Product Reliability

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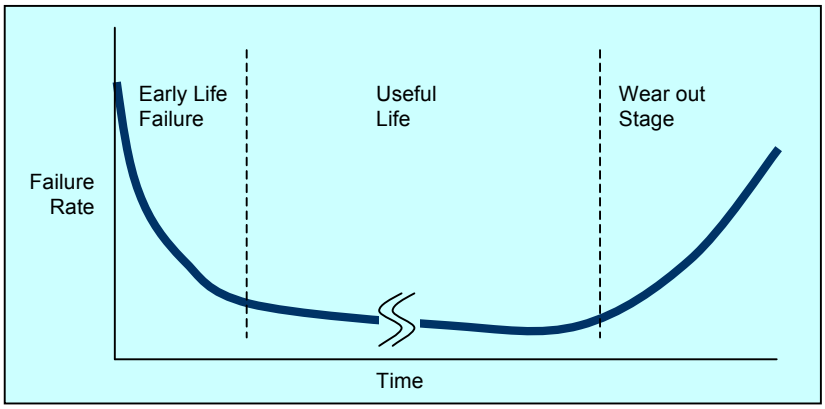
Measuring Reliability

MOX is committed to delivering high quality products that are reliable and maintainable.

In all manufactured products there is a measure of reliability called failure rate. A concept related to failure rate (its mathematical inverse) is often used to more clearly specify or measure reliability. This concept is called the "mean time between failure" (MTBF). This is the average time that the product will operate before a failure will occur. The MTBF of a product should not be confused with the life of an item. MTBF is a measure of random failures.

The failure rate varies in a predictable manner over the life of the product and can be considered as occurring in three different periods of the life of the product. This variation forms what has been called a **bath-tub** curve because of its shape. This curve is illustrated below



During the first period of **Early Life Failure**, failures are usually high and decrease rapidly. MOX Products attempts to eliminate early life failures in delivered product through the use of burn in and stabilization staging. Depending on a client's requirements, full burn in to derived methods of the US Military Specifications MIL-STD-883E Method 1015.9 may be conducted.

A minimum 48 hour burn in at high temperature is conducted by MOX on the product component electronics. In addition, a 48hr early life stabilization staging is conducted by MOX on all finished manufactured products prior to delivery. Comprehensive testing is conducted immediately before the staging event and a subsequent functional test verifies each individual product.

The second period is the **Useful Life** of the product. This may vary due to particular installation conditions and other stresses such as temperature, voltage, humidity or other atmospheric conditions. The Useful Life of the product may be extended in some environments through the use of Conformal Coating. Essentially the products must be designed and manufactured such that the MTBF is much greater than the Useful Life.

The third period in the life of the product is the **Wear Out Stage**. The failure rate again climbs rapidly and is caused by the general physical and/or chemical deterioration with time such that the functioning of the product is unacceptable.

Product Reliability Calculations

Based on actual and extrapolated field installation data and product return data, the reliability information has been calculated. The following general theoretical calculation methods have been utilized.

MTBF: Mean Time Between Failure (hours)

MTTR: Mean Time To Repair (hours)

FR: Estimated Failure Rate (1/hrs)

RR: Repair Rate (1/hrs)

A-SS: Steady State Availability

U-SS: Steady State Unavailability

$$\text{Total Hours of Operation} = \sum_{i=1}^{\text{Total units}} \text{unit operational hours}$$

$$\text{MTBF} = \frac{\text{Total Hours of Operation}}{\text{Total Applicable Failures}}$$

$$\text{FR} = 1 / \text{MTBF}$$

$$\text{RR} = 1 / \text{MTTR}$$

$$\text{U-SS} = \text{FR} / \text{RR}$$

$$\text{A-SS} = 1 - \text{FR} / \text{RR}$$

In a dual redundant or hot standby installation, the availability of the operational pair should take into consideration the combination of the two units. It is clear that improvements should be made. The following availability calculations apply. The assumptions are:

- That one repair-man is sufficient to perform the repair successfully within the given MTTR
- That switching to the redundant unit is seamless and transparent to the process and the switching time is effectively zero.

$$FR_{TOT} = \frac{2 \times FR^2}{3 \times FR + RR}$$

$$RR_{TOT} = RR$$

$$U\text{-}SS_{TOT} = FR_{TOT} / RR_{TOT}$$

$$A\text{-}SS_{TOT} = 1 - FR_{TOT} / RR_{TOT}$$

Product Reliability Results

All calculations use the maximum Mean Time To Repair (MTTR) hours. It is expected that clients will have available spare parts which will allow replacement of the failed item within a three hour period.

Product Reliability Information calculated with reference to a 12 month period

Product	MTBF (hours)	MTBF (years)	Failure Rate (1/hrs)	MTTR (hours)	Repair Rate (1/hrs)	U-SS (total)	A-SS (TOT) (total)	U-SS (hours)
MOX OC	355,680	40.6	2.81E-06	3	0.33333	8.43E-06	99.9992%	0.07
MOX Origin	266,760	30.5	3.75E-06	3	0.33333	1.12E-05	99.9989%	0.10
MOX Unity/Gateway	444,600	50.8	2.25E-06	3	0.33333	6.75E-06	99.9993%	0.06
MOX Ionix	386,720	44.2	2.59E-06	3	0.33333	7.76E-06	99.9992%	0.06
MOX 603 I/O	430,258	49.1	2.32E-06	3	0.33333	6.97E-06	99.9993%	0.06

Product Dual Redundant Installation Reliability Information calculated with reference to a 12 month period

Product	MTBF (hours)	MTBF (years)	Failure Rate (1/hrs)	MTTR (hours)	Repair Rate (1/hrs)	U-SS (total)	A-SS (TOT) (total)	U-SS (hours)	U-SS (secs)
MOX OC	355,680	40.6	4.74E-11	3	0.33333	1.42E-10	99.999999986%	0.0000012	0.0044869
MOX Unity/Gateway	444,600	50.8	3.04E-11	3	0.33333	9.11E-11	99.999999991%	0.0000008	0.0028716
MOX 603 I/O	430,258	49.1	3.24E-11	3	0.33333	9.72E-11	99.999999990%	0.0000009	0.0030663

The MTTR should be recalculated if spare parts are not retained by the clients.

For in country repairs where product is returned to the local MOX Office, a repair time of 72 hrs maximum is expected from time of shipment from the client's site. (This depends very much on the method of shipment chosen and the time when it is shipped)

An out of country warranty repair service is utilized. If returning to Australia, a repair time of 14 days or 336 hrs is expected from date of shipment from the client's site. (This again depends very much on the method of shipment chosen. MOX Products recommends TNT Worldwide Express)

Operational Influences on MTBF Values

As previously discussed, the failure statistics of all manufactured products from every company correspond to the bathtub curve. General rules of thumb apply to industrial automation equipment:

- The failure rate during the first three months is four times higher than afterwards
- Where equipment power is cycled on & off every day, the failure rate is expected to double
- Where wide temperature fluctuations occur, the failure rate is also expected to double

Implementation Considerations

The reliability calculations and resulting information may be used by the end customer to determine installation and implementation strategies. Some simple rules may be followed:

- An average product will not need any repair until the end of its useful life (assumed to be 20 years)
- Due to the low number of expected repair cases and the very specific components and tools required, the customer should not need to consider the setup of a test and repair facility on their site.
- The expected useful life of an individual product is far greater than the expected support time from any semiconductor or component manufacturer (a particular semiconductor is available for approx. 3 years; with some rare stocks up to 10 years) Normally, products will be repaired by MOX under the terms of the product warranty. Additionally, MOX will generally hold parts to cater for the expected repairs required over the useful life of the product family. However, there is no guarantee that parts will always be available. To be certain a customer's installation remains fully operational, we recommend the purchase of spare parts for the required application life time. The MTBF figures may be used to estimate required volumes of spare parts. Alternatively, MOX is committed to the development of new products in order to keep abreast of current technologies. We would expect full backward compatibility will be maintained and therefore suitable replacement products will always be available to our customers.

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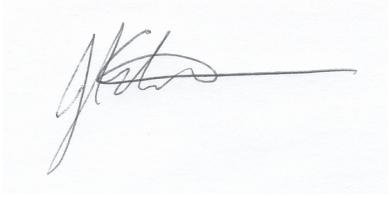

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