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Reliability in system designed for Water Supply in Chandigarh (India): A Review

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Abstract

Chandigarh is a well planned city and one of the modern cities of India. The city is having spacious roads, lush green gardens, good network of Sewerage and Storm water system. The city also owns a well designed Water supply system. Due to the importance of the city, people all across the country has been settled and enjoy facilities of International level. Chandigarh is the only city which earns its 70% of the revenue helping the govt. to plan its funds in darker zones. This level of service has been achieved by the Municipal Corporation Chandigarh by increasing the reliability of the mechanism involved in water supply from the source to disposal of the water. The optimization of the system also has features like 24 Hrs. Water supply in some sectors, 3 times regular supply in routine to all the sectors, villages and slum colonies. The system include pumping the water from Kajauli Water Works (On Bhakhra Canal), Distt. Ropar, Punjab to Sector 39 Chandigarh, Treatment of water, distribution, metering, disposal and further treating the sewage for recycling purpose. This paper reflects the application of "DFR" in Water Supply System of Chandigarh.

Introduction

Challenge before the departments engaged in water supply is to achieve high reliability, meet scheduled time with required pressure and to ensure achievement in low budget. For this purpose "DFR" design for reliability can be brought into use. DFR is a systematic approach based on the physics of failure. It imparts an understanding of how, why and when to use the wide variety of reliability engineering tools available today. It also offers fundamental insight into the design cycle from the reliability point of view. It extends from the idea phase through product development cycle down to product obsolescence. It includes reliability verification.

Background

Chandigarh is a well planned modern city with the view to provide best services to the citizens. As the city is a capital of two leading states of India and a hub of many administrators, technocrats

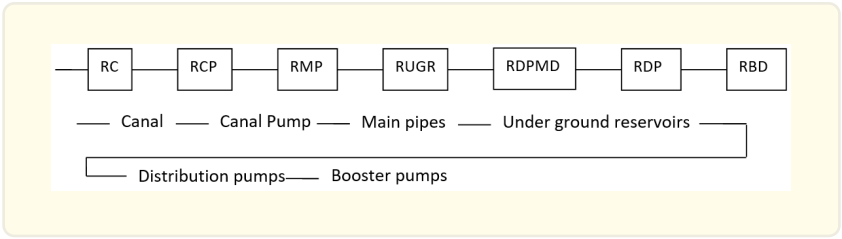
and high profile residents, the service level requirements are very high. To meet the requirement of basic amenities like water supply among the resident is "must achieve at optimum level". Hence to meet the above system need full proofing. The system is having various components like source, machinery, pipes, valves etc. To meet the 100% expectations, reliability of a system also need to be around 100%.

Planning

Four steps are required to arrive at the reliability specifications of a system:

1. Analyze the consequences of possible system failures for each sub-system.
2. From this failures analysis, partition failures into appropriate classes.
3. For each failure class identified, set out a suitable metric for reliability. Different metrics may be used for different reliability requirements.
4. To reduce changes of critical failures, identify functional reliability requirements.

Reliability of the system as a whole depends on the way in which the subsystem and its elements are connected together. Standard approach for analyzing complex system is to break them into subsystem of convenient size-each representing a specific function. Reliability of these subsystems is then estimated and combined to determine the reliability of the entire system.



Formulation

Overall system reliability prediction can be made by looking at the reliabilities of the component which make up the whole system or product. Reliability wise configuration of components must be determined beforehand. Components are assumed to be statically independent, means that failure of one component does not affect other components in the system. In the discussion that follows each component is considered critical in the sense that its function must be performed to enable the system to perform. Over all system reliability predication can be made by looking at the reliabilities of the components which make up whole system or product. Reliability-wise configuration of components must be determined beforehand. Components are assumed to be statistically independent. The term statistically independent means that failure of one component does not affect other components in the system. In the discussion that follows, each component is considered critical in the sense that its function must be performed to enable the system to perform reliable. Reliability of a system is calculated by applying the rules of probability according to the configuration of the components within the system. A configuration can be as simple as units as chained in series or parallel. There can also be system of combined series/parallel configuration or complex system that cannot be decomposed into groups of series and parallel configuration. When examining the reliability of system, we will considers the following two reliability distribution that all most often used in reliability engineering.

1. Experimental distribution this has constant failure late. Equation for this is

$$R(t) = e^{-\lambda t}$$

2. Waybill distribution

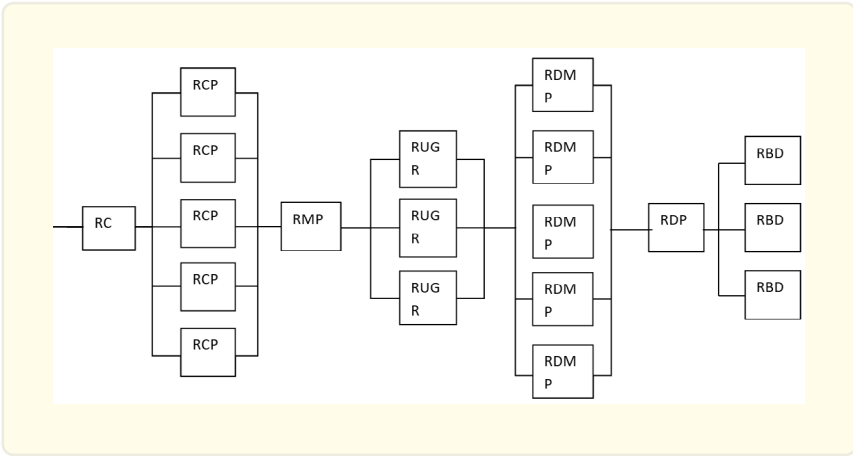
$$R(t) = e^{-\left(\frac{t-\gamma}{\eta}\right)^{\beta}}$$

Where
η = scale parameters.
β = shape (or slope) parameter.
γ= location parameter.
Visually location parameter γ is taken as zero. In that case.

$$R(t) = e^{-\left(\frac{t}{\eta}\right)^{\beta}}$$

If β <1, There is decreasing failure rate.
If β =1, There is constant failure rate.
If β >1, There is increasing failure rate.

Implementing formulation in the system of water supply



Having backup in parallel to the system in series is the best arrangement to get best possible results. In a system of water supply the arrangement can be followed by applying the combination of both. In Series as well as in parallel System the reliability issue is curbed by adding and multiplying the efficiencies improving the Reliability above all.

RC – Canal.
RCP- Pump installed in Canal.
RMP - Main Pumping Station.
UGR - Under Ground Reservoir.
RDMP- Distribution MainPump.
RDP - Distribution Pump.
RBD - Boosting Pumps.

Typical Mechanism supporting reliability concept in water supply system of Chandigarh

Parallel arrangements of some components along with a series arrangement of others is to curb the problem if occurred in parallel system. The k-out of n configuration is a special case of parallel. This type of configuration requires that at least k components succeed out of the total n parallel components for the system to succeed. As per the above the distribution pumping system has five pumps. Furthermore, that the design of the system is such that at least two pumps are required to cater total 56 sectors for full pressure water supply-n configuration, where k = 2 and n =5. More specifically, they are in a 2-out-of-4 configuration. Advantage of the system can be

taken from the fact that even 1 pump is sufficient to cater the city water supply in low pressure. This means that the system has been designed assuring the least point of failures. The k-out-of-n configuration can also be viewed as a general configuration type. As the number of units required to keep the system functioning, approaches the total number of units in the system, the system's behavior tends towards that of a series system. If the number of units required is equal to the number of units in the system, it is totally a series system, it is totally a series system. In other words, a series system of statistically independent components is an n-out-of-n system and a parallel system of stastically independent components is a 1-out-of-n-system.

Cost Effectiveness

The cost is also an affair with the system in parallel increases the cost but at the same time when optimum service level is directly proportional to Revenue generated. The implementation becomes easier though there are some constraints due to govt policies and administrative approvals. The service level of water supply system in Chandigarh reflects an exemplary efficiency. The initial cost may be on higher side because of the system redundancy but effective revenue generation can curb the problem in longer run.

Conclusion

Water supply is important service which require ultimate maintenance management and service backup. For the departments engaged in water supply need reliability near to 100%. DFR can be the best opted tool before planning and installing water supply system. End user or residents should have 24 hours availability is the customer delight in India when most of the cities/towns not have even 6 hrs water supply. Where as, in a phased manner Chandigarh has reached the optimum limit of 24 hours in some sector. While in getting 24 hours supply for rest of the sectors the augmentation and enhancement in coming future with implementation of DFR can meet the target. Using DFR in the system, has enhanced the service level of the departments engaged in water supply of Chandigarh, the goal of providing all the Sectors with 24 hours water supply can be achieved in phased manner. Whereas continuous approach for maintenance management and effective metering can meet the required constraints involved in making the system economic.

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