Technical Guide

"Mean Time To Repair (MTTR) Measuring Maintainability"

Small and Medium Enterprises Development Authority
Ministry of Industries & Production
Government of Pakistan

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1.1 Introduction to SMEDA:

The Small and Medium Enterprises Development Authority (SMEDA) was established in October 1998 with an objective to provide fresh impetus to the economy through development of Small and Medium Enterprises (SMEs).

With a mission "to assist in Employment Generation and Value Addition to the national income, through development of SME sectors, by helping increase the number, scale and competitiveness of SMEs", SMEDA has carried out 'sectoral research' to identify Policy, Access to Finance, Business Development Services, strategic initiatives and institutional collaboration & networking initiatives.

Preparation and dissemination of prefeasibility studies in key areas of investment has been a successful hallmark of SME facilitation by SMEDA.

Concurrent to the prefeasibility studies, a broad spectrum of Business Development Services is also offered to the SMEs by SMEDA. These services include identification of experts and consultants and delivery of need-based capacity building programs of different types in addition to business guidance through help desk services.

For more information on services offered by SMEDA, please contact our website: www.smeda.org

1.2 Industry Support Program

In order to enhance competitiveness of SMEs and achieve operational excellence, SMEDA established an Industry Support Cell (ISC) for provision of foreign technical support and knowledge transfer in collaboration with International Development Organizations. SMEDA's Industry Support Program (ISP) initially launched with Japan International Cooperation Agency (JICA) and actively engaged in reducing energy inefficiencies and improving production and quality of products with the support of Japanese Experts. Later on, similar activities with other international partner organizations like German Corporation for International Cooperation (GIZ), Training and Development Centers of the Bavarian Employers' Association (bfz), Germany, and United Nations Industrial Development (UNIDO) were also successfully implemented.

2. Understanding Key Terms?

Before we explain the concept of Mean Time To Repair (MTTR) it is necessary to understand some basic concepts.

2.1 Repair:

Repair is defined as an action that restores a failed part or system to its operating condition.

2.2 Repair Rate (μ)

The Repair or restoration rate is expressed in **μ** and is measured using following formulae.

$$\textbf{Repair Rate } (\mu) = \frac{\textbf{Total Number of Breakdowns}}{\textbf{Total Downtime Time}}$$

2.3 Uptime:

The time during which a repairable system or unit is operating as per design specification.

2.4 Repairable System:

A repairable system is one that can be restored or repaired to satisfactory performance other than replacement.

2.5 Non-Repairable System:

A non-repairable system is one that needs to be replaced after a single failure.

2.6 Maintainability:

It is defined as the probability that a failed equipment or system will be repaired within a given amount of time. It is also used to improve the maintainability of products and systems primarily by reducing the amount of time required to diagnose and repair the failures.

M(t) = Probability of Repair in specified time t

$$M(t) = 1 - e^{-\mu t}$$

Where **"μ"** is the repair rate
And **"t"** is the permissible time constraint for the maintenance action.

2.7 Maximum Maintenance Time, $T_{M\,Max}$:

The maximum maintenance time is defined as the 95th percentile of the maintainability function M(t) as described in 2.6 above. It is time in which 95% of all maintenance actions can be accomplished satisfactorily. i.e. not more than 5% of the maintenance task may exceed $\mathbf{t_{MMax.}}$ For the normal distribution it is expressed as follows:

$$T_{M\,Max} = MTTR + 1.65\ \sigma_t$$

Where σ **t** is the standard deviation of the normally distributed maintenance times.

For the exponential distribution we will use following equation.

$$T_{M\,Max} \cong 3 * MTTR$$

3. What is Mean Time To Repair (MTTR)?

Technological failures are inevitable but highly expensive. High maintainability acts as backup plan where breakdown does occur. One of the key metrics to monitor the time required to repair and troubleshoot is Mean Time To Repair (MTTR).

We can define Mean Time To Repair (MTTR) in a number of ways.

1. Mean Time To Repair (MTTR) is the time period between the start of the incident and the moment the system returns to its normal operation for a repairable system. For non-repairable system we use different metrics like Mean Time To Failure (MTTF).

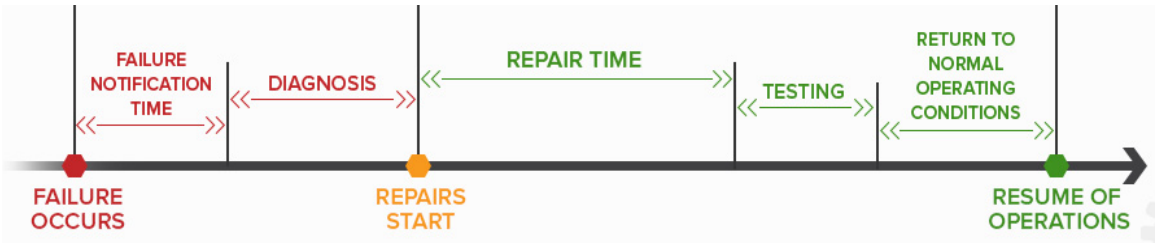

Figure # 1: Concept of MTTR

2. MTTR is the total average time to restore an asset to its normal operating condition after undergoing a failure or breakdown.

3. MTTR is the reciprocal of Repair Rate i.e. **M.T.T.R. = (1/Repair Rate) = 1/ μ**

MTTR is expressed using formula as follow.

$$\textbf{Mean Time To Repair (MTTR)} = \frac{\textbf{Total Downtime}}{\textbf{Total Number of Breakdowns}}$$

MTTR does not consider planned shutdown activities (like breaks, cleaning, inspection and lubrication etc.). MTTR represents how quickly an organization can respond to unplanned breakdowns and repair them. It highlights the longer than normal times especially for the highest demand and important equipment. In this way it improves efficiency and limit unplanned downtime.

MTTR measurement and analysis is very helpful in deciding whether to repair or replacement any equipment. In case if any of your critical equipment becomes old and started to take longer times to repair as compared to your historical data, it might be good decision to replace it. MTTR is measured in units of hour. MTTR considers all times as follow **(Refer Figure # 1).**

1. Failure notification time
2. Diagnosis
3. Repair time
4. Testing
5. Return to normal operating conditions.

4. Defining "MTTR" Correctly:

The **"R"** in the term **"MTTR"** is sometimes used to represent **"Repair"** and **"Recovery"** but the two terms will also change the meaning of MTTR.

Mean Time To **Recovery** represents not only the repair time but also includes failure notification time, diagnosis, testing and return to normal condition time etc.

Mean Time To **Repair** normally represents the average time required to repair a piece of equipment after breakdown (not including notification or diagnosis time) etc.

Most of the times both the terms are used as the combination of the two concepts as explained above. Similar practice we adopted in this guide to explain the concept.

It is important to distinguish between the two while making maintenance contracts or service level agreements so that people must know exactly what they may be measuring in **"MTTR"** and how to set the targets.

5. MTTR Vs MTBF Vs MTTF?

In order to get the clarity, three important terms which are usually misunderstood by the business owners and production staff are defined below:

1. **MTTR** - Mean Time To Repair: It is commonly used to determine how long it will take to get a failed product running again

2. **MTBF** - Mean Time Between Failures: It is commonly used to determine average time between failures for repairable products. Refer to Heading # 2.5 for further details.

3. **MTTF** - Mean Time To Failure: It is commonly used for measuring the amount of time a non-repairable or replaceable asset operates before failure.

6. How to measure MTTR, Repair Rate and Maintainability?

The formula used to calculate MTTR is as follow.

$$\textbf{Mean Time To Repair (MTTR)} = \frac{\textbf{Total Downtime}}{\textbf{Total Number of Breakdowns}}$$

If MTTR is known, we can calculate the Repair Rate which is the reciprocal of MTTR and is measured as follow.

$$\textbf{Repair Rate } (\mu) = \frac{\textbf{Total Number of Breakdowns}}{\textbf{Total Downtime Time}}$$

Or We can say that

$$\mu = \frac{1}{\textbf{MTTR}}$$

We have MTTR and Repair Rate calculated as shown using the above formulae. If we want to know the probability of repairing the equipment in specified time say "t". We will use following formula.

M (t) = Probability of Repair in specified time t

$$M(t) = 1 - e^{-\mu t}$$

Where,

M (t) = Maintainability
μ = Repair Rate
MTTR = Mean Time To Repair

Example Case # 1:

Let suppose we have priority repairable equipment installation, the logbook data show there were 15 breakdowns occurred and total 1200 minutes wasted in breakdown maintenance. The prior data on this equipment tells the repair times were exponentially distributed. A warranty contract between the equipment supplier and the government suggest a penalty for any downtime exceeding 100 minutes. Find the following:

1. The MTTR and repair rate
2. Maintainability function for say 100 minutes
3. Time in which 95% of the maintenance action can be completed.

Solution:

1. **Calculating MTTR & Repair Rate:**

MTTR = $\frac{\text{Total Downtime}}{\text{Total Number of Breakdowns}}$

Total Downtime = 1200 Minutes
Total Number of Breakdowns = 15

MTTR = $\frac{1200}{15}$ => 80 Minutes

Calculating Repair Rate:

Repair Rate (μ) = $\frac{\text{Total Number of Breakdowns}}{\text{Total Downtime Time}}$

Or

Repair Rate (μ) = $\frac{1}{MTTR}$

Repair Rate (μ) = $\frac{1}{80}$

= 0.0125 Repairs/Minute

2. **Calculating Maintainability for 100 Minutes:**

M (t) = Probability of Repair in specified time t

$$M(t) = 1 - e^{-\mu t}$$

μ = 0.0125 Repairs/ minute, t = 100 minutes

$$M(100) = 1 - e^{-(0.0125)(100)}$$
$$= 1 - e^{-(1.25)}$$
$$= 1 - 0.286$$
$$M(100) = 0.714$$

or a 71% probability of meeting the warranty requirements.

3. **Calculating Time in which 95% of the maintenance action can be completed:**

The maximum maintenance time $T_{M\ Max}$ is defined as the 95th percentile of the maintainability function M (t) as described in 2.6 above. The prior data on this equipment tells the repair times were exponentially distributed.

For the exponential distribution we will use following equation.

$$T_{M\ Max} \cong 3 * MTTR$$

From the previous data we calculated the MTTR to be

MTTR = 80 Minutes

Time within which 95% of the maintenance actions can be calculated is calculated as follow.

$$T_{M\ Max} \cong M_{0.95} = 3 * MTTR = 3\ (80) = 240\ Minutes$$

In 240 minutes time, 95% of all maintenance actions can be accomplished satisfactorily.

7. How to improve MTTR?

As the name suggests MTTR represents the mean time required to repair a system facing downtime. It is the representative Key Performance Indicator (KPI) that how your maintenance department and core technical team is performing. Just in case the performance represents a problem i.e. MTTR is high beyond your set targets resulting in higher downtimes, production losses and increased maintenance cost. What can you do to improve the performance of the maintenance department and improve the MTTR? Below we present the four stages of MTTR. We need to understand and measure which stages are taking more time in overall repair process and need to work on improving those.

1. **Identification** (Time Failure Occurs till when Maintenance Become Aware of issue)
2. **Knowledge** (Diagnosing the Problem)
3. **Fix** (Time it takes to fix the issue)
4. **Verify** (Ensuring the Solution is Working Fine)

The most time consuming stage in above is Knowledge stage i.e. diagnosing the problem. Calling to peers for solution, meetings and Incorrect diagnoses leads to time losses. Following preventive maintenance schedules, documenting repaired/replaced components and making asset history of failure with record of solution taken will help reduce diagnosis time for similar problems that occurred in past and sustainable solution is already available.

In the following we present some other important measures that will help improve the MTTR.

1. Collect the MTTR metrics data and analyze it.
2. Standardize the repair and maintenance procedures
3. Training & development of maintenance team
    a. Use Single Point Lessons (Short, Visual lessons on Single Point)
    b. Analyzing the Breakdowns data
4. Timely availability of spare parts
5. Utilize Modern Monitoring Technologies
6. Make design Improvement that needs less maintenance.