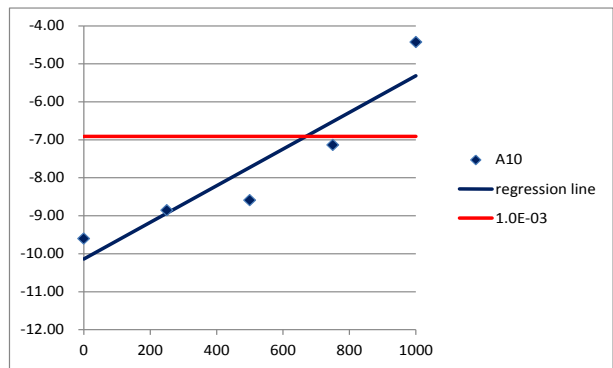
[Figure 1-1-1-6] 試料 A6



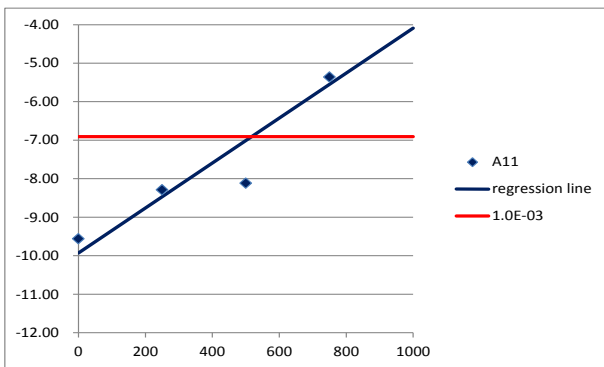
[Figure 1-1-1-7] 試料 A7



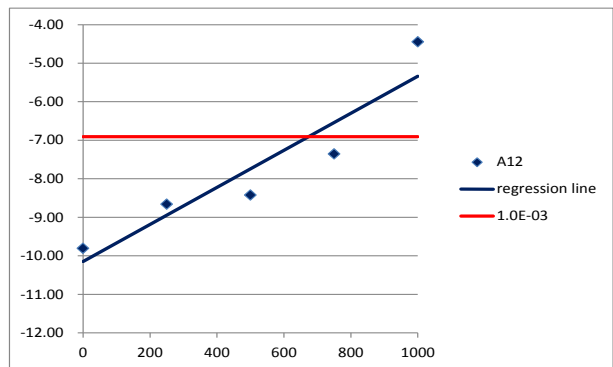
[Figure 1-1-1-8] 試料 A8



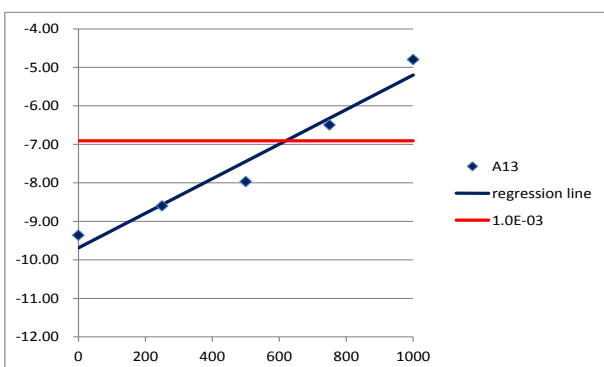
[Figure 1-1-1-9] 試料 A9



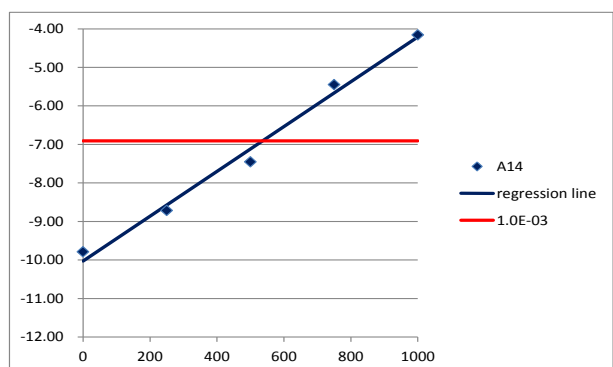
[Figure 1-1-1-10] 試料 A10



[Figure 1-1-1-11] 試料 A11



[Figure 1-1-1-12] 試料 A12

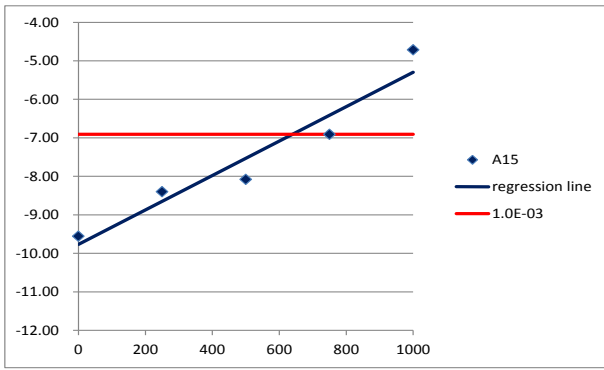


[Figure 1-1-1-13] 試料 A13

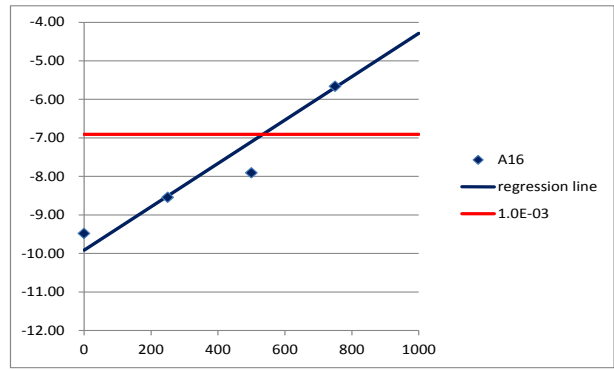


[Figure 1-1-1-14] 試料 A14

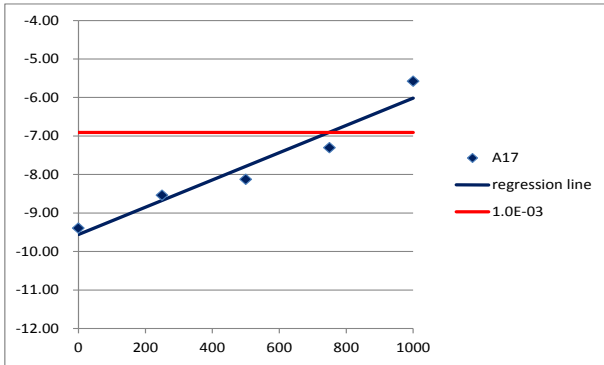




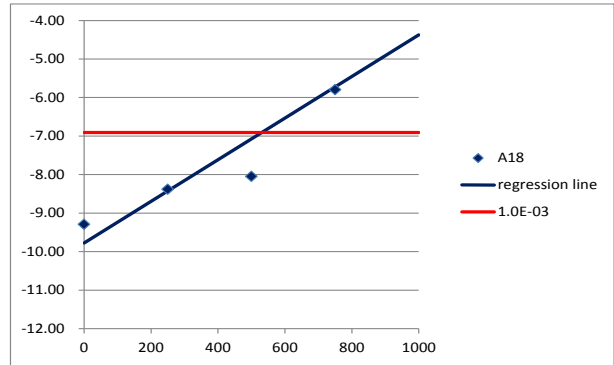
[Figure 1-1-1-15] 試料 A15



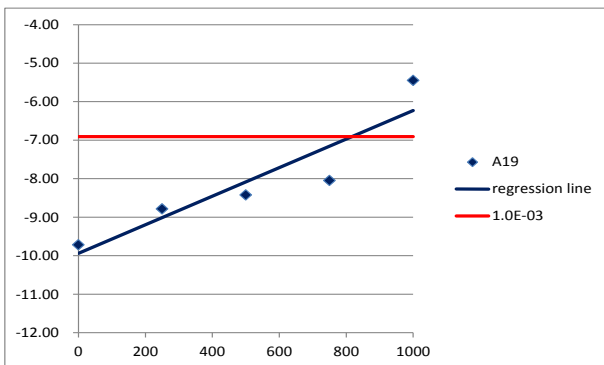
[Figure 1-1-1-16] 試料 A16



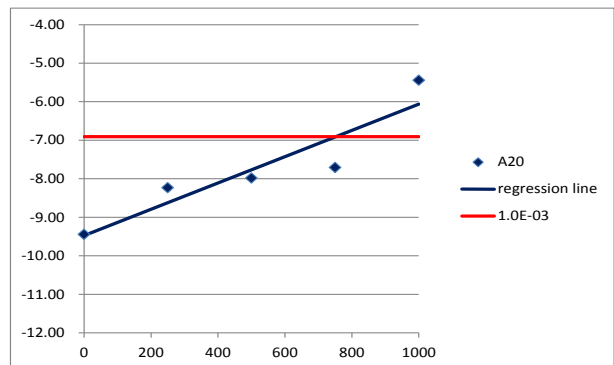
[Figure 1-1-1-17] 試料 A17



[Figure 1-1-1-18] 試料 A18



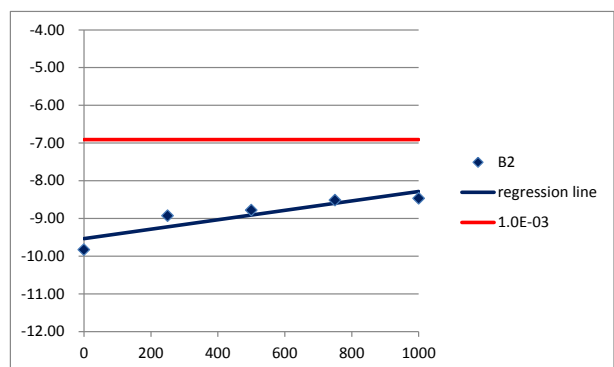
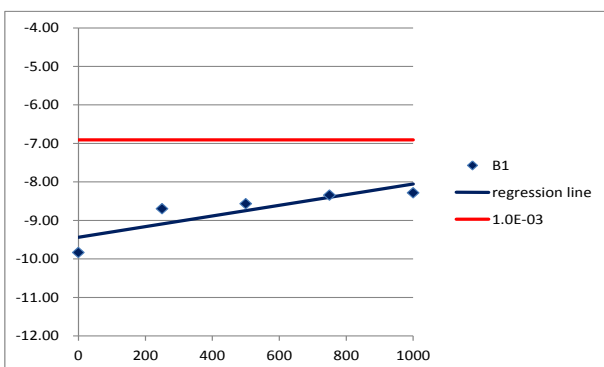
[Figure 1-1-1-19] 試料 A19



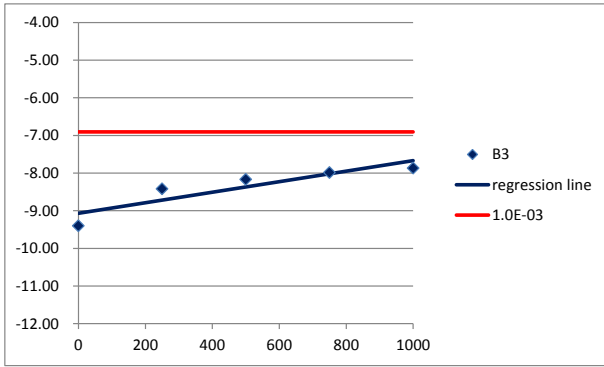
[Figure 1-1-1-20] 試料 A20

1-1-1-2 80°C/70%RH

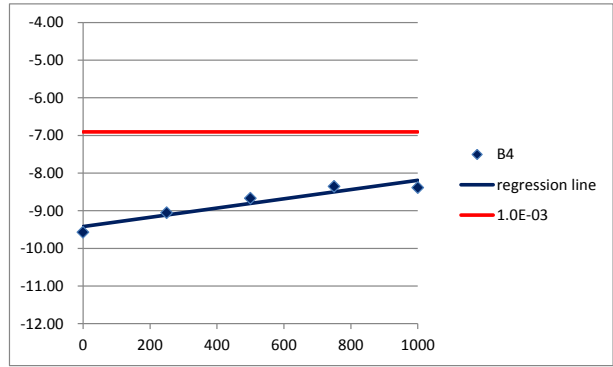
[Figure 1-1-1-2-1]から[Figure 1-1-1-2-20]に各試料のグラフを示す。



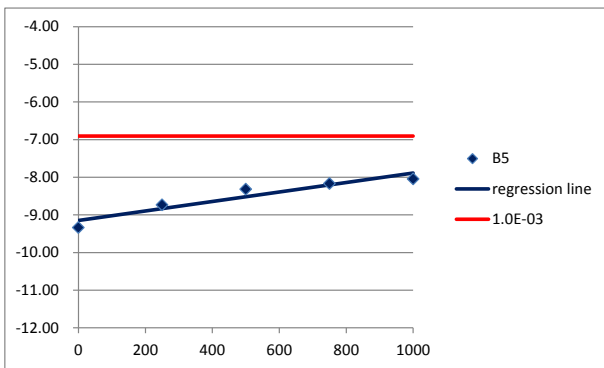
[Figure 1-1-1-2-1] 試料 B1



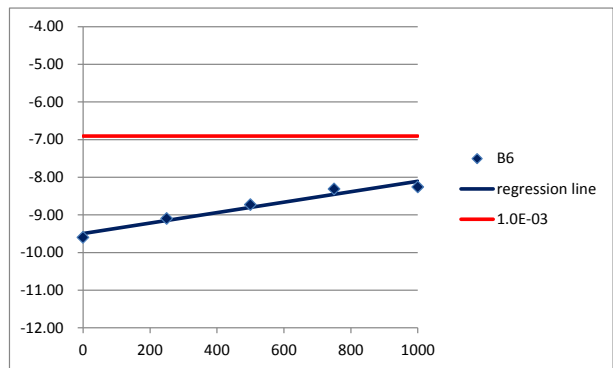
[Figure 1-1-1-2-2] 試料 B2



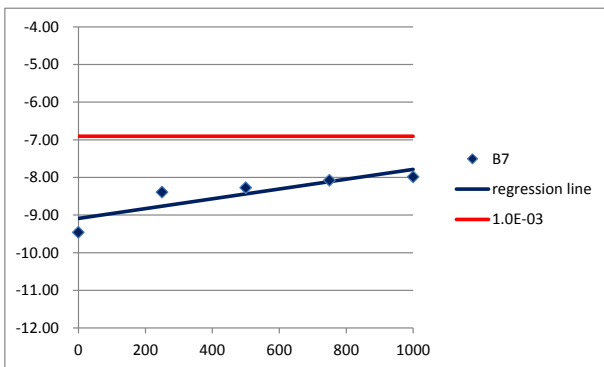
[Figure 1-1-1-2-3] 試料 B3



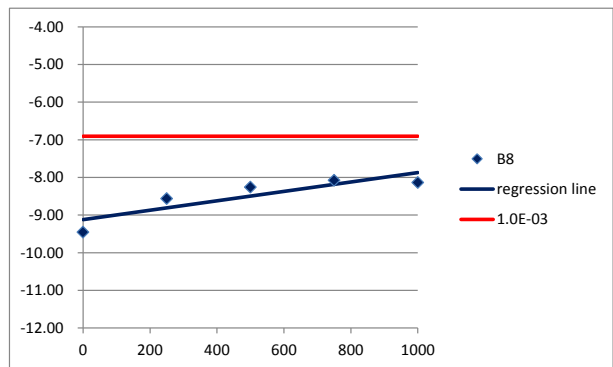
[Figure 1-1-1-2-4] 試料 B4



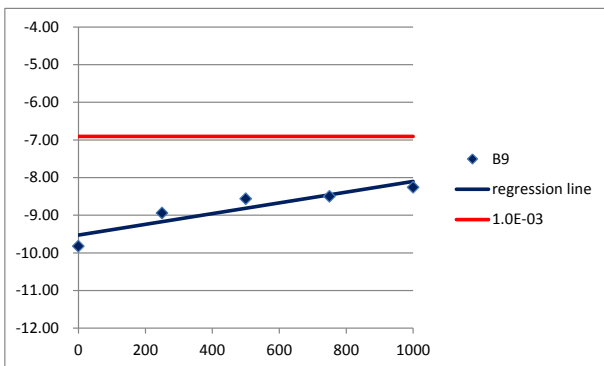
[Figure 1-1-1-2-5] 試料 B5



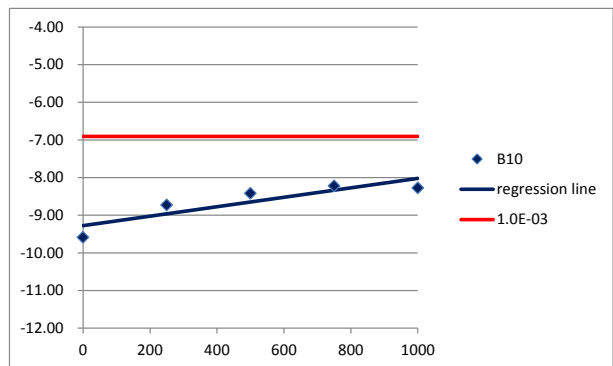
[Figure 1-1-1-2-6] 試料 B6



[Figure 1-1-1-2-7] 試料 B7



[Figure 1-1-1-2-8] 試料 B8

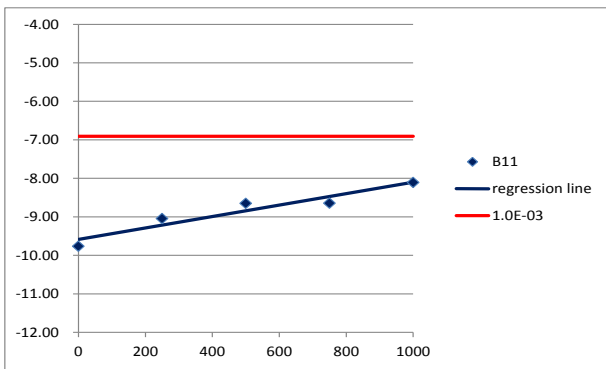


[Figure 1-1-1-2-9] 試料 B9

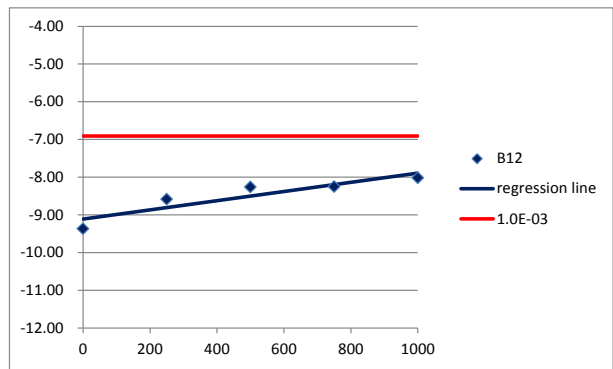


[Figure 1-1-1-2-10] 試料 B10

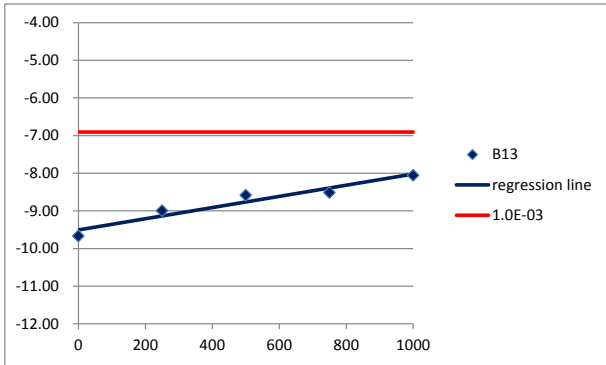




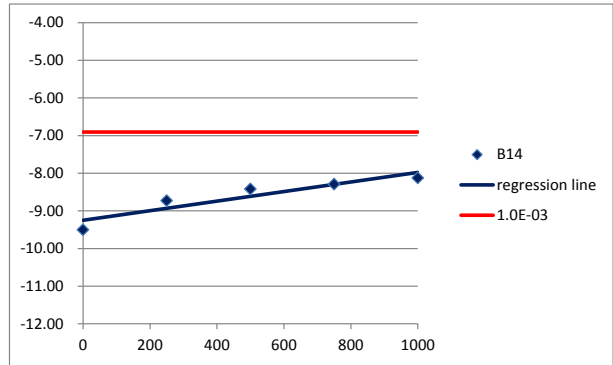
[Figure 1-1-1-2-11] 試料 B11



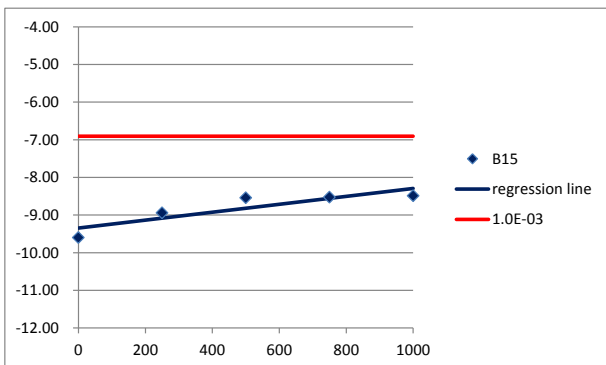
[Figure 1-1-1-2-12] 試料 B12



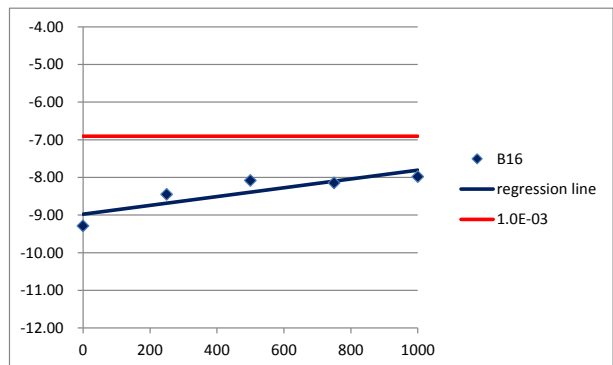
[Figure 1-1-1-2-13] 試料 B13



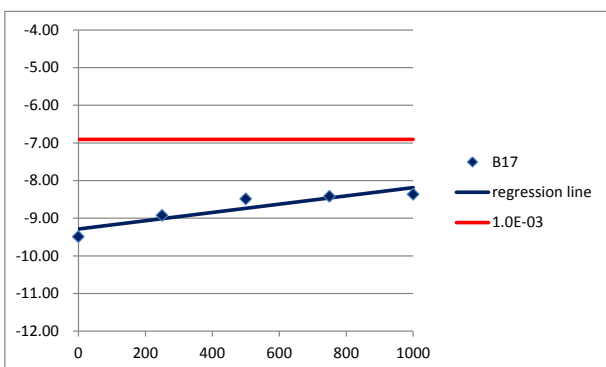
[Figure 1-1-1-2-14] 試料 B14



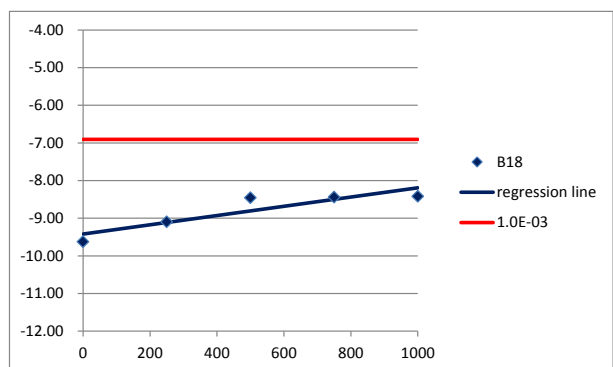
[Figure 1-1-1-2-15] 試料 B15



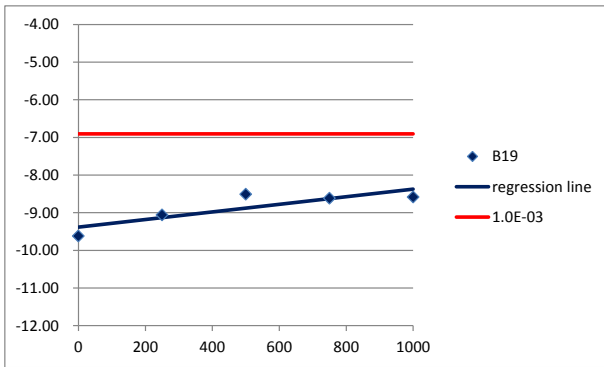
[Figure 1-1-1-2-16] 試料 B16



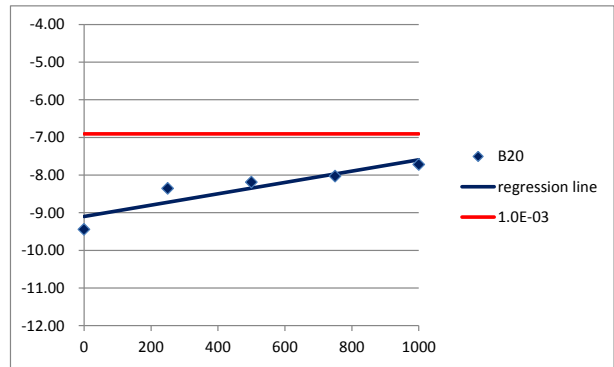
[Figure 1-1-1-2-17] 試料 B17



[Figure 1-1-1-2-18] 試料 B18



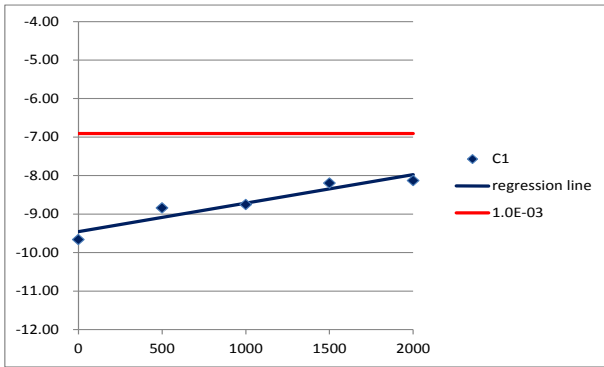
[Figure 1-1-1-2-19] 試料 B19



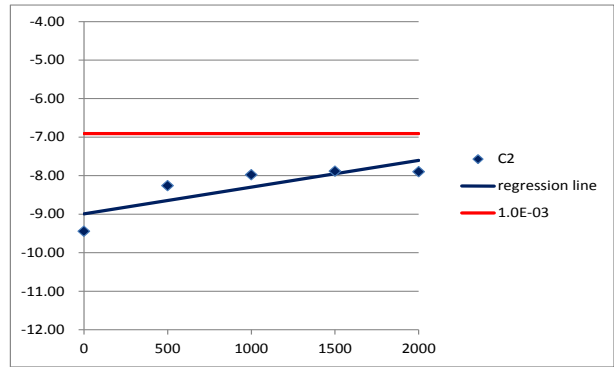
[Figure 1-1-1-2-20] 試料 B20

5-1-1-3 65°C/80%RH

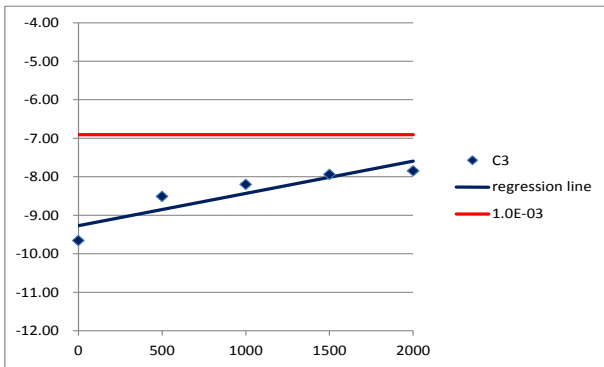
[Figure 1-1-1-3-1]から[Figure 1-1-1-3-20]に各試料のグラフを示す。



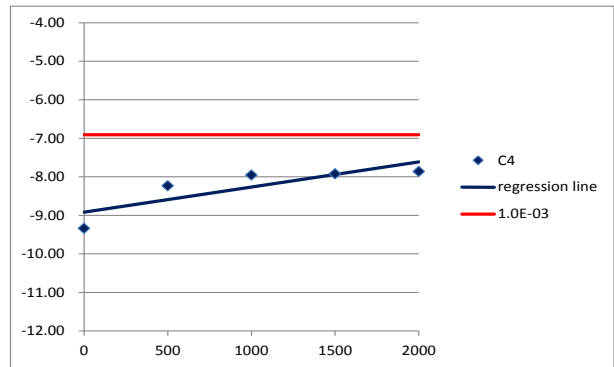
[Figure 1-1-1-3-1] 試料 C1



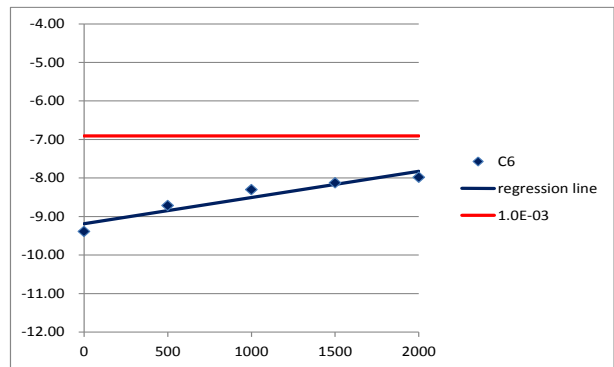
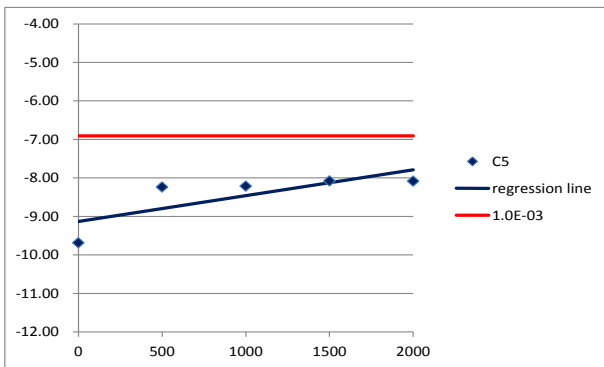
[Figure 1-1-1-3-2] 試料 C2



[Figure 1-1-1-3-3] 試料 C3

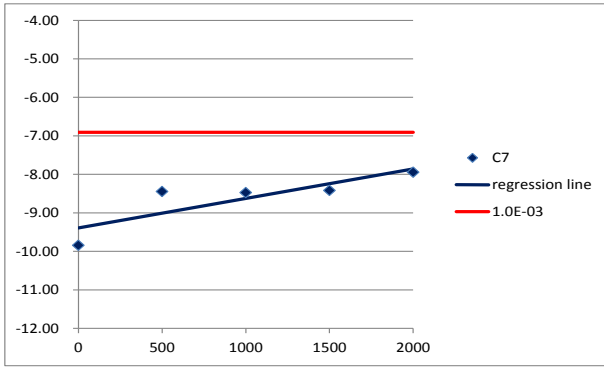


[Figure 1-1-1-3-4] 試料 C4

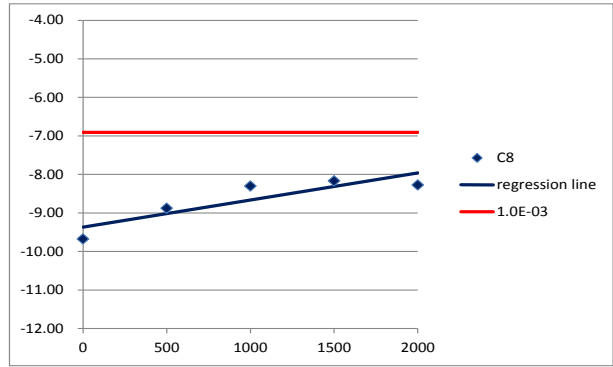




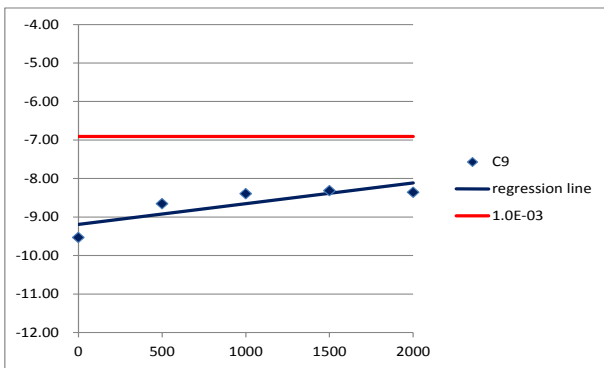
[Figure 1-1-1-3-5] 試料 C5



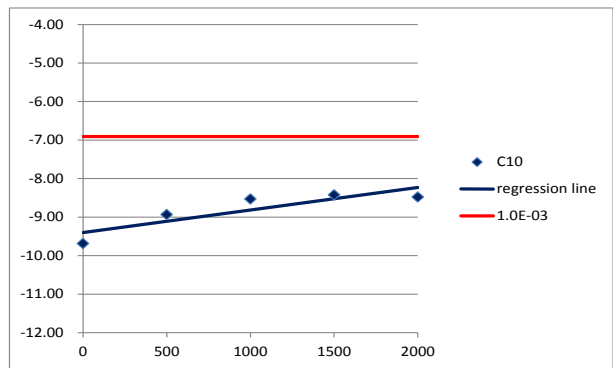
[Figure 1-1-1-3-6] 試料 C6



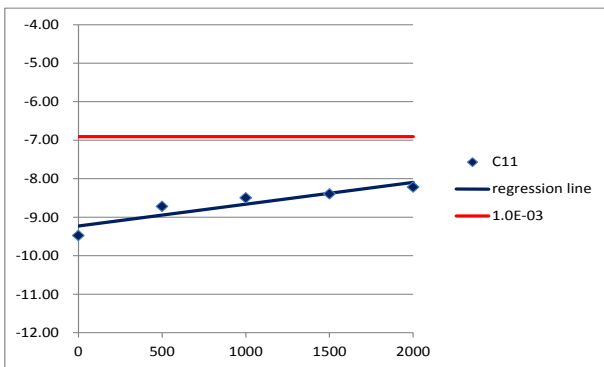
[Figure 1-1-1-3-7] 試料 C7



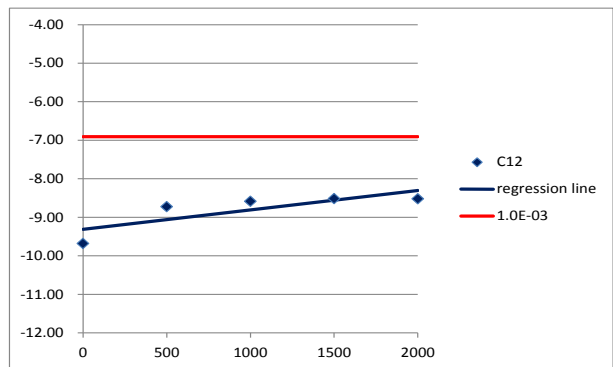
[Figure 1-1-1-3-8] 試料 C8



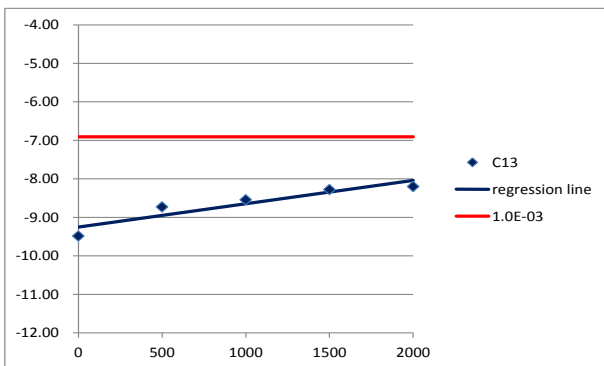
[Figure 1-1-1-3-9] 試料 C9



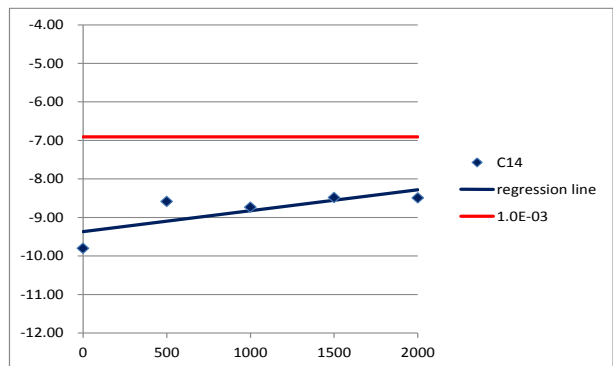
[Figure 1-1-1-3-10] 試料 C10



[Figure 1-1-1-3-11] 試料 C11

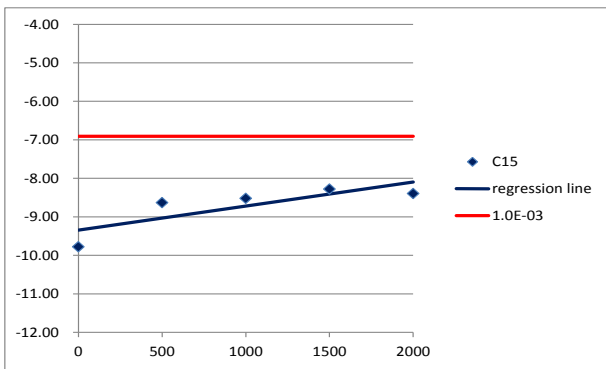


[Figure 1-1-1-3-12] 試料 C12

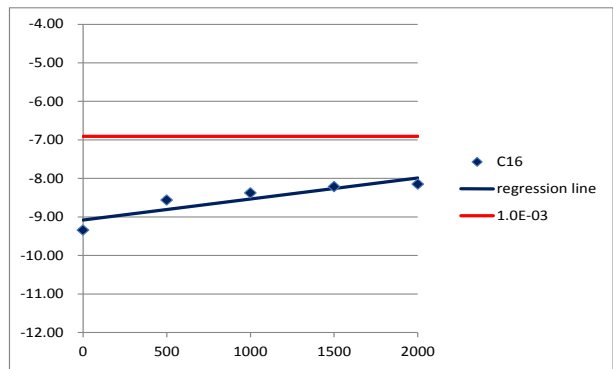


[Figure 1-1-1-3-13] 試料 C13

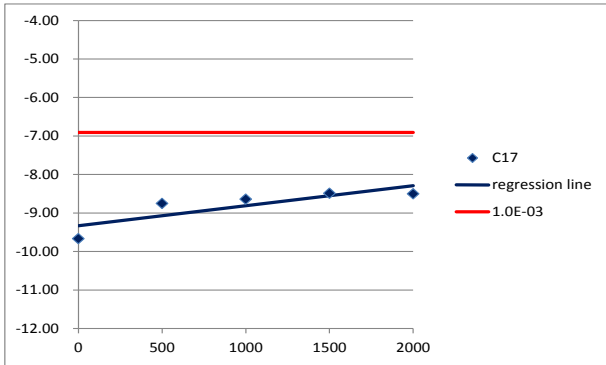
[Figure 1-1-1-3-14] 試料 C14



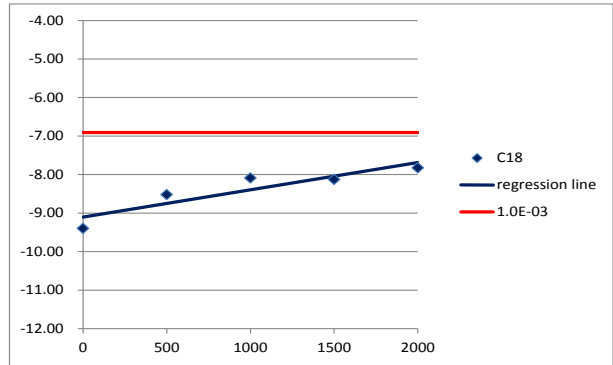
[Figure 1-1-1-3-15] 試料 C15



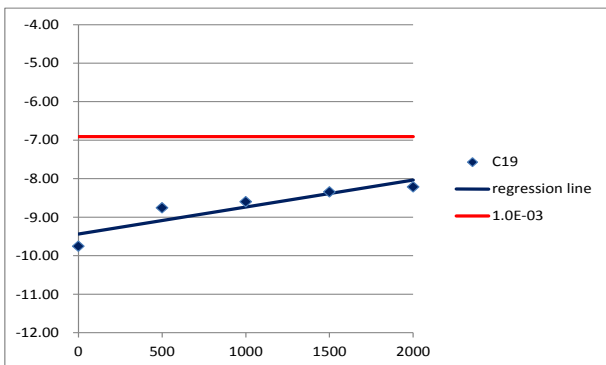
[Figure 1-1-1-3-16] 試料 C16



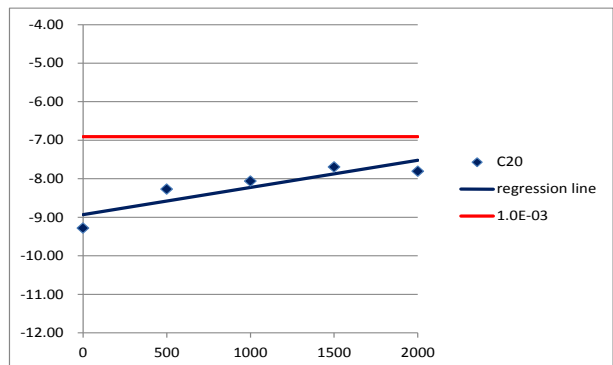
[Figure 1-1-1-3-17] 試料 C17



[Figure 1-1-1-3-18] 試料 C18



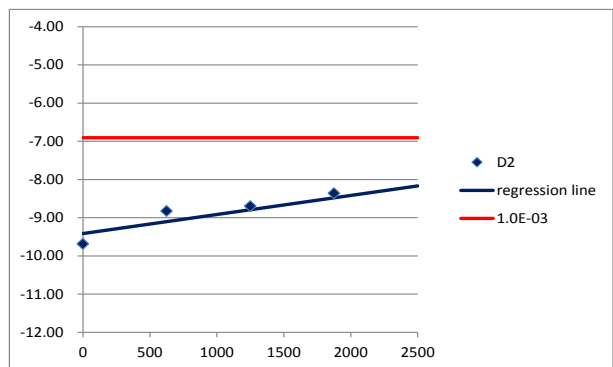
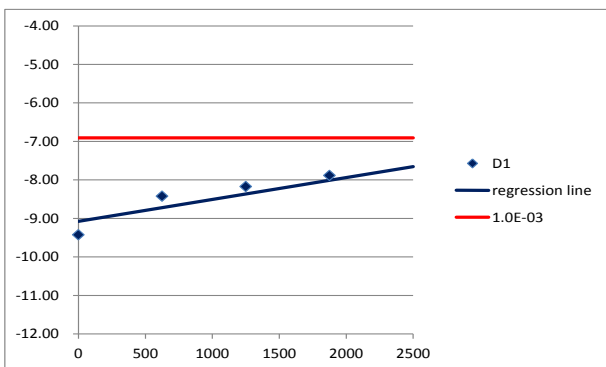
[Figure 1-1-1-3-19] 試料 C19



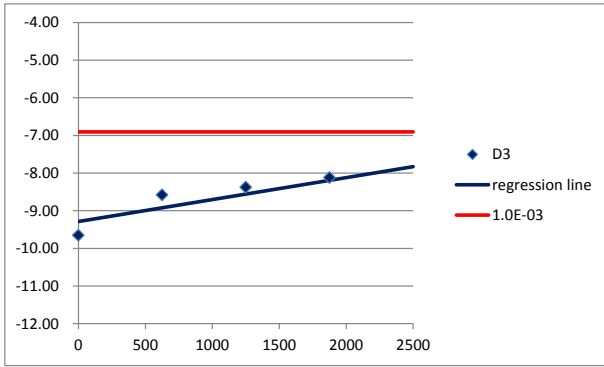
[Figure 1-1-1-3-20] 試料 C20

5-1-1-4 70°C/75%RH

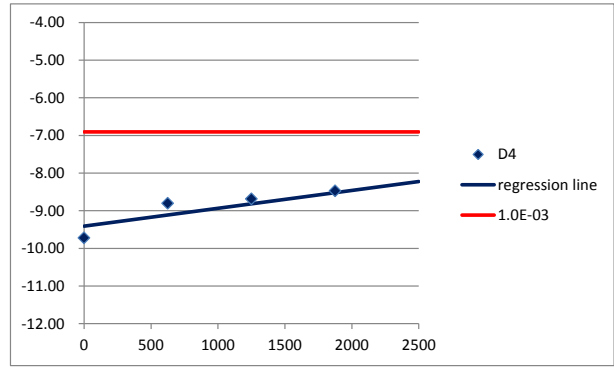
[Figure 1-1-1-4-1]から[Figure 1-1-1-4-30]に各試料のグラフを示す。



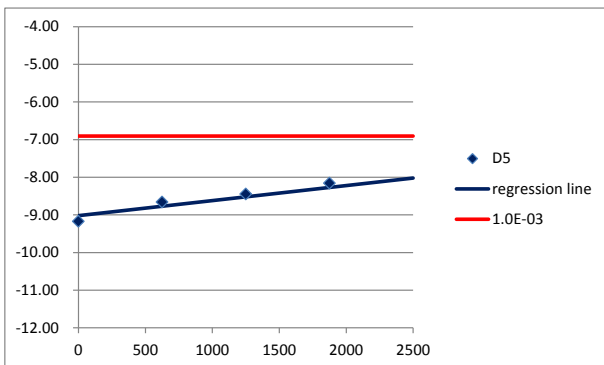
[Figure 1-1-1-4-1] 試料 D1



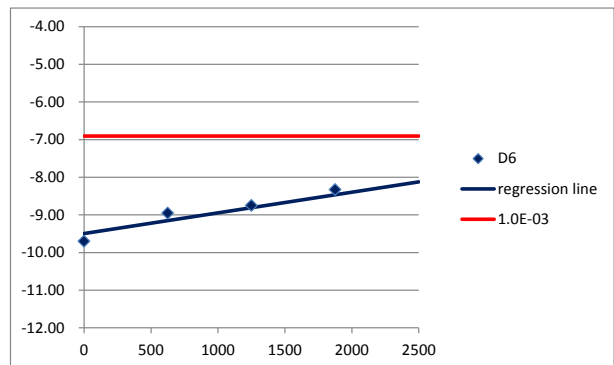
[Figure 1-1-1-4-2] 試料 D2



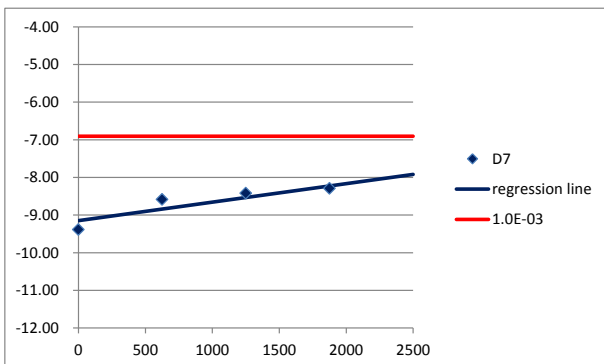
[Figure 1-1-1-4-3] 試料 D3



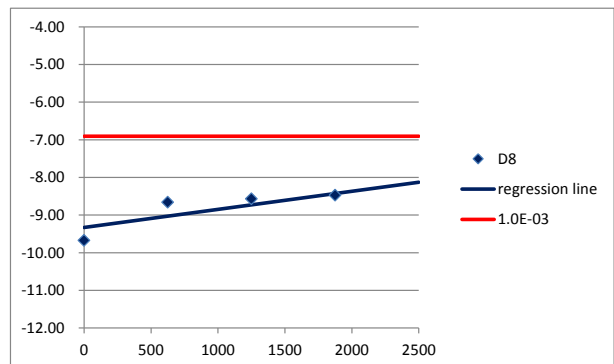
[Figure 1-1-1-4-4] 試料 D4



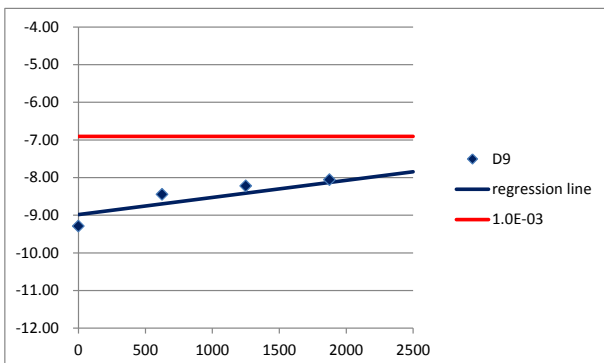
[Figure 1-1-1-4-5] 試料 D5



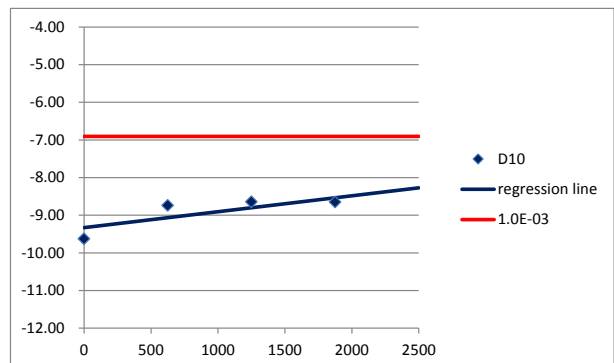
[Figure 1-1-1-4-6] 試料 D6



[Figure 1-1-1-4-7] 試料 D7

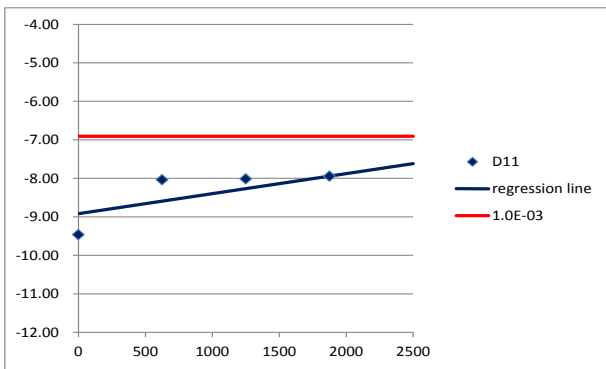


[Figure 1-1-1-4-8] 試料 D8

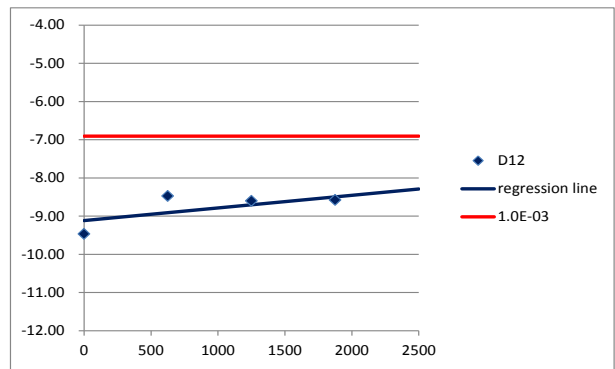


[Figure 1-1-1-4-9] 試料 D9

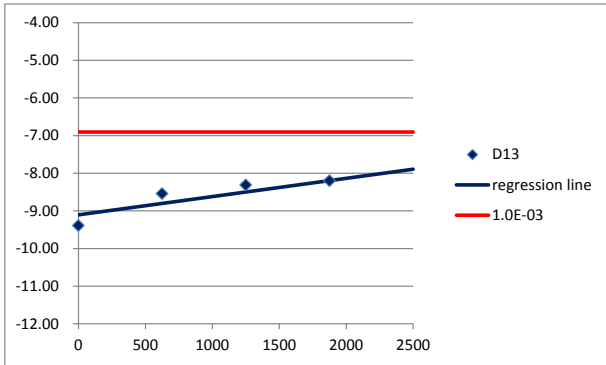
[Figure 1-1-1-4-10] 試料 D10



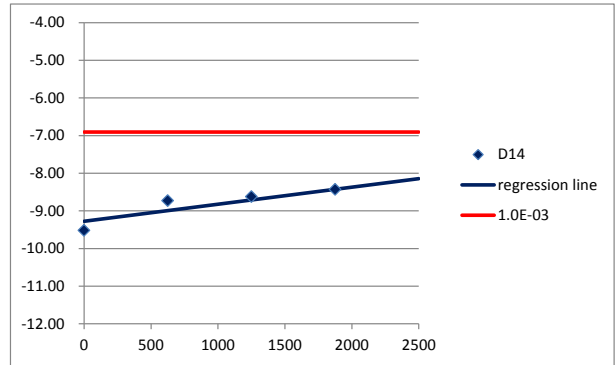
[Figure 1-1-1-4-11] 試料 D11



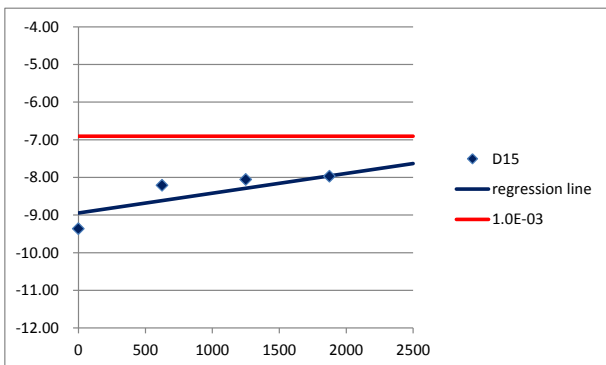
[Figure 1-1-1-4-12] 試料 D12



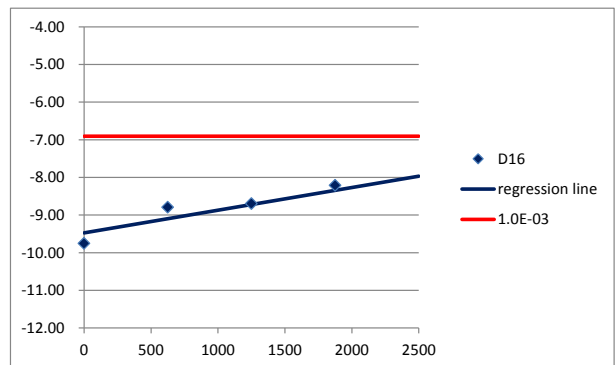
[Figure 1-1-1-4-13] 試料 D13



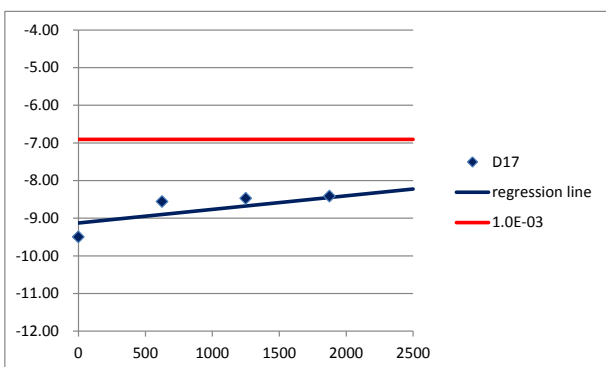
[Figure 1-1-1-4-14] 試料 D14



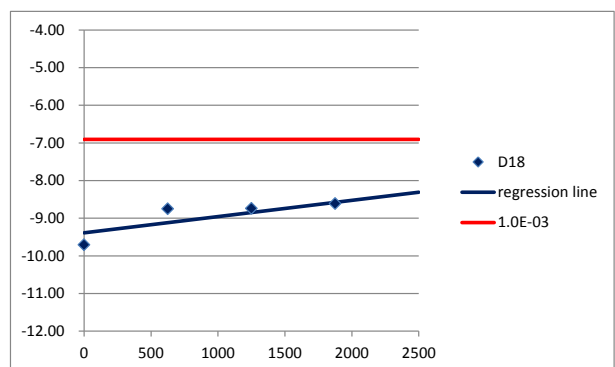
[Figure 1-1-1-4-15] 試料 D15



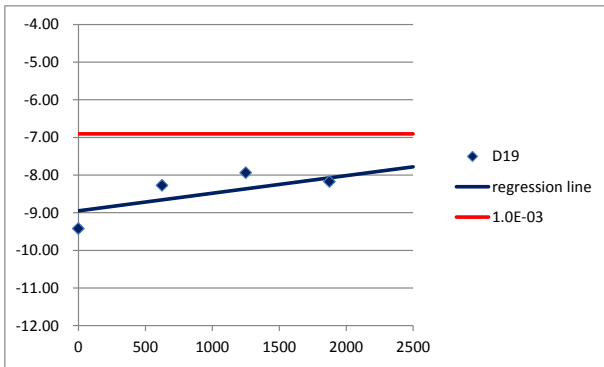
[Figure 1-1-1-4-16] 試料 D16



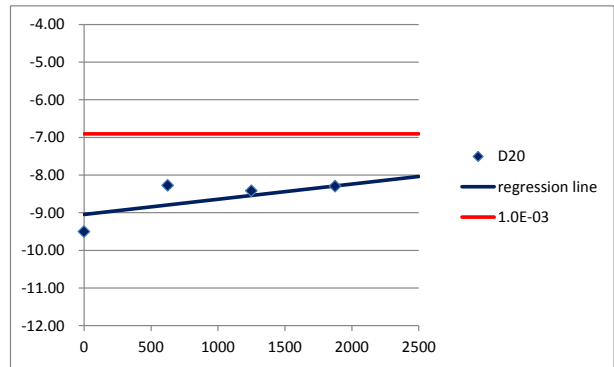
[Figure 1-1-1-4-17] 試料 D17



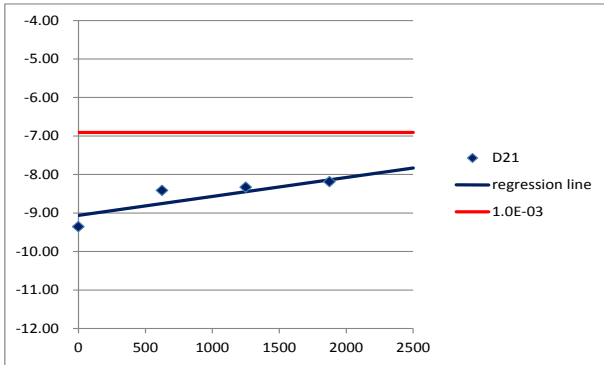
[Figure 1-1-1-4-18] 試料 D18



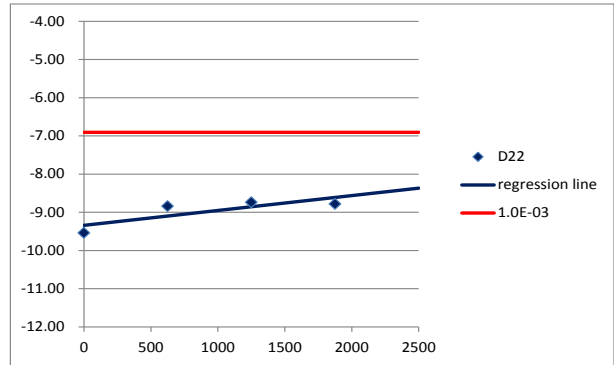
[Figure 1-1-1-4-19] 試料 D19



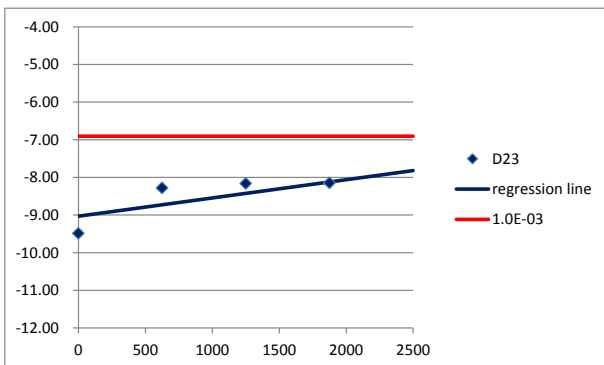
[Figure 1-1-1-4-20] 試料 D20



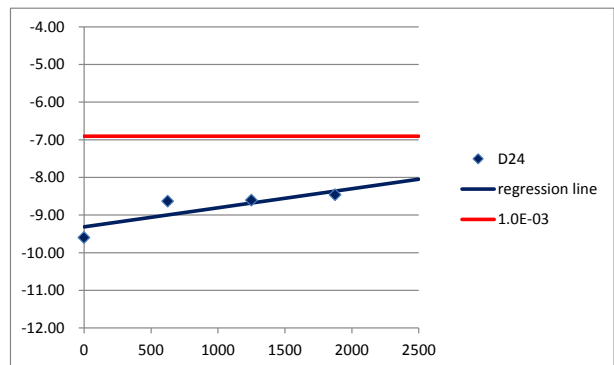
[Figure 1-1-1-4-21] 試料 D21



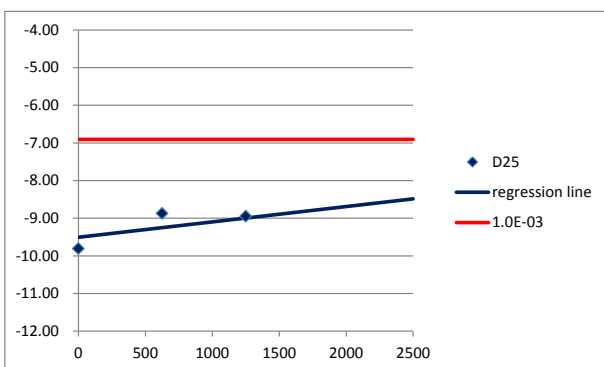
[Figure 1-1-1-4-22] 試料 D22



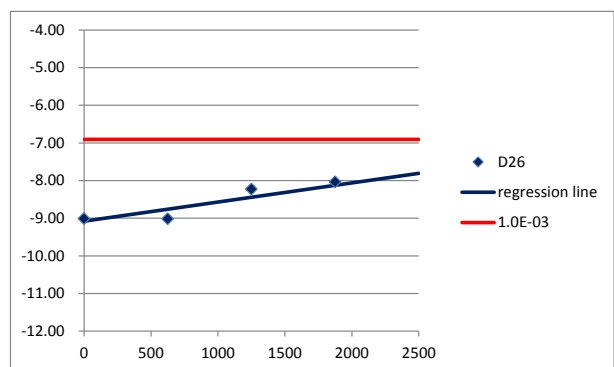
[Figure 1-1-1-4-23] 試料 D23



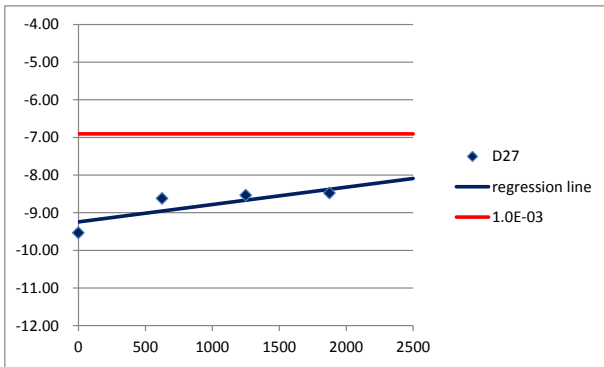
[Figure 1-1-1-4-24] 試料 D24



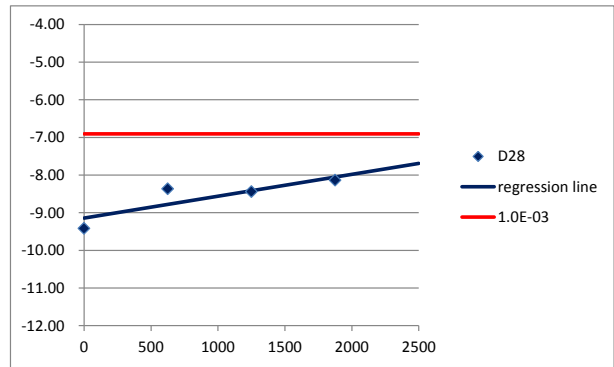
[Figure 1-1-1-4-25] 試料 D25



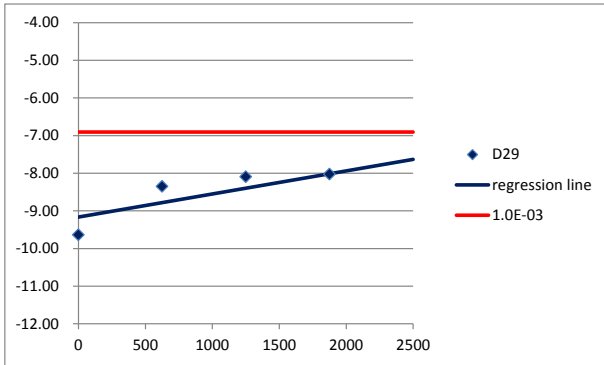
[Figure 1-1-1-4-26] 試料 D26



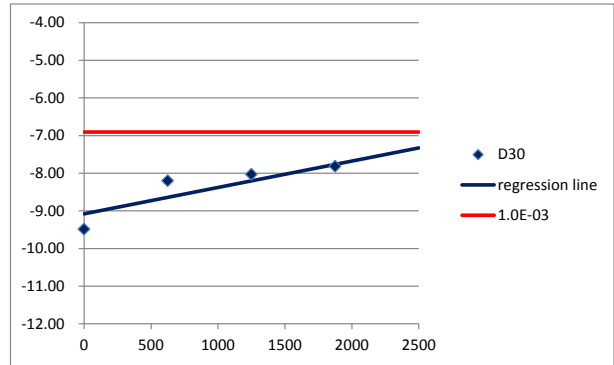
[Figure 1-1-1-4-27] 試料 D27



[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  $\ln(\text{Error}_i)$  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。

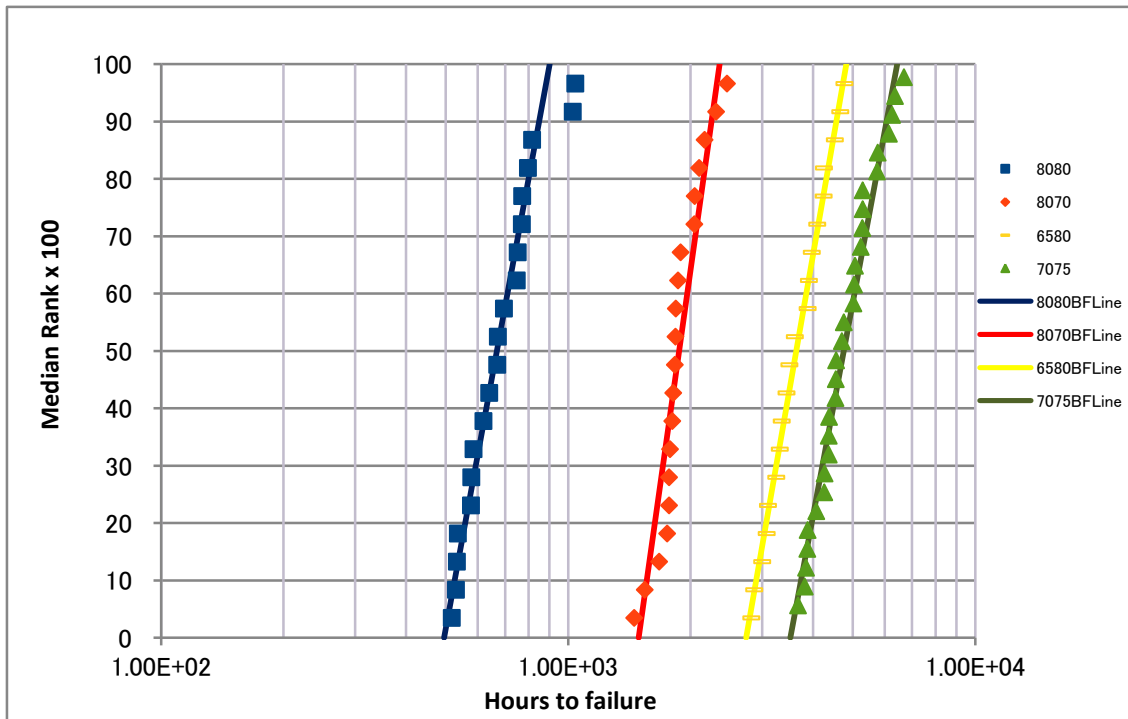
また median rank 対故障時間の対数グラフを、[Figure 1-3-1-1]に示す。

[Table 1-3-1-1]

| Order number | Group A   | Group B   | Group C   | Group D   |
|--------------|-----------|-----------|-----------|-----------|
|              | 80°C80%RH | 80°C70%RH | 65°C80%RH | 70°C75%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]

| 80°C/80%RH   |                 |        | 80°C/70%RH  |              |                 | 65°C/80%RH |             |              | 70°C/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°C/80%RH  |              |                 | Group B |             |              | 80°C/70%RH      |        |             | Group C      |                 |        | 65°C/80%RH  |              |                 | Group D |             |  | 70°C/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 | 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。

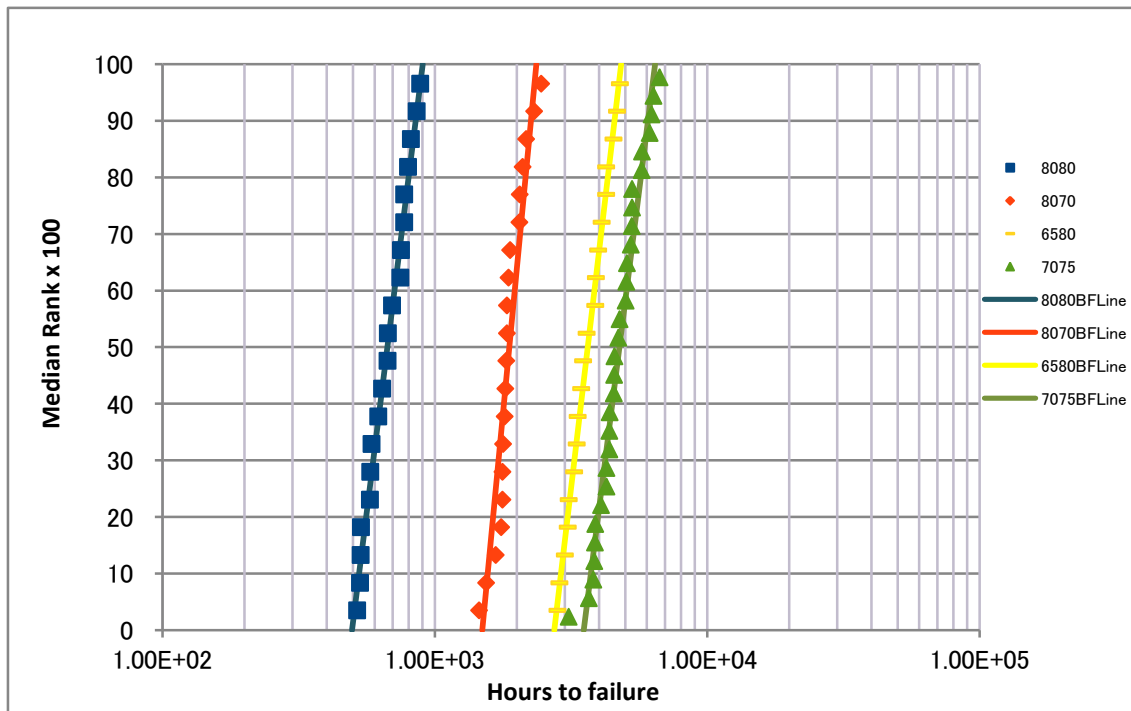
[Table 1-5-1]～[Table 1-5-2]に各試験条件の complete data set を示し、[Figure 1-5-1]にグラフを示す。

[Table 1-5-1]

| Order number | Group A   | Group B   | Group C   | Group D   |
|--------------|-----------|-----------|-----------|-----------|
|              | 80°C80%RH | 80°C70%RH | 65°C80%RH | 70°C75%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]

| 80°C/80%RH   |                 |        | 80°C/70%RH  |              |                 | 65°C/80%RH |             |              | 70°C/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( $\sigma$ )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( $(B_5 \text{ Life})_L$ )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 |
|-----------------------------------|-----------------|-----------------|----------------------------------|
| $\hat{\beta}_0$                   | $\hat{\beta}_1$ | $\hat{\beta}_2$ | $\hat{\sigma}_{ism}$             |
| -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 |
|               | Years | 6692     |
| $\ln B_5$     |       | 17.5393  |
| $B_5$ Life    | Hours | 41420402 |
|               | 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       | $\Delta H/k$ | $\ln(A)$ |
| -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 |
|------------------|-----|---------------------|------------------|----------------------|
| °C               | %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°C/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

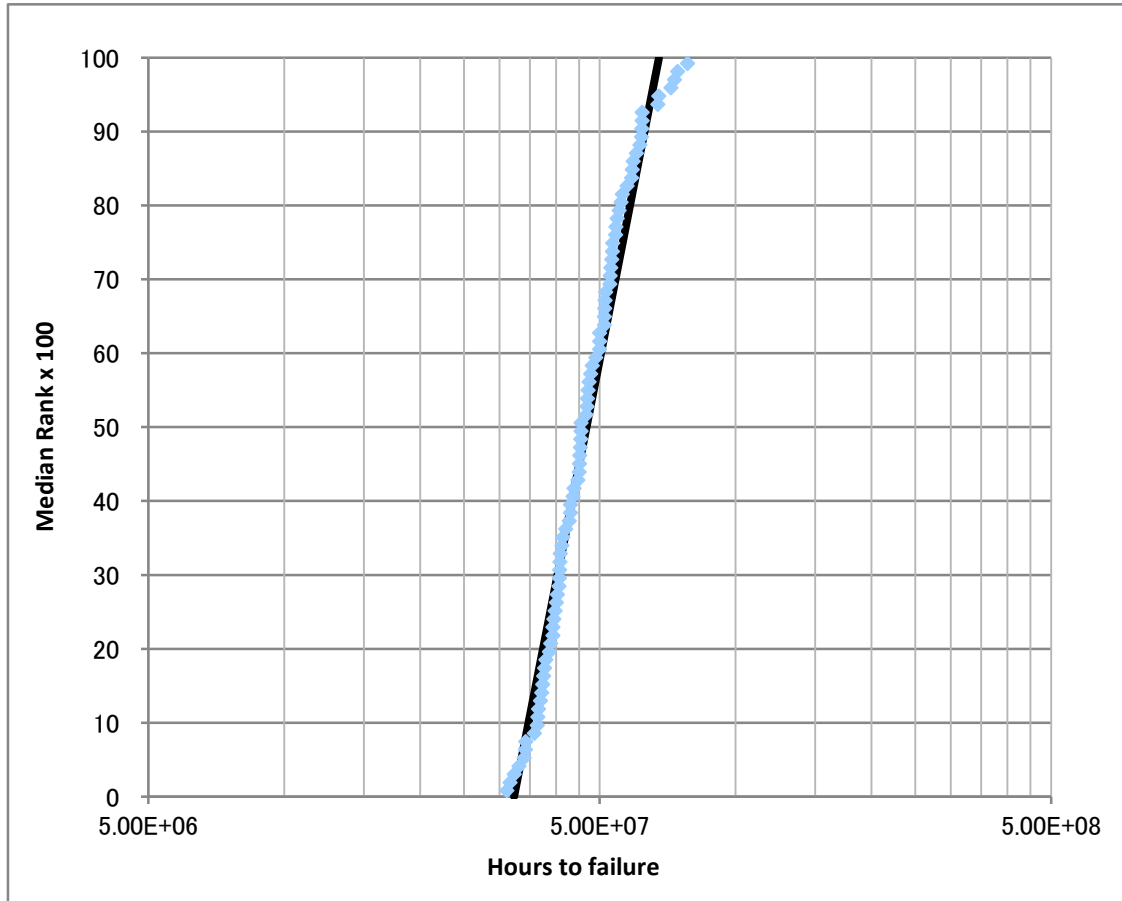
| Time-to-failure | Group # | Normalized to 25°C50%RH | Ln    | Group # | Normalized to 25°C50%RH | Order | Media rank |
|-----------------|---------|-------------------------|-------|---------|-------------------------|-------|------------|
| 518             | A       | 36474821                | 17.41 | 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°C/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°C/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. (°C)       | %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<sub>50</sub> Life, B<sub>5</sub> Life and 95% lower confidence bound of B<sub>5</sub> Life (= (B<sub>5</sub> Life)<sub>L</sub>) for the maximum-likelihood method with least squares method.

|                      |       |          |
|----------------------|-------|----------|
| B <sub>50</sub> Life | Hours | 58659119 |
|                      | Years | 6692     |

|                                    |       |          |
|------------------------------------|-------|----------|
| B <sub>5</sub> Life                | Hours | 41420402 |
|                                    | Years | 4725     |
| (B <sub>5</sub> Life) <sub>L</sub> | Hours | 24600642 |
|                                    | Years | 2806     |

B<sub>50</sub> Life, B<sub>5</sub> Life and the point estimates of the 5% with variation ( = B<sub>5V</sub> Life) for the acceleration-factor method.

|                      |       |          |
|----------------------|-------|----------|
| B <sub>50</sub> Life | Hours | 46703456 |
|                      | Years | 5328     |
| B <sub>5</sub> Life  | Hours | 33137793 |
|                      | Years | 3780     |
| B <sub>5V</sub> 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