Section 2 Reliability

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Section 2 Reliability

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Reliability definition

Newly added

1. The ability of an apparatus, machine, or system to consistently perform its intended or required function or mission, on demand and without degradation or failure.

2. Manufacturing: The probability of failure-free performance over an item's useful life, or a specified timeframe, under specified environmental and duty-cycle conditions. Often expressed as mean time between failures (MTBF) or reliability coefficient. Also called quality over time. This is concept that we are considering in this material.

Updated

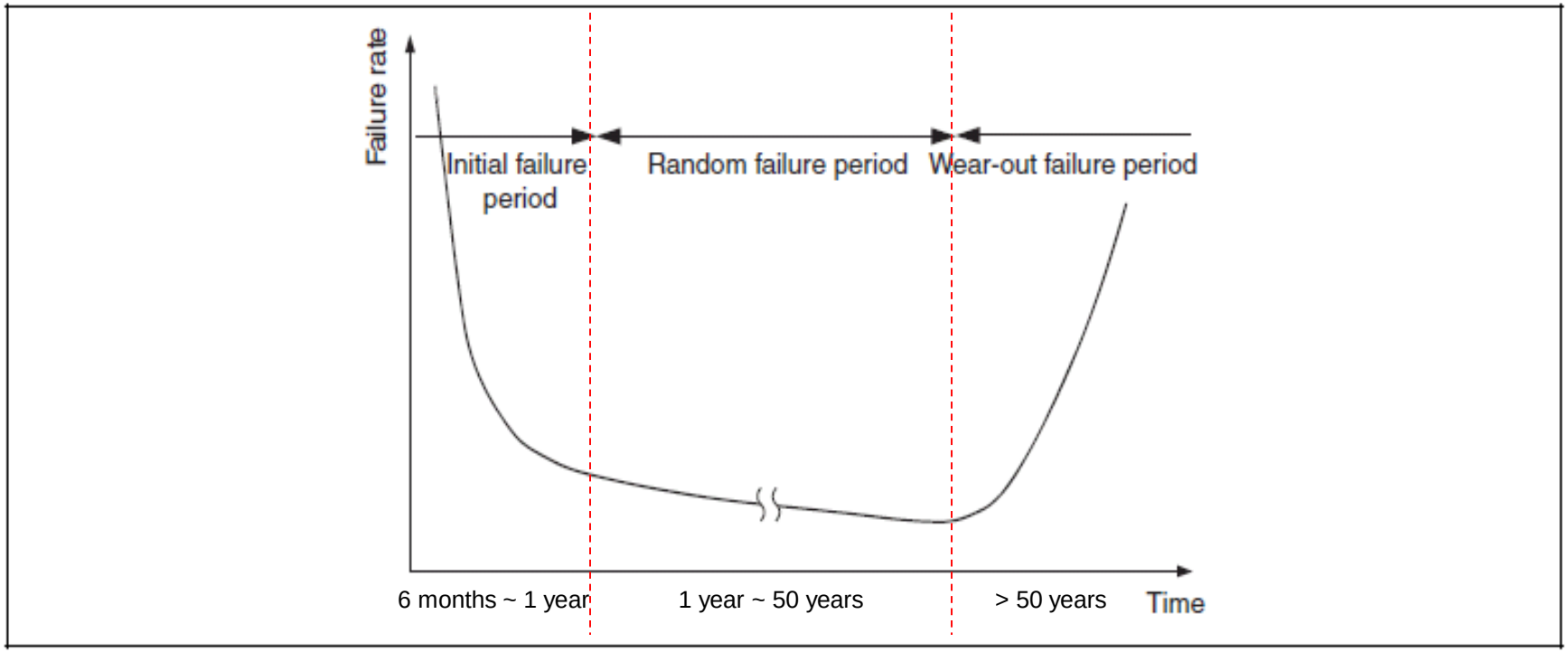


Figure 2.1 Failure Rate Curve (Bathtub Curve)

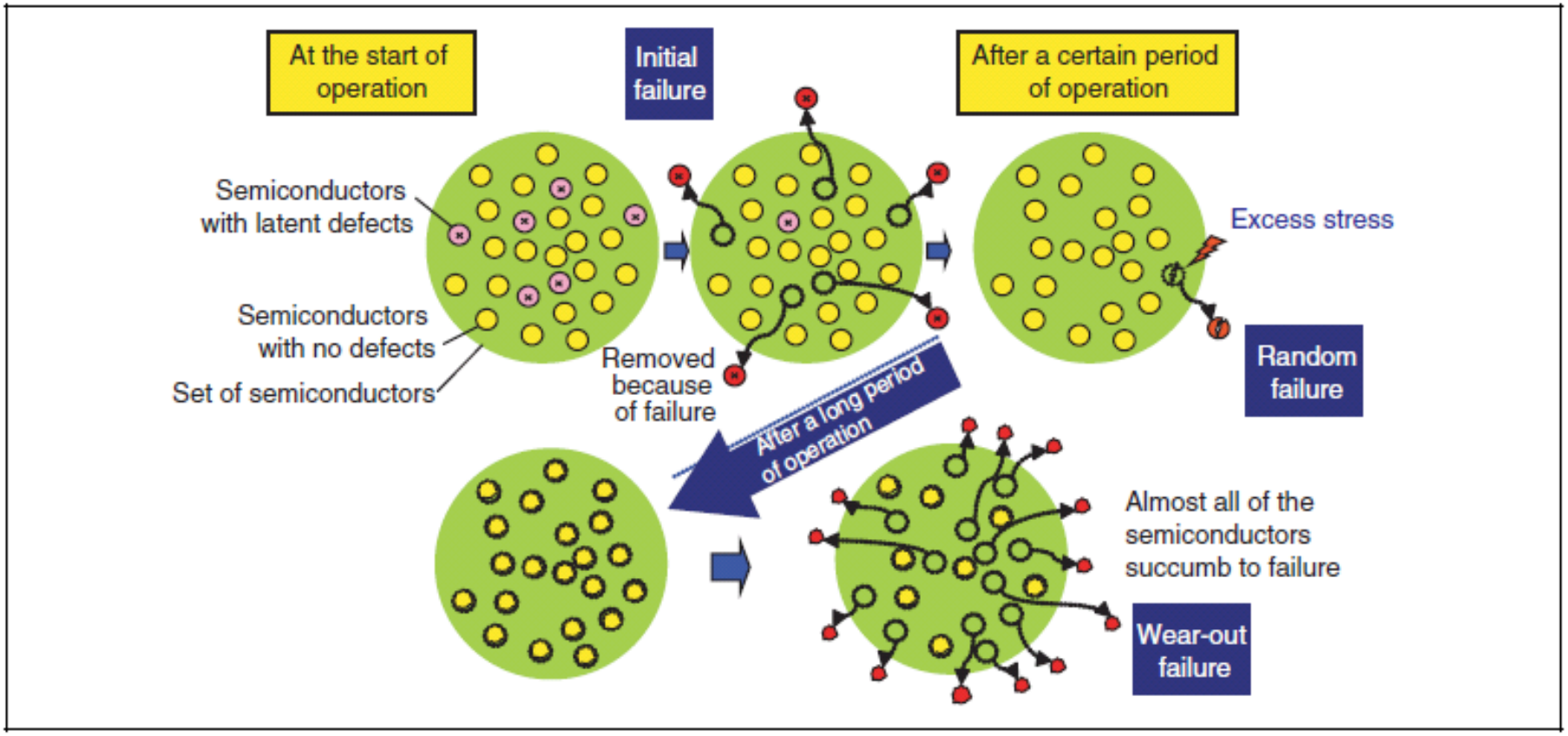


Figure 2.2 Image Showing Changes in the Semiconductor Failure Rate Results in a Bathtub Curve

There are three types of failure mode

Initial / Random / Wear out

If we summarize them , we can get Bath tub curve.

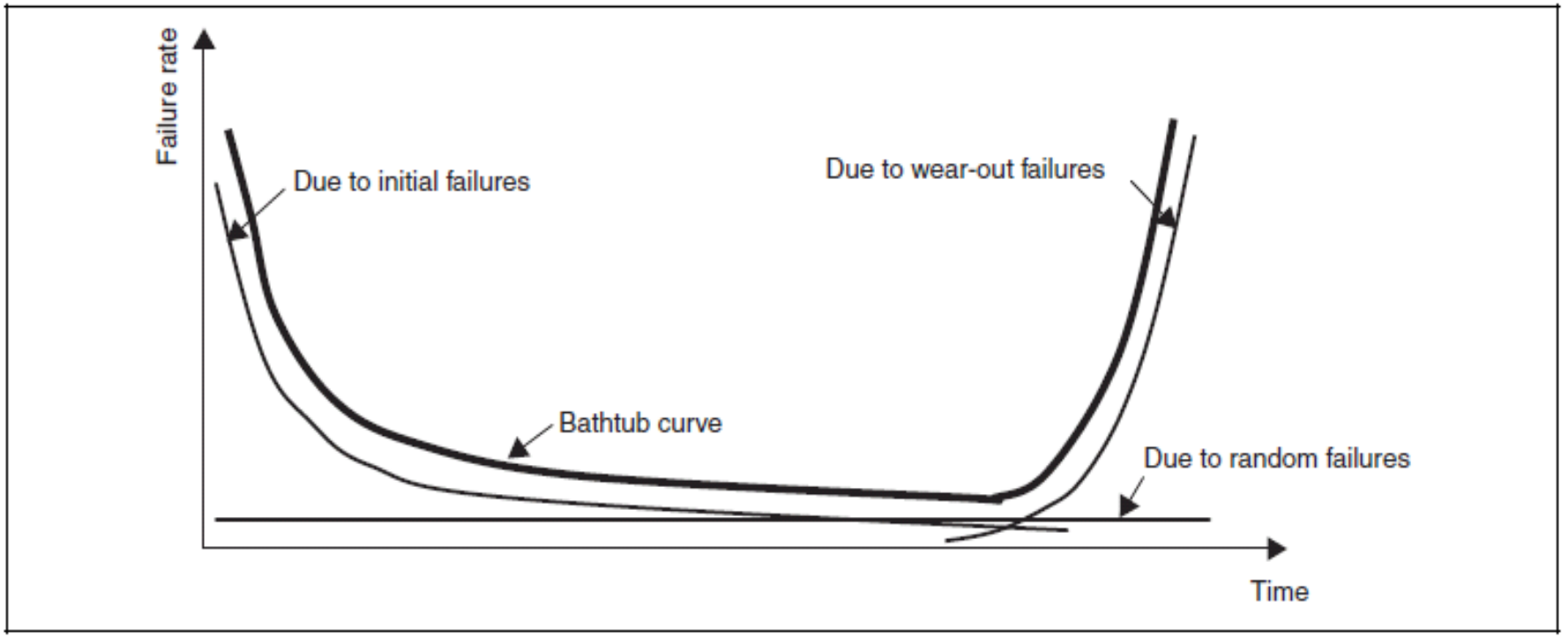


Figure 2.3 Factors Creating the Bathtub Curve

Failure rate ?

Reliable function : R(t)
(Cumulative alive rate)

Failure function : F(t)
(Cumulative failed rate)

$$R(t) + F(t) = 1$$

$$\text{Failure distribution function} = f(t) = \frac{dF(t)}{dt}$$

$$\text{Failure rate} = \lambda(t) = \frac{dF(t)/dt}{R(t)} = \frac{f(t)}{R(t)}$$

Probability that the parts operating normally become failure per hour.

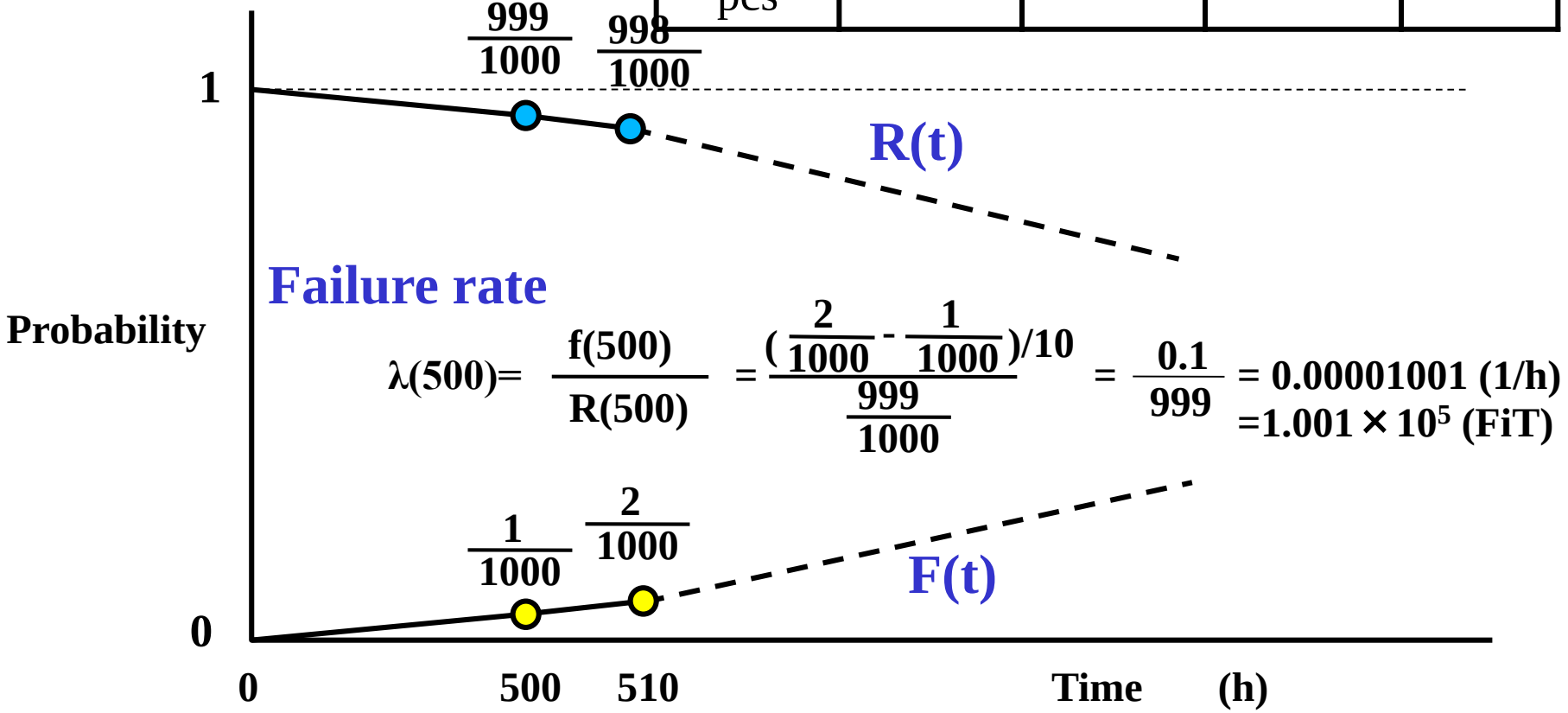
Unit of failure rate :

Fit (Failure In Time) ---- $1\ \text{Fit} = 1 \times 10^{-9}$ (1/h)

%/1000h ---- $1\%/1000\text{h} = 1 \times 10^{-4}$ (1/h)

Example of failure rate

Sample size	Cumulative failure count at each time			
	0h	500h	510h	
1000 pcs	0	1	2	



F(t); Failure function = Cumulative failed rate

R(t); Reliable function = Cumulative alive rate

$$F(t) + R(t) = 1 ;$$

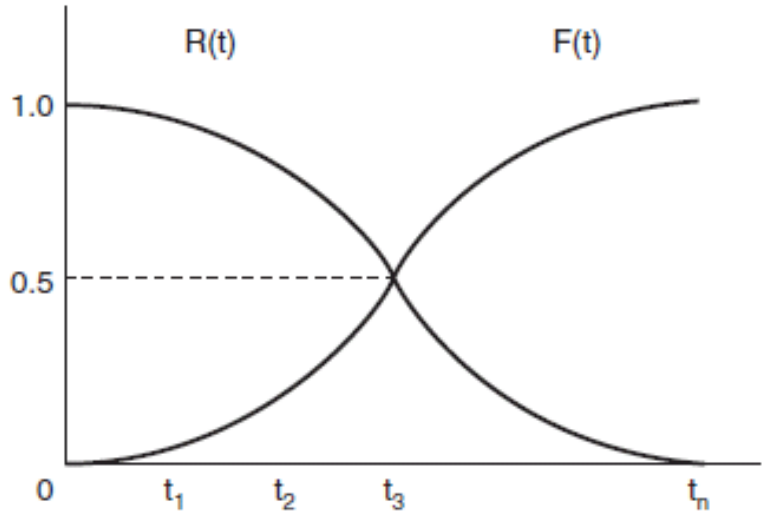


Figure 2.6 Example of *R*(*t*) and *F*(*t*)

F(t); Failure function = Cumulative failed rate

R(t); Reliable function = Cumulative alive rate

$$F(t) + R(t) = 1 ;$$

f(t); Failure distribution function

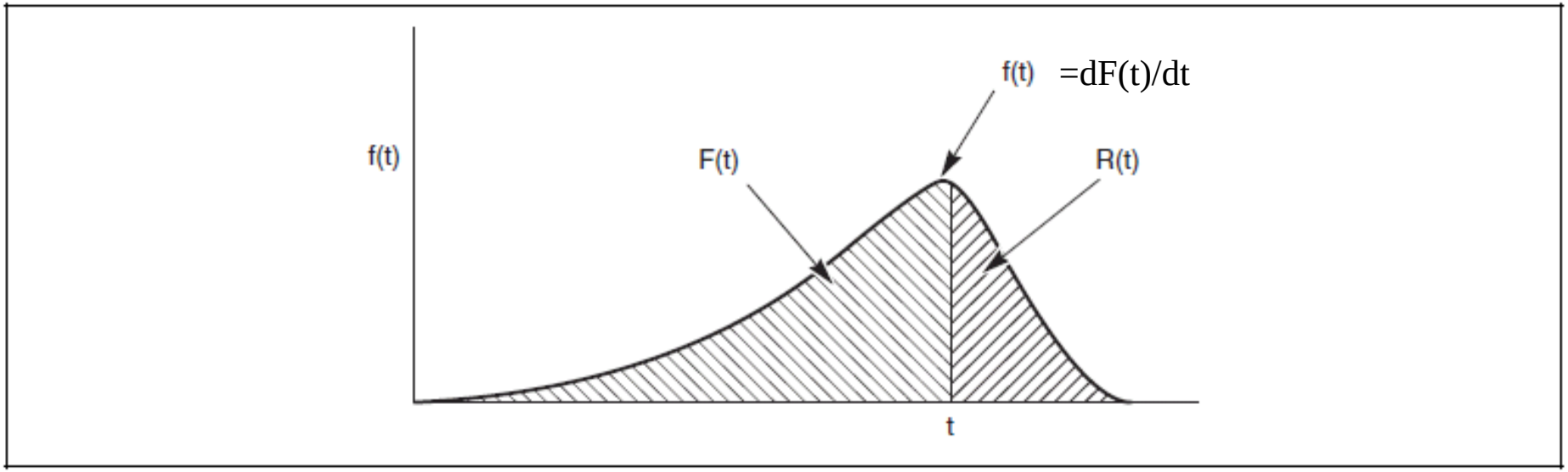


Figure 2.7 Schematic of $f(t)$, $R(t)$, $F(t)$

Quality basic 3 parameters
Initial (ppm) / Random (fit) / Wear out (year)
fit = 1 ppm failure at 1000 h

Table 1.1 Quality Levels

Quality Level	Description	Typical Product Applications
High reliability	High-quality products	Vehicles (drive-train systems) and general traffic systems
Industry	Industrial applications	Vehicles (accessories) and industrial factory automation
Consumer	General-use products (including products subject to PPM (parts per million) control and custom-made products)	PCs, home appliances, and mobile phones
Custom	Products with individual specifications (products not fitting into any of the levels above and set with different standards)	Video games, mobile phones, and applications requiring ultra high reliability*

Note: * Designed under a separate contract

Summary

Newly added

Factor	Initial	Random	Wear-out
Unit	ppm	fit	year
Appearance time	6 months ~ 1 year	1 year ~ 50 years (*)	> 50 years (*)
	(*) 50 years : is wear-out time		
Failure reason	Latent defect	Excess stress	Design
Sharp parameter (m)	<< 1	1	>>1
Examples	Foreign substance	ESD, cosmic ray, alpha ray	Design reach it end of life
Impact	Small	Very small	Most serious

Renesas Electronics Corporation