Inspection And Maintenance Interval Forecasting of Fire Alarm System Using Reliability Prediction Technique

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Abstract- *This research paper helps in failure rate analysis of Fire Alarm System. Once we got the failure rate it is very convenient for us to predict the system reliability elements MTBF, MTTR, availability, etc. This research paper develops the concept of reliability analysis and the prediction that form the foundation upon which all the inspection, testing, and maintenance programs are based. Without a thorough understanding of the impact of inspection, testing and maintenance program has on the mission effectiveness of the Fire Alarm System cannot use a performance-based, objective-oriented design approach.*

Keywords- Fire Alarm System; failure rate; reliability; prediction, maintenance.

I. INTRODUCTION

Time is the most important commodity in fire protection. The fire protection community‘s objective is to reduce reaction time, evacuation time, response time and suppression time. Past fire events have shown that codes and standards, complying with fire alarm systems can provide the “window of safety” need to meet the fire protection goals.

With each passing year in understanding the fire and its behavior enables designers to design a better fire alarm system to achieve the specific objectives and level of performance rather than compliance with minimum perspective standards. Yet, no performance-based or objective oriented design is complete without an explicit quantitative assessment of the level of confidence one can have that the fire alarm system will perform as intended. For that, the reliability analysis and prediction techniques are background areas from the basis for inspection, testing & maintenance requirements for the fire alarm system and components.

This research is especially limited to inspection, testing, and maintenance of the fire alarm system. This system is designed to sense fire, transmit the information to the control unit and active personal warning, whether for the person occupying the site.

Reliability is recognized as an essential need for the fire alarm system. It is looked upon as a means for reducing cost from the factory, where rework of defective components adds nonproductive overhead expenses to the manufacturer and to the user, where repair cost includes not only parts and labor but also transportation and storage. More, importantly, reliability direct impacts force effectiveness, measured in terms of availability and or sortie rates.

The achievement of reliability is the function of reliability engineering. Every aspect of the fire alarm system, from the purity of the material used in the component device to the operator’s interface, have an impact on reliability. Reliability engineering must, therefore, be applied throughout the system’s development in a diligent and timely fashion, and integrated with another engineering discipline.

II. ROLE OF RELIABILITY PREDICTION IN ENGINEERING

The reliability prediction provides the quantities baseline needed to access progress in reliability engineering. A prediction mode of a proposed design may be used in several ways.

The effect of complexity on the probability of mission success can be evaluated through reliability prediction. The need for redundant or backup system may be determined with the aid of reliability prediction. A tread off of redundancy against other reliability enhancing techniques like more cooling, higher part quality must be based on reliability prediction coupled with other pertinent considerations such as cost, space limitations, etc.

The prediction will also help evaluate the significance of reported failure. For example, if several failures of one type or component occur in the system, the predicted failure rate can determine whether the number of failures is commensurate with the number of components used in the system or that it indicate the problem area.

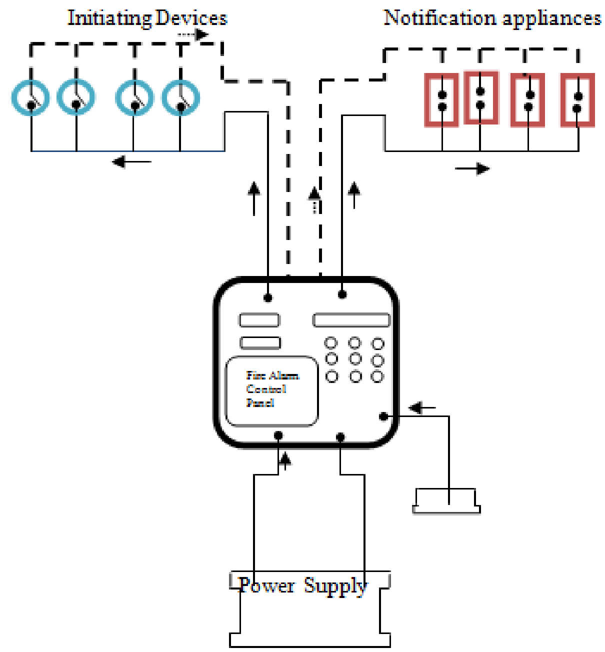
III. THE RELIABILITY PROBLEM

When it is proposed to design a fire alarm system to perform its expected job, it is assumed that the required investment will be justified according to the perfection by which the job is performed or by the large numbers of items in which the system can do the job. This assumption cannot justify when a system fails to perform upon demand or fail to perform repeatedly.

Reliability is a consideration at all levels of electronics, from material to operating system , because materials go to make up parts, parts compose assemblies are combined in the system for ever increasing complexity and sophistication. Therefore at any level of development and design, it is natural to find the influence of reliability engineering acting as a discipline founded to devote special engineering attention to the unreliability problem. Reliability engineering is concerned with the time degeneration of material, physical and electronic measurement, equipment design, process, and system analysis and synthesis. None of these can be isolated from the overall electronics context but must be carried on in conjunction with many other disciplines.

IV. FIRE ALARM SYSTEM

Modern Fire alarm systems vary in complexity from those that are simple to those that incorporate advanced detection and signaling equipment. The design, installation, and approval of a fire detection and alarm system may also require acceptances testing by regulatory agencies before new buildings are occupied or the system is placed in service.



A fire alarm system that simply sounds an audible signal and flashes strobe light in a space is conveying a signal of information. The Fire alarm system sends a voice announcement, flashlight indication to convey the information. They may signal a fire alarm and give a specific location and information on how and where they evacuate or relocate. As the cost of the emergency voice/alarm system comes down closer to the conventional system, they are being used more and more by designers. They are almost required by codes in high rise buildings but can also be effectively used in the smaller buildings. When provided with detailed information about a fire emergency, people tend to evacuate more quickly and effectively.

Audible and visible appliances may also be used to indicate a trouble condition in a fire alarm system, or they may be used as a supervisory signal to indicate the condition or status of other fire protection systems like an automatic sprinkler system.

3.1 Fire Alarm System

The fire alarm system constructed from various different components like:-

1. Fire alarm Control Unit
2. Initiating Device
3. Notification appliances
4. Primary & Secondary Power Supply
   Wiring / Cabling

The Fire Alarm System is constructed with many types electronic subcomponents like Semiconductors, Resistors, capacitors, inductors, transformers etc. these all subcomponents have their own failure rate, this failure rate depends upon various factors like :

- Environment Factor
- Power factor
- Temperature Factor
- Voltage Stress Factor
- Load Stress Factor
- Electrical Stress Factor
- Quality Factor
- Series Resistance Factor
- Contact Form Factor
- Mating/Unmaking Factor
- Utilization Facto

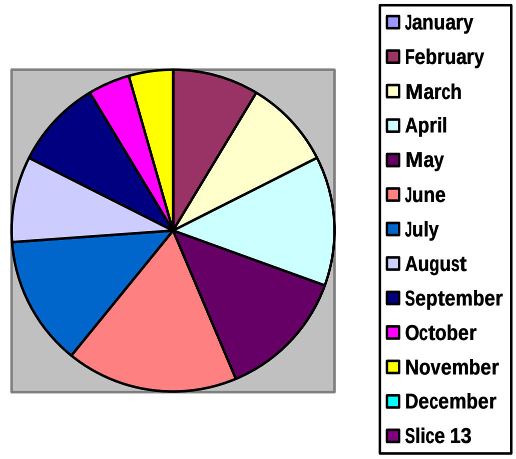


Fig.1 Annual Failure Occurrence

V. MATHEMATICAL MODELING

Abbreviations and Acronyms

Pt =Planned Time
Dt =Down Time
At = Availability
λ = Failure Rate
MTBF = Mean Time Between Failure

TABLE-I: Failure Observations

Month	Planned Time (Hrs.)	Down Time (Hrs.)	Available Time (Hrs.)	Number of Failure
January	744	0	744	0
February	672	0.91	671.09	2
March	720	1.08	718.92	2
April	720	1.16	718.84	3
May	744	1.58	742.42	3
June	696	2.58	693.42	4
July	744	2.18	741.82	3
August	744	1.75	742.25	2
September	720	1.6	718.4	2
October	744	1.5	742.5	1
November	720	1.1	718.9	1
December	744	0	744	0

Calculation of Failure Rate

$$MTBF = \frac{\text{Available Time}}{\text{Number of Failure}}$$

$$\text{Failure Rate } (\lambda) = \frac{1}{MTBF}$$

TABLE-II Calculated Failure Rate

Month	MTBF (Hrs.)	Failure Rate
January	744	0.0027
February	355.54	0.0041
March	359.5	0.0040
April	329.61	0.0057
May	247.47	0.0040
June	173.35	0.0026
July	247.27	0.0027
August	185.56	0.0013
September	179.6	0.0013
October	247.5	0.0013
November	718.9	0.0013
December	744	0.0029

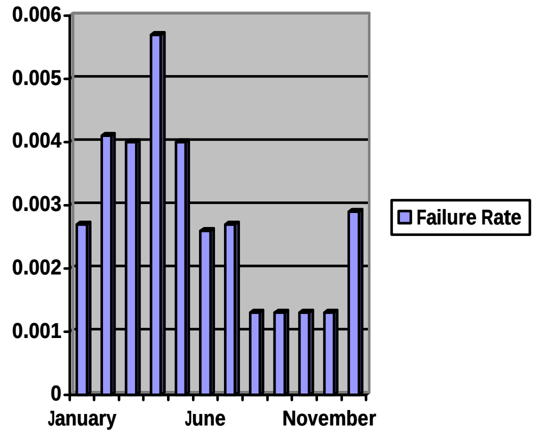


Fig. 2 Monthly Failure Rate occurrence

That required reliability can be calculates from

$$R=e^{-\lambda Tr}$$

Where

R= Reliability of System
e = Naperian Logarithm base, 2.71828
λ=Inherent Failure Rate of System
T=Time period for which the Reliability has been computed

The factor T is the interval of time between each execution of the inspection, testing and maintenance procedure for the system. Assuming maintenance restores the entire system to complete operability, the required maintenance interval is computed from

$$T_R = \frac{\ln R_R}{-\lambda}$$

Where

In R_R =Naperian log of required reliability, R_R
λ = Inherent failure rate of the system
T_R = Required maintenance interval to achieve the required reliability

We want to get Fire Alarm System performance with 90% Reliability. That means

$$\ln R_R = \ln(0.90)$$

By Using above tool the calculated required time interval is

TABLE-III: Calculated required Maintenance Interval (Monthly)

Month	Required Maintenance Interval (Hrs/Month)
January	36
February	24
March	24.75
April	17.33
May	24.72
June	37.11
July	36
August	74.25
September	72
October	74.4
November	74.4
December	33.55
Inherent Time Period (Σ)	528.51

VI. RESULT

On converting Inherent Failure Rate (Σ) we get the required maintenance interval 24 days to maintain the Fire Alarm System with 90 % reliability.

VII. CONCLUSION

It Indicates that this Fire Alarm, with the failure rate used, will require the complete inspection test and maintenance routine every seventh day in order to maintain at least 90 % reliability in achieving design objective. A reliability of 0.90 is a very high reliability, well above that of most system. It means that there is on 5 percent chance that there will be any form of failure during the lifetime of the system

VIII. ACKNOWLEDGMENT

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