Written by Neil Bloom, Southern California Edison
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Addressing hidden failure modes is a key aspect for successfully achieving plant reliability.

Reliability Centered Maintenance (RCM) is not new. Airline Maintenance Steering Group (MSG) Logic, the predecessor to RCM, has existed since the early 1960s. F. Stanley Nowlan and Howard Heap of United Airlines introduced formal RCM to the commercial aviation industry in 1978. Airline reliability is primarily based on this work. The vision is as relevant today as it was when the first edition of *Reliability Centered Maintenance* was published in 1978.

Today, almost everyone in a manufacturing, power generating, or technological environment is familiar with the concept of RCM. However, the perceived degree of familiarity with RCM may be deceiving. RCM is simple in concept but also sophisticatedly subtle in its application.

As with many processes, a simplistic and limited understanding of RCM may prove more problematic than beneficial. The false comfort level of naïvely believing that a superficial implementation of the process will become a panacea for plant equipment problems and then depending on that process to produce significant reliability results is unrealistic.

Analyzing a system

The simple understanding of RCM consists of identifying system functions, functional failures, consequences of those failures, etc. However, Nowlan and Heap gave great importance to understanding hidden failures which are not widely understood and are often overlooked when performing an RCM analysis.

The true reliability benefits of RCM become evident only with a thorough understanding of how to functionally analyze a system. Understanding hidden failure modes, understanding when a single-failure analysis is not acceptable, and understanding when run-to-failure (RTF) is acceptable, are the real cornerstones of RCM. Additionally, the subtle but important distinction between true redundancy and redundant components fulfilling a backup function is also a key to reliability success.

Many utilities and other industries have implemented an RCM program only to find that they continued to have fundamental reliability issues that were not addressed by their analysis. The primary reason is the lack of a grass-roots philosophical understanding of the principles governing the analysis.

Identifying important equipment
Optimizing a preventive maintenance program consists of three phases: Phase 1, identifying equipment that is important to plant safety, operation, and asset protection; Phase 2, specifying the requisite PM tasks for the equipment identified in Phase 1; and Phase 3, properly executing the tasks specified in Phase 2.

At the very least, identifying equipment important to plant safety, operation, and asset protection consists of three programmatic principles that must be well understood before commencing an RCM analysis.

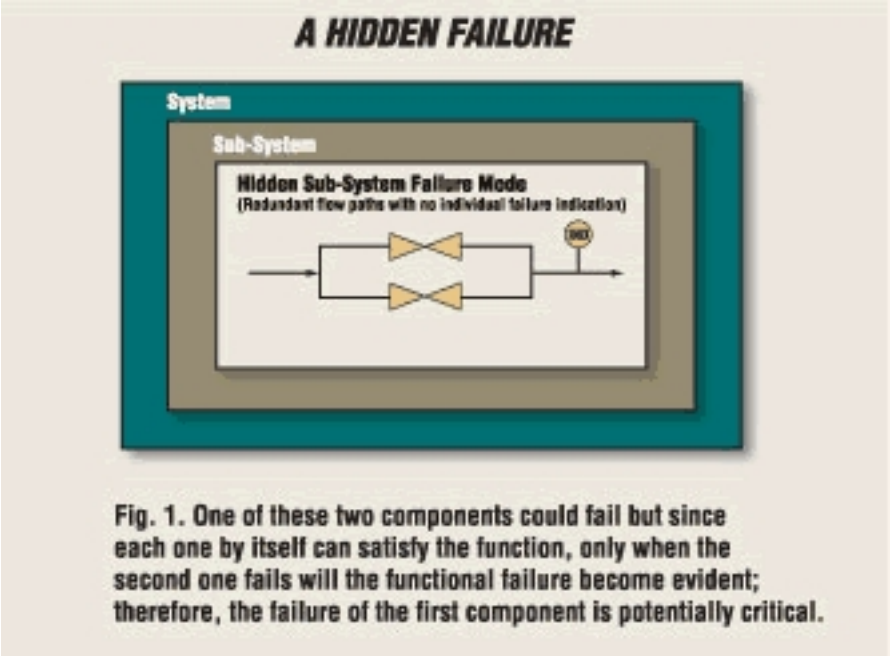
1. Understand the cornerstones for developing an effective RCM program.
2. Identify the defensive strategies for maintaining an effective RCM program.
3. Identify when a component can be classified as RTF and understand the limitations governing RTF components.

A look at each of these principles in detail will illustrate the key areas for successfully achieving plant reliability and maximizing cost containment efforts.

Understand the cornerstones
There are three cornerstones that must be understood for developing an effective RCM program:

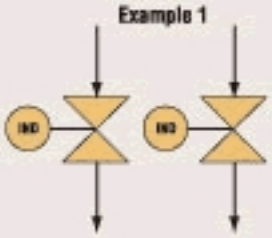
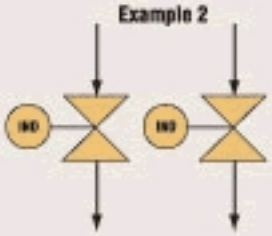
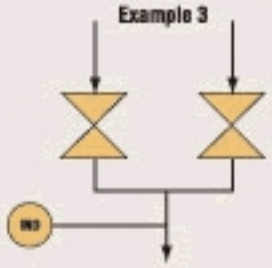
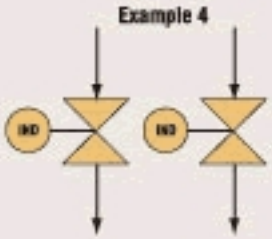
- Know when a single-failure analysis is not acceptable.
- Identify hidden failures.
- Know when a multiple-failure analysis is required.

A single-failure analysis is not acceptable when the occurrence of the failure is hidden. When a component is required to perform its function and the occurrence of the failure is not evident to operating personnel, that is, the immediate overall operation of the system remains unaffected in either the normal or demand mode of operation, then the failure mode is defined as hidden.


A HIDDEN FAILURE
System
Sub-System
Hidden Sub-System Failure Mode
(Redundant flow paths with no individual failure indication)
Fig. 1. One of these two components could fail but since each one by itself can satisfy the function, only when the second one fails will the functional failure become evident; therefore, the failure of the first component is potentially critical.

[illegible]

TYPICAL EXAMPLES OF COMPONENT CLASSIFICATIONS

	CONDITIONS	COMPONENT CLASSIFICATION
Example 1 	**a)** Two of two are required. **b)** Indication of failure is evident **c)** Failure of one valve will result in a plant effect.	Component is considered critical due to its immediate effect on the plant. Preventive maintenance is required to prevent failure.
Example 2 	**a)** Both are operating but only one is required to provide the function. **b)** Indication of failure is evident. **c)** Failure of one valve will not result in a plant effect or economic consequence. **d)** When failure becomes evident, corrective maintenance on that first failure is to take place in a timely manner.	The component failure is evident, a CM is written, and corrective maintenance is completed in a timely manner. This is a run-to failure component.
Example 3 	**a)** Both are operating but only one is required to provide the function. **b)** Individual indication of failure is not evident. **c)** Failure of one valve will not result in a plant effect or economic consequence. Failure of both, however, will result in a plant effect.	The component failure is potentially critical due to multiple failure consequences. Preventive maintenance is required to prevent the consequence of the hidden failure in combination with one or more additional failures.
Example 4 	**a)** Only the backup is required to supply the function. **b)** Either component can function as the backup for the other component. **c)** Indication of failure is evident on the backup component.	When a component is called upon to operate in a backup function it is assumed that the normally operating component has failed. If the backup should fail, a plant effect would occur. Failure of the backup is considered critical and a PM is required. Since either component may act as the backup for the other, they are both critical.

NOTE: Although only one of two is required as in Example 2, note the difference between Example 4 and Example 2.

Fig. 2. There is a vast difference between a component operating in a backup function and one that is not.

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