



## MTBF (Mean Time Between Failures) and MTTR (Mean Time to Repair) for NEPSI's Metal-Enclosed Solutions

The Applicability (or Inapplicability) of Mean Time Between Failures (MTBF) and Mean Time To Repair (MTTR) to Metal-Enclosed Capacitors Banks and Harmonic Filter Banks and the NEPSI experience.

### BACKGROUND

Many buyers of equipment look to MTBF (mean time between failures) and other related metrics MTTR (mean time to repair), MTTF (mean time to failure) to gauge product reliability and performance. These metrics can be helpful when evaluating products such as mass produced electronic commodities (an iphone), but occasionally, buyers of capacitor banks and harmonic filter banks seek the same information.

This document presents the concept of MTBF and MTTR, and examines why use of such metrics is inappropriate in the real-world evaluation of capacitor banks and harmonic filter banks.

As with all metrics, it is necessary to understand intentions, parameters, and to clearly define all inputs to ap-

propriately evaluate the usefulness of the metric and comparability of the products under evaluation. To understand the usefulness of this metric it is first necessary to understand the metric itself.

### MEAN TIME BETWEEN FAILURES (MTBF)

**WHAT IS MTBF?** MTBF is the average uptime between successive failures (assuming repair is possible). That is, for example, the average time a filter system operates until it fails and needs to be repaired. The MTBF value can change significantly based on assumptions made and inputs used. It is easy to remove or add parameters to move the MTBF in a favorable direction, and customers should be wary of misunderstanding or misrepresentation.



Open-Air



Metal-Enclosed

*Empirically, it is easy to conclude that metal enclosed harmonic filter banks and capacitor banks offer improved reliability (higher MTBF) and maintainability (lower MTTR) when compared to open-air harmonic filter systems. For an expanded analysis of the advantages of metal-enclosed systems refer to "The Metal-Enclosed Advantage" on the technical resource page at [www.nepsi.com](http://www.nepsi.com).*



**ASSUMPTIONS -**

**FAILURE:** What is or is not included in the definition of failure can have a significant impact on the ultimate MTBF value, and any MTBF value can be influenced with simple modifications to those parameters. For example, a failure could be defined as a harmonic filter system fault that would result in shutting down a concentrator plant. Another definition could be the failure of an individual component, a capacitor for example, which may or may not result in a plant shutdown or complete shutdown of the filter system. Are acts of god (floods, lightning, earthquakes, etc.) that cause filter system shutdown considered failures? And what if a system is running, but in a degraded capacity. Do you remove certain categories of shutdowns when using a MTBF formula to yield a higher (“better”) MTBF value?

**OPERATING TIME:** If in the MTBF formula you included all operating time from when the filter system was commissioned (or recommissioned), and not only when the filter system was under working stress, your MTBF value would be higher. But that MTBF value would not be directly comparable to a filter system that is continually working and hardly ever idling. Simply, you cannot use MTBF as an indicator to compare the two identical filter systems that are operating in an environment with different duties or duty cycles.

**ENVIRONMENT/MAINTENANCE:** The key to meaningful metrics is standardization and uniformity. To make sense of a MTBF calculation you need to know the specific situation and operating scenarios being measured, and have an observable set from which to draw and record data. Even if all other definitions are consistent, variables such as altitude, dust, moisture, maintenance, and how clean the power is can impact a filter system and therefore must be taken into consideration when evaluating comparative reliability. For example, two identical filter systems can have vastly different MTBF if one is in a more stressful environment than another. Even the diligence with which a piece of equipment is maintained can skew the final values in one direction or another.

**COMPONENTS:** When considering MTBF for a filter system, on an individual component level (the power capacitor, fuse, capacitor switch/breaker, current limit-



*The ease and convenience of maintaining and repairing ground level equipment leads to short repair times and increased reliability*

ing reactor, filter reactor, etc), the choice and reliability of the component is the same across various equipment assemblers, whether metal-enclosed or open-rack, as these components are in common with one another. Yes, some component suppliers are better than others, but there is a finite pool from which to purchase. A key but unmeasurable item is the reliability and knowhow that is built into the proper choice and application of each component and its placement and application within a filter assembly. This is where the experience and knowhow of one supplier’s system can significantly impact the MTBF calculation and why component level calculation alone is not accurate for estimating MTBF.

**MEAN TIME TO REPAIR (MTTR)**

**WHAT IS MTTR?** Like MTBF, MTTR is a basic measurement used to evaluate the maintainability and, by



extension, availability of a filter system. It represents the average time required to repair a failed component or device.

Here again it is critical that inputs are clearly and consistently defined in order to draw thoughtful conclusions.

## ASSUMPTIONS -

**TIMING:** Does the clock start ticking when the filter system goes, down, when the actual failure is identified, when parts are ordered, or when the physical repairs begin? Defining the start time of the repair clock can have notable impact on the MTTR.

**PARTS:** MTTR generally does not include lead time for parts not readily available or other administrative or logistic downtime. Is this a reasonable omission, or can that be a bellwether of overall customer satisfaction? Depending on whether spare parts/components are purchased by the customer as part of the total package can have major impact on the MTTR value. If a low MTTR is desired, you must have spare parts on hand. Lead-times on various components, reactors and capacitors for example, can be as high as 8-weeks.

**PROTECTION:** Protection systems, such as over-current, overload, overtemperature, arc-flash, etc, when properly designed and purchased as part of the harmonic filter system can greatly impact MTTR. The purchase of a ABB UFES system (ultra-fast earthing switch), for example could nearly eliminate all damage associated with a flashover, reducing the repair to the simple replacement of a component. On the other hand, a protection system that does not adequately eliminate faults quickly will result in collateral damage and require significant repair time. The filter protection can have a significant impact in MTTR and is often-overlooked in the purchase of harmonic filter systems.

NEPSI understands the critical nature of harmonic filter protection systems and draws upon 20+ years of experience in the design of their protection systems. As such, potential failures that can be catastrophic are caught beforehand, and MTTR is minimized.

**MAINTENANCE:** Knowledge and training can mean the difference between a short or long MTTR and should

not be underestimated. NEPSI offers how-to-videos on their website, extensive operation and maintenance manuals, onsite training, live phone support, and an on-call serviced group that stands ready to help with any repair should you need it.

## THE METAL-ENCLOSED ADVANTAGE

When comparing NEPSI's metal-enclosed designs to other popular configurations, such as open-air designs, it can be empirically concluded that the metal-enclosed systems provide higher reliability (higher MTBF) and short repair times (lower MTTR).

When compared to open-air filter systems, the metal-enclosed solution increases MTBF with advantages in the following areas:

- Less failure from environment influences including dust, bird strikes, solar radiation, earth quake, snow, ice, etc.
- Less failures from a lack of maintenance. With the ease of maintainability, metal-enclosed systems are more likely to be maintained.
- Less failures from miss-operation and inadvertent contact.
- Less failures with improved and redundant protection and control systems.

When compared to open-air filter systems, the metal-enclosed solution reduces MTTR with advantages in the following areas:

- Less time to repair with improved accessibility: With everything at ground level, no lifting devices are required, no cranes, no need for fall protection, and more.
- With improved protection systems, the metal-enclosed system is less likely to experience catastrophic failure. Component failures are easily detected, repaired, and the metal-enclosed system put back in to operation.



## THE NEPSI EXPERIENCE

With custom equipment such as is provided by NEPSI, the data set is too varied to provide a consistent observable MTBF or MTTR. Additionally, data to make such calculations is not available and often goes unreported by our customers. Each filter system is designed specifically to address the unique needs of our customer: electrical, environment, altitude, humidity, dust, and more. It is for this reason, and the aforementioned open possibility for definition/parameter selectivity, that NEPSI finds MTBF and MTTR to be inappropriate for use in measuring product reliability.

It is NEPSI's core mission to provide only the highest quality equipment and support to our customers. In addition to the product itself, NEPSI provides comprehensive manuals, parts, and technical resources such that our customers rarely suffer from failures significant enough to contact us. Technical issues are most often resolved swiftly, with on-site personnel, using the tools we provide, resulting in significantly reduced downtime

and satisfied customers.

NEPSI and NEPSI's harmonic filter systems embrace a 0-Harm policy. They are inherently safer, offer only controlled and safe access to live parts, reduce arc-flash hazards through numerous initiatives and design features, and prevent out-of-sequence operation. For more information on arc-flash mitigation within metal-enclosed harmonic filter banks, refer to "[Arc Flash Hazard Mitigation in Metal-Enclosed Power Capacitor Banks](#)" on our resource page at [www.nepsi.com](http://www.nepsi.com).

Further, NEPSI is ISO 9001:2008 third party certified. With this system we track customer satisfaction, and currently boast 98% overall customer satisfaction. We record all failures and customer complaints – we develop a corrective action plan (CAP), and we implement plans that result in continuous improvement that is unsurpassed in the industry. With 20+ years in the design and development of harmonic filter systems, this process has left NEPSI with the highest MTBF and shortest MTTR in the industry.



*A large metal-enclosed harmonic filter system located at a large Copper concentrate plant in North America. NEPSI and NEPSI's harmonic filter systems embrace a 0-Harm policy. They are inherently safer, offer only controlled and safe access to live parts, reduce arc-flash hazards through numerous initiatives and design features, and prevent out-of-sequence operation.*