Summary of Life Estimation Test Archive BD-R DL and TL of Mitsubishi Kagaku Media

Tested by Archive Disc Test Center

NPO-Entity

2013

Lifetime Estimation of MKM Archive BD-R Disc

- Tested by Archive Disc Test Center NPO-Entity
- Test Method
  - Based on Test method for the estimation of lifetime specified in ISO/IEC 16963: 2011 for writable CD and DVD optical discs
  - Stress-condition in Table 1 was used for Eyring method, which is modified for BD-R discs.
- Criteria for Time to failure
  - RSER(Random Symbol Error Rate) < 1×10^{-3}

Table 1 Basic stress-condition for use with Eyring method

Test cell number	Stress condition (Incubation)		Number of specimens	Total incubation subinterval time	Total incubation time	Intermediate RH	Equilibration duration time
	Temp. (℃)	%RH	-	Hours	Hours	%RH	Hours
A	80	80	20	250	1000	30	14
B	80	70	20	250	1000	30	12
C	65	80	20	500	2000	35	18
D	70	75	30	625	2500	33	22

- Data Analysis
  - The coefficients A, ΔH/ k and B of the followong reduced Eyring equation are determined by using test results

$$\ln(t)=\ln(A)+\Delta H/kT+B\times RH$$

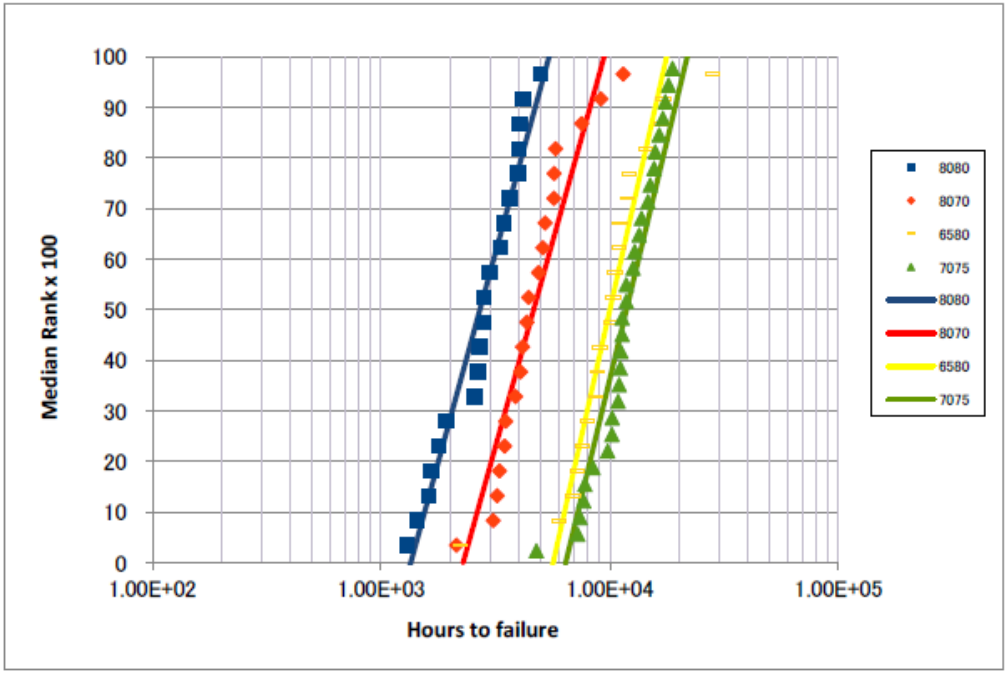
t is the time to failure; A is the pre-exponential time constant;
ΔH is the activation energy per molecule; k is the Boltzmann's constant
T is the temperature (in Kelvin);
B, C are the RH exponential constants; RH is the relative humidity;

- Estimated Lifetime of 95% lower confidence bound of 5% failure at 25℃/50%RH
  - DL : 336 years
  - TL : 2672 years

Table 2 Estimated Lifetime at 25degree/50%RH

95 % lower confidence bound of 5 % failure time				
Regression analysis	Least squares method		Acceleration factor method	
Statistical method	16963	10995	16963	10995
BD-R DL	390 years	660 years	336 years	554 years
BD-R TL	3414 years	4613 years	2672 years	3588 years

DL - Least Squares Method -



Reduced Eyring equation

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2$$

where

$$y = \ln(t),\ \beta_0 = \ln(A),\ \beta_1 = \Delta H/k,\ x_1 = 1/T$$
$$\beta_2 = -B,\ x_2 = RH$$

Figure A.1
Best fit lines of specimen group
A, B, C, D and E on lognormal paper
(Verify that the fitting lines for all stress conditions are reasonably parallel to one another)

Regression coefficients			Sum of squared residual errors	Standard deviation of residual errors
β0	β1	β2	$\hat{S}e$	σ
-20.7605	12071.58	-0.06950	11.78629	0.36807

Table A.1
Regression analysis results

Controlled storage condition		Point estimation	
Temp.(℃)	RH(%)	50percentile	
25	50	lnB50	16.2526
		B50Life(hours)	11439500
		B50Life(years)	1305

Table A.2
50 percentile of
Life distribution ($\ln B_{50}$)

DL - Least Squares Method -

- Based on 16963 method
  - ln B_{50} = 16.25 (B_{50} life = 1305.0 years)
  - σ = 0.36807
  - ln B_5 = ln B_{50} – 1.64 x σ = 15.65 (B_5 life = 713.6 years)
  - 95% lower confidence bound of B_5 Life is
    (B_5 life)$_L$ = exp (ln B_5 – 1.64 x σ) = exp (15.05) = 390 years
- Based on 10995 method
  - ln B_{50} = 16.25 (B_{50} life = 1305.0 years)
  - σ = 0.36807
  - ln B_5 = ln (L(0.05, ln B_{50}, σ)) = 15.65 (B_5 life = 712.3 years)
  - 95% lower confidence = 0.07604
  - 95% lower confidence bound of B_5 Life is
    (B_5 life)$_L$ = exp (ln B_5 – 0.07604) = exp (15.57) = 660 years

DL - Acceleration Factor Method -

Table B.1 Log mean for each stress condition

Group	Log mean	Temp.	1/T(Kelvin)	Humidity
A	7.9017	80	0.002831658	80
B	8.4420	80	0.002831658	70
C	9.2113	65	0.002957267	80
D	9.3788	70	0.002914177	75

Table B.2 Coefficients of reduced Eyring equation

B	ΔH/k	ln(A)
-0.0674	11742.2604	-19.9899

Table B.3 Acceleration factor for each stress condition

Stress		Calculated Life using "best fit" B, ΔH/k, ln(A)		Acceleration factors
℃	%RH			
80	80	2612.77	hours	3483.07
80	70	5126.43	hours	1775.20
65	80	11419.81	hours	796.90
70	75	9644.38	hours	943.60
25	50	9100449.46	hours	
25	50	1038.2	years	1 year = 365.25 days

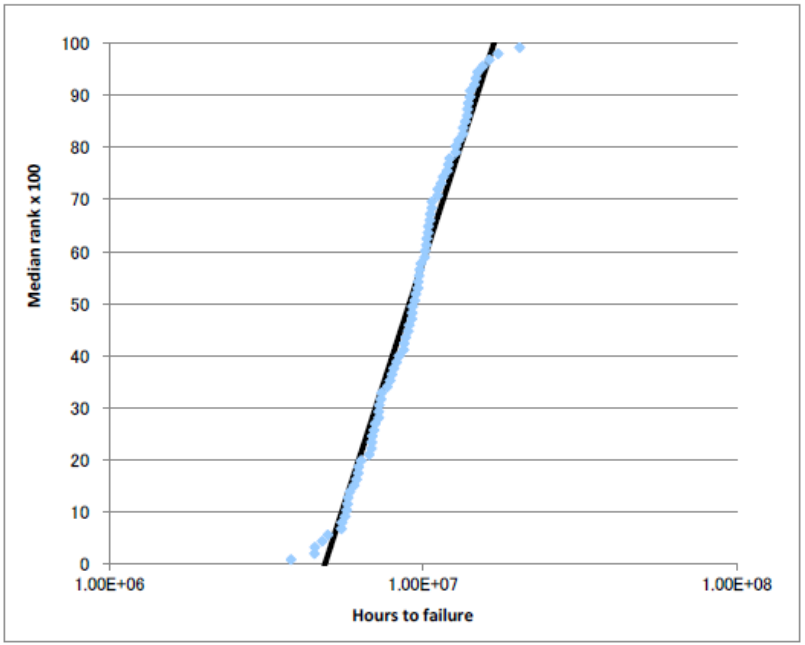
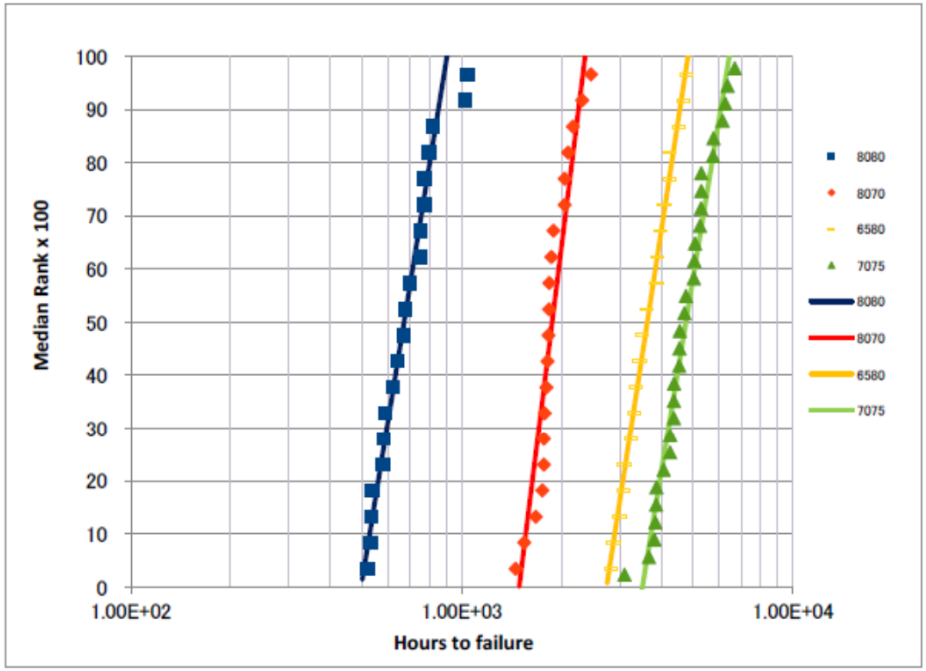


Figure B.1 - Plot of normalized data

DL - Acceleration Factor Method -

- Based on 16963 method
  - ln B_{50} = 16.05 (B_{50} life = 1066.2 years)
  - σ = 0.35184
  - ln B_5 = ln B_{50} – 1.64 x σ = 15.47 (B_5 life = 598.6 years)
  - 95% lower confidence bound of B_5 Life is
    $(B_5 \text{ life})_L$ = exp (ln B_5 – 1.64 x σ) = exp (14.90) = 336 years
- Based on 10995 method
  - ln B_{50} = 16.05 (B_{50} life = 1066.2 years)
  - σ = 0.35184
  - ln B_5 = ln (L(0.05, ln B_{50}, σ)) = 15.47 (B_5 life = 597.5 years)
  - 95% lower confidence = 0.07528
  - 95% lower confidence bound of B_5 Life is
    $(B_5 \text{ life})_L$ = exp (ln B_5 – 0.07528) = exp (15.40) = 554 years

TL - Least Squares Method -



Reduced Eyring equation

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2$$

where

$$y = \ln(t),\ \beta_0 = \ln(A),\ \beta_1 = \Delta H/k,\ x_1 = 1/T$$
$$\beta_2 = -B,\ x_2 = RH$$

Figure C.1
Best fit lines of specimen group
A, B, C, D and E on lognormal paper
(Verify that the fitting lines for all stress conditions are reasonably parallel to one another)

Regression coefficients			Sum of squared residual errors	Standard deviation of residual errors
β_0	β_1	β_2	$\hat{S}e$	σ
-26.6528	15060.04	-0.11907	3.86306	0.21072

Table C.1
Regression analysis results

Controlled storage condition		Point estimation	
Temp.(°C)	RH(%)	50percentile	
25	50	$\ln B_{50}$	17.9054
		B_{50}Life(hours)	59735287
		B_{50}Life(years)	6814

Table C.2
50 percentile of
Life distribution ($\ln B_{50}$)

TL - Least Squares Method -

- Based on 16963 method
  - $\ln B_{50} = 17.91$ (B_{50} life = 6814.4 years)
  - $\sigma = 0.21072$
  - $\ln B_5 = \ln B_{50} - 1.64 \times \sigma = 17.56$ (B_5 life = 4823.3 years)
  - 95% lower confidence bound of B_5 Life is
    $(B_5 \text{ life})_L = \exp(\ln B_5 - 1.64 \times \sigma) = \exp(17.21) = 3414$ years
- Based on 10995 method
  - $\ln B_{50} = 17.91$ (B_{50} life = 6814.4 years)
  - $\sigma = 0.21072$
  - $\ln B_5 = \ln(L(0.05, \ln B_{50}, \sigma)) = 17.56$ (B_5 life = 4818.4 years)
  - 95% lower confidence = 0.04353
  - 95% lower confidence bound of B_5 Life is
    $(B_5 \text{ life})_L = \exp(\ln B_5 - 0.04353) = \exp(17.52) = 4613$ years

TL - Acceleration Factor Method -

Table D.1 Log mean for each stress condition

Group	Log mean	Temp.	1/T(Kelvin)	Humidity
A	6.5050	80	0.002831658	80
B	7.5358	80	0.002831658	70
C	8.1987	65	0.002957267	80
D	8.4668	70	0.002914177	75

Table D.2 Coefficients of reduced Eyring equation

B	ΔH/k	ln(A)
-0.1159	14751.4004	-26.0218

Table D.3 Acceleration factor for each stress condition

Stress		Calculated Life using		Acceleration
℃	%RH	"best fit" B, ΔH/k, ln(A)		factors
80	80	650.10	hours	71862.74
80	70	2071.69	hours	22550.66
65	80	4146.57	hours	11266.65
70	75	3920.20	hours	11917.24
25	50	46717966.77	hours	
25	50	5329.45	years	1 year = 365.25 days

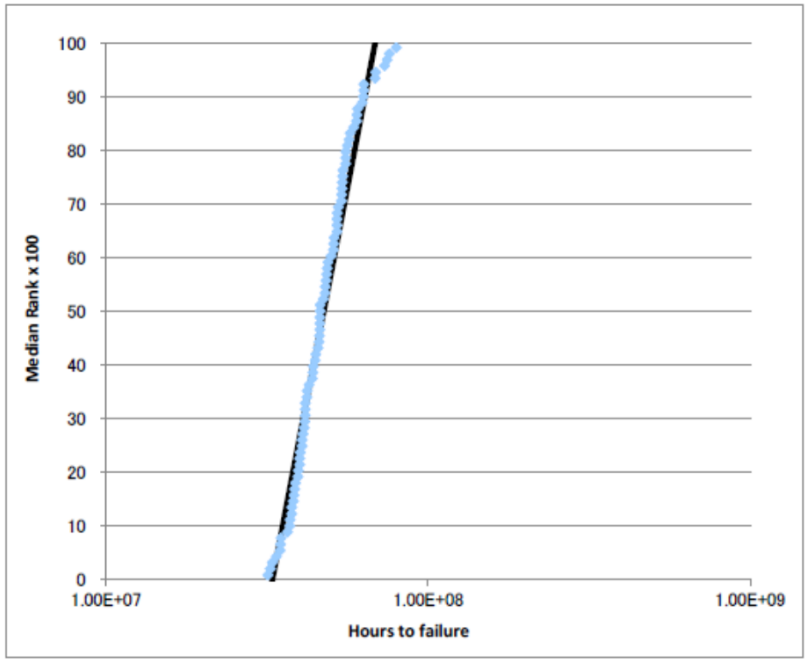
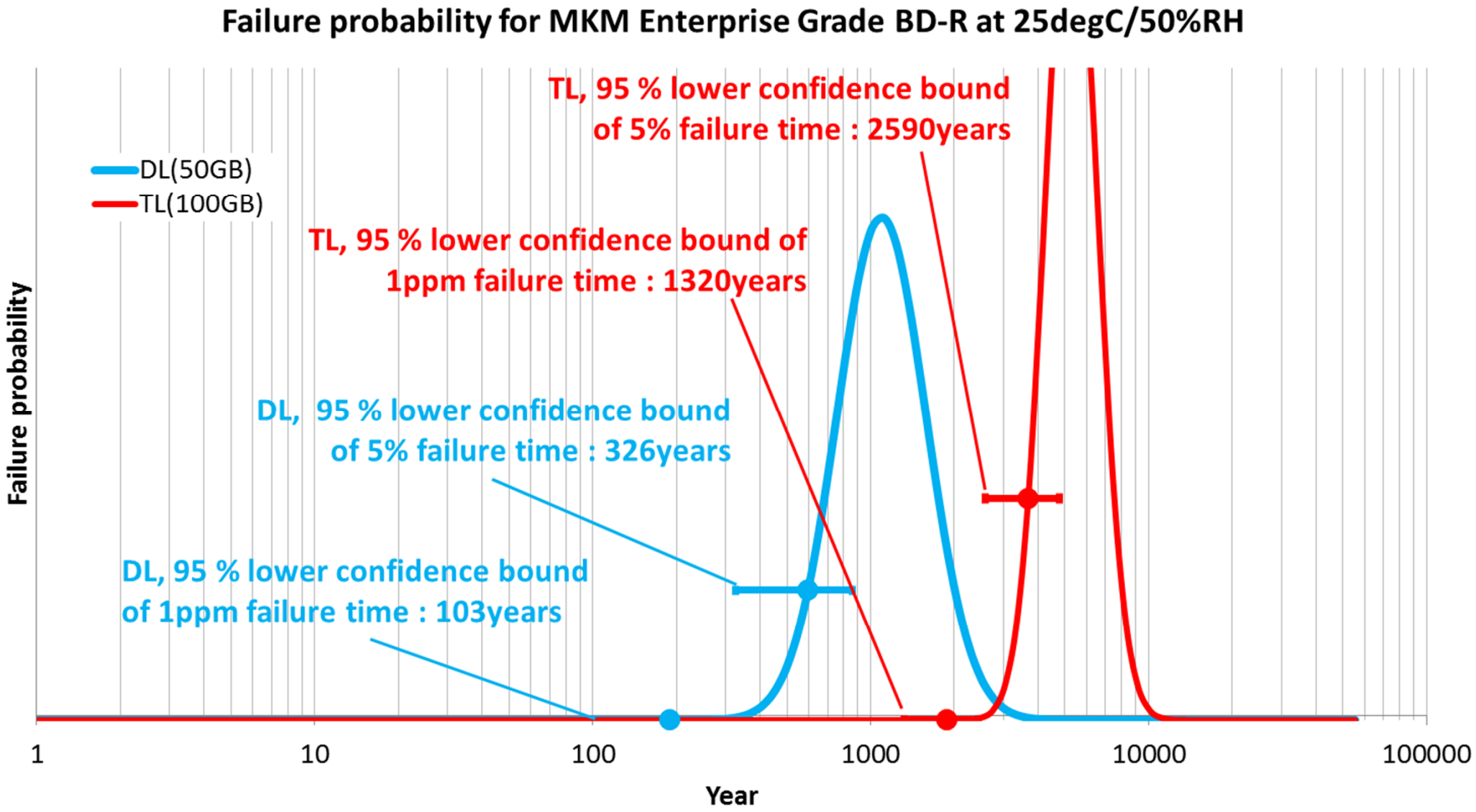


Figure D.1 - Plot of normalized data

TL - Acceleration Factor Method -

- Based on 16963 method
  - $\ln B_{50} = 17.65$ (B_{50} life = 5265.9 years)
  - $\sigma = 0.20684$
  - $\ln B_5 = \ln B_{50} - 1.64 \times \sigma = 17.31$ (B_5 life = 3751.1 years)
  - 95% lower confidence bound of B_5 Life is
    $(B_5 \text{ life})_L = \exp(\ln B_5 - 1.64 \times \sigma) = \exp(16.97) = 2672$ years
- Based on 10995 method
  - $\ln B_{50} = 17.65$ (B_{50} life = 5265.9 years)
  - $\sigma = 0.20684$
  - $\ln B_5 = \ln(L(0.05, \ln B_{50}, \sigma)) = 17.31$ (B_5 life = 3756.1 years)
  - 95% lower confidence = 0.04346
  - 95% lower confidence bound of B_5 Life is
    $(B_5 \text{ life})_L = \exp(\ln B_5 - 0.04346) = \exp(17.26) = 3588$ years

Long term stability=Less migration



Based on Life Estimation Test Report of MKM BD-R DL and BD-R BDXL TL by ADTC (Archive Disc Test Center-NPO Entity)