EFCOG
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"RELIABILITY CENTERED MAINTENANCE (RCM)"

Presented by:
Neil Bloom
Author of

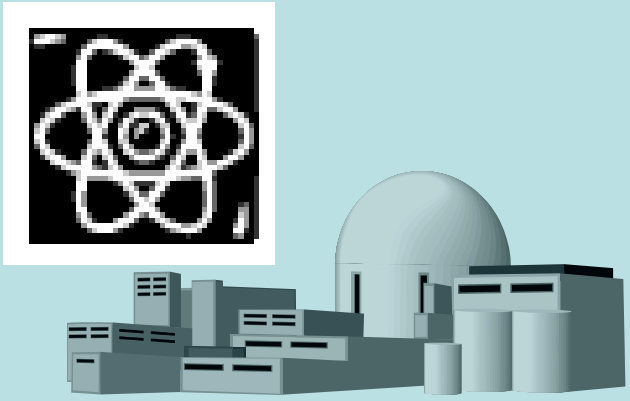
"RCM – IMPLEMENTATION MADE SIMPLE"
Published by McGraw-Hill

PRESENTATION AGENDA

- Who I Am …. My Background and Experience.
- RCM's Greatest Myths.
- A No-Nonsense Approach to RCM.
- A Look at Disasters.
- The Anatomy of a Real Life Disaster.
- The Definition of RCM.
- The History of RCM.
- Why I Wrote This Book.
- The "Key Elements" of RCM.
- What "RCM Is" and "What It Is Not."
- Why the Archaic Approach to RCM Does Not Work.
- Why Functions Are Identified at the Component Level.
- Typical Failure Analyses.
- The "Missing Link" of RCM.
- The "Canon Law" of Run-To-Failure.
- My RCM Philosophy.
- What I Did At The Nevada Test Site.
- Questions and Answers.

You are probably asking yourself, who am I and what is my background? Both are very pertinent questions.

Let me tell you a little bit about myself and my background…….



- ***I Graduated from the University of Miami with a degree in Mechanical Engineering where I also minored in Economics.***

- ***Over 35 years of experience both as a practitioner and as a member of senior management in Engineering and Maintenance working with the two leading edge federal agencies most responsible for safety and reliability, namely the Federal Aviation Administration (FAA) and the Nuclear Regulatory Commission (NRC).***

- ***Responsible for developing and managing what is perhaps, even today, one of the most comprehensive RCM programs ever implemented. Over 125,000 individual components were analyzed in one of the country's largest nuclear power facilities.***

- ***I have been a guest speaker on RCM at some of the most prestigious national and international conferences including the Electric Power Research Institute (EPRI), The American Society of Mechanical Engineers (ASME), The Argonne National Laboratory (ANL) which is operated by the University of Chicago for the Department of Energy (DOE), The Edison Electric Institute (EEI), and the International Atomic Energy Agency (IAEA) in Vienna, Austria.***

- ***I serve as an Instructor at the University of California - Irvine in their Continuing Education Division teaching RCM, reliability, and preventive maintenance strategies.***

- ***I have written the book titled "Reliability Centered Maintenance – Implementation Made Simple" which was published world-wide by McGraw-Hill in December 2005.***

Hopefully, that gives you a little insight into my background and who I am.

Let me state a well known proven fact:

The actual success rate for implementing an RCM program is in the 5-10% range. Putting it another way, over 90% of all RCM programs result in failure!

This lack of success does not have to become your experience.

How many of you believe RCM can only be implemented by consultants and/or experienced RCM trained facilitators?

RCM'S GREATEST MYTHS

- **RCM should not be attempted by the layman.**
- **RCM requires a specialized facilitator training regimen.**
- **RCM is a very difficult process to implement.**
- **RCM is by definition an expensive process.**
- **RCM can only be accomplished by consultants.**

Like all myths, all of the above are untrue!

WHY?

Why has RCM been so difficult to implement successfully?

There are countless reasons why and I do not have the time to delve into all of them during this presentation. However, all of the potential pitfalls and roadblocks affecting a successful RCM program are thoroughly explained in detail in my book and as part of my training program.

RCM can be a powerful Asset Management reliability tool but unfortunately, and unjustly, it has become what is greatly perceived as a complex, difficult, and costly undertaking.

As a result, I have introduced innovative concepts allowing the RCM process to reach a new plateau for the average layperson, thusly making the entire process less daunting, more straightforward and simpler.

A NO NONSENSE APPROACH TO CLASSICAL RCM

What I Have Done

- Introduced totally new concepts to make the RCM implementation process, including the 7 questions of SAE RCM Document JA1011, extremely simple.
- Explained the fundamental concepts of RCM in laymen's terms.
- Explained the entire RCM process from the viewpoint of a practitioner, not a consultant.
- Integrated a complex and mostly subjective decision process into a simplified, straightforward, integrated, and objective decision process.
- Tailored the RCM process to make it universally applicable to any industry and to any type or size of plant or facility.

DISASTERS

Disasters can be caused by:

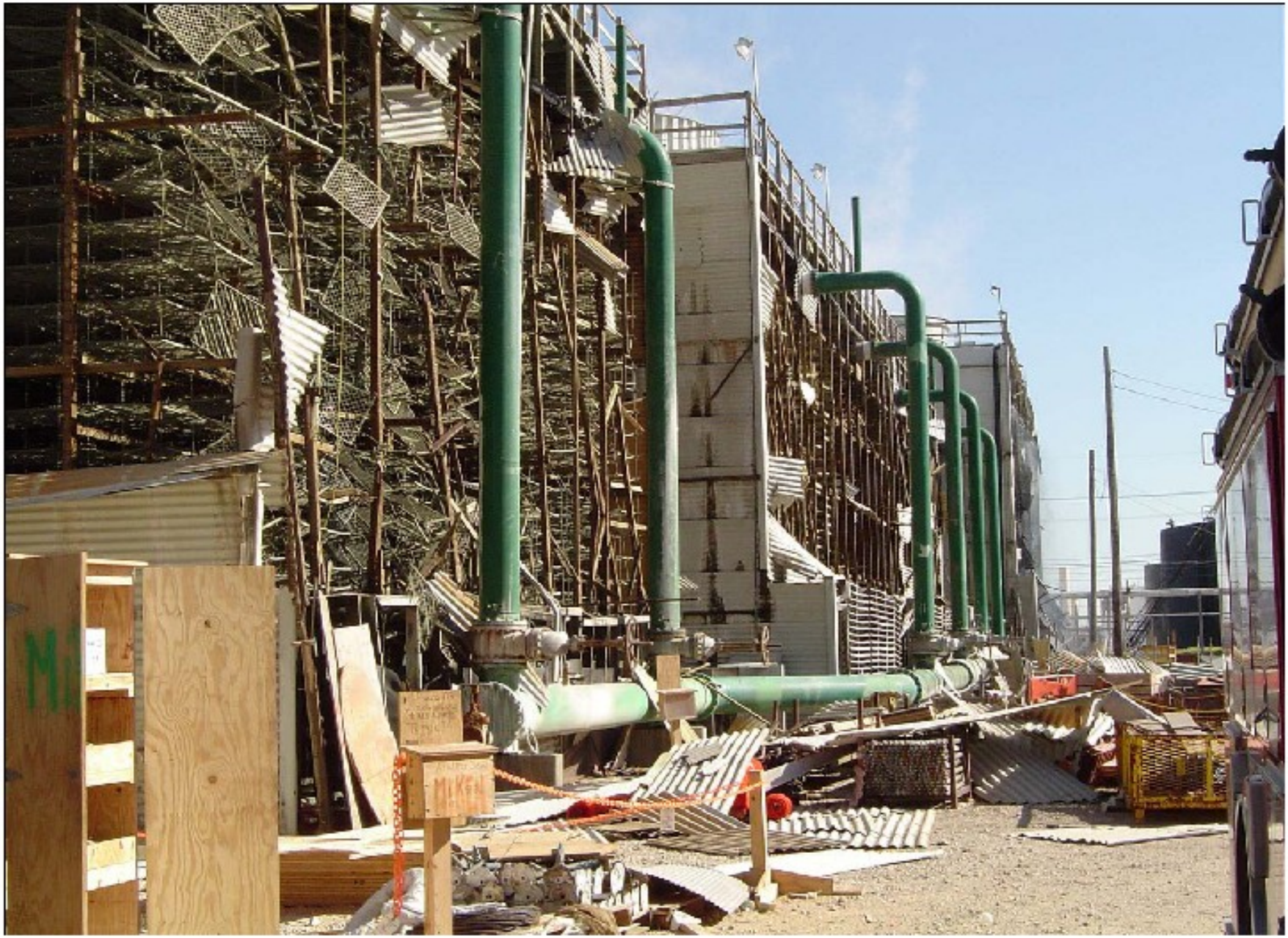
- *Acts of Nature.*
  - ** Tsunamis*
  - ** Hurricanes*
  - ** Tornadoes*
  - ** Earthquakes*

- *Human Error.*
  - ** Pilot Error*
  - ** Chernobyl*
  - ** Three Mile Island*

- *Equipment Failures.*

Let's look at some pictures of a disaster caused by equipment failures…

The following are photographs of the recent BP Refinery disaster in Houston, Texas. It was caused entirely by equipment failures due to an inadequate preventive maintenance program.

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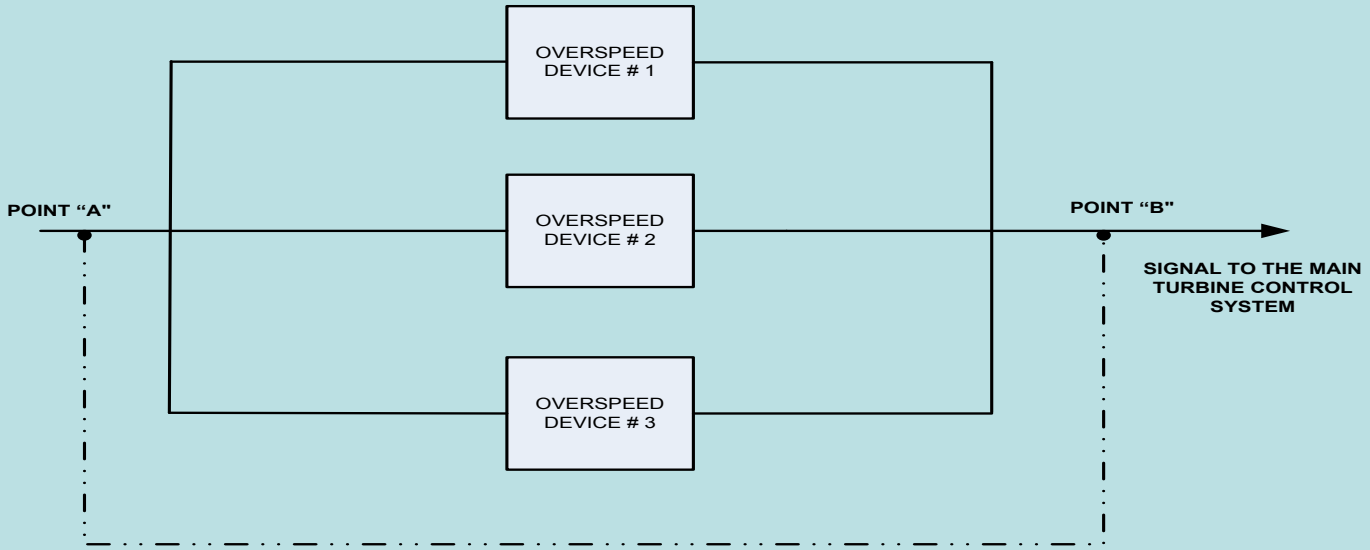
A CLOSER LOOK INTO THE ANATOMY OF ANOTHER DISASTER

ANOTHER REAL LIFE DISASTER

**AN EXAMPLE OF TRIPLE REDUNDANCY,
OR IS IT?**

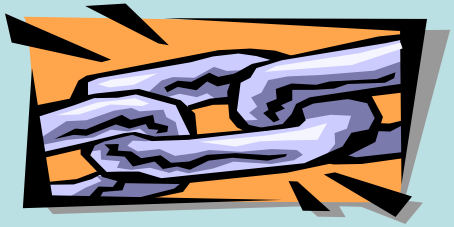


**WHAT IS
WRONG HERE ?**

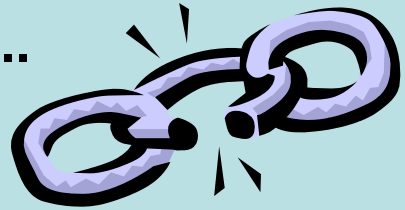
REMEMBER, YOUR PM PROGRAM IS ONLY AS STRONG AND EFFECTIVE AT PREVENTING A DISASTER AS YOUR WEAKEST LINK.

YOU MAY WANT YOUR PM PROGRAM TO LOOK LIKE THIS……

BUT YOUR PROGRAM MAY REALLY BE LIKE THIS…



AND SUBSEQUENTLY WILL BECOME THIS…. A DISASTER WAITING TO HAPPEN…..



WHAT IS RCM?

RCM is a common sense approach for achieving reliability. It is the best known proven method for developing a preventive maintenance (PM) program for any type of plant or facility.

DEFINITION OF RCM

"RCM is defined as a set of tasks generated on the basis of a systematic evaluation that are used to develop or optimize a maintenance program. RCM incorporates decision logic to ascertain the safety and operational consequences of failures and identifies the mechanisms responsible for those failures".

THE HISTORY OF RCM

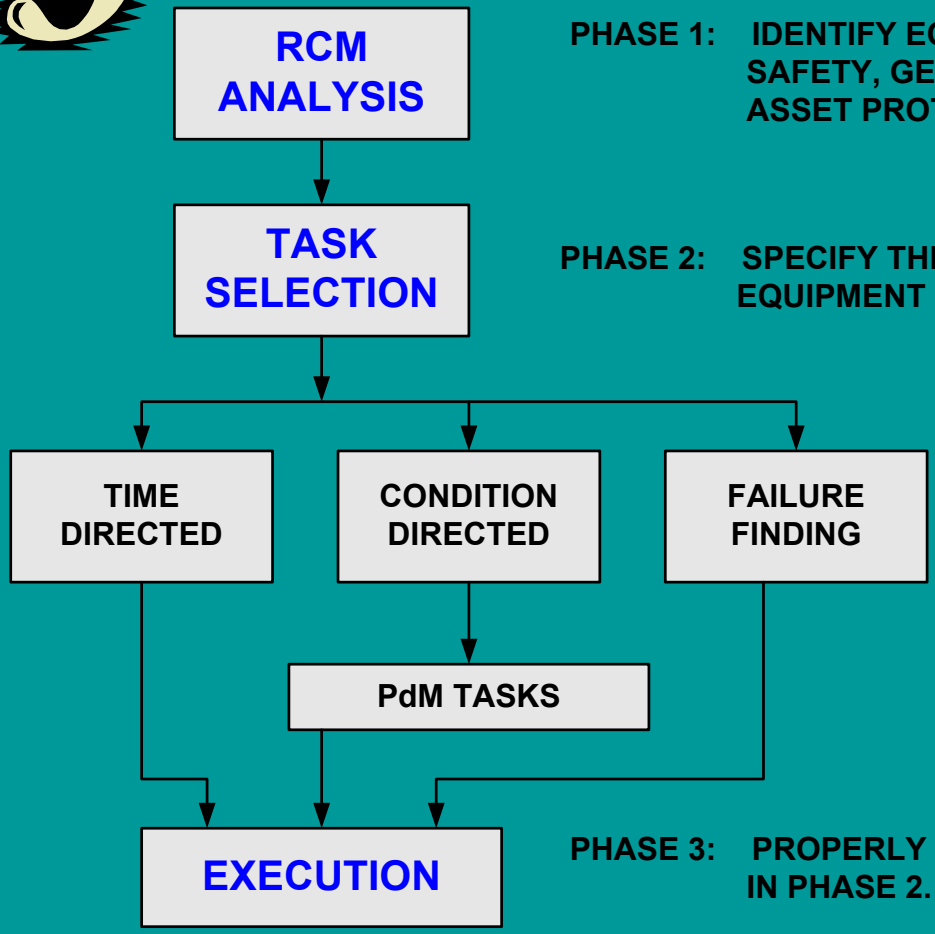
- **RCM had its origin in the Commercial Airline Industry.**
- **Aircraft overhauls were not the answer.**
- **Run-To-Failure was acceptable but it needed to be well understood.**

Why Did I Write This Book?

- **Because Classical RCM (not streamlined RCM) was and still is the absolute best methodology for developing a preventive maintenance program.**
- **Because RCM has been made very complicated and obfuscated, and therefore has eluded becoming a useful tool for industry.**
- **Because industry, in general, has not been able to reap the benefits of a premier RCM based preventive maintenance program.**
- **To take RCM to a whole new level of understanding so that reliability laymen the world over can implement a premier RCM program at their plant or facility, on their own, without the need for any outside expertise, and be able to realize the safety and reliability goals that were always intended to be relatively easy to obtain.**
- ***Lastly, to reverse the decline and undo the difficulty that unfortunately has become the widely perceived image of RCM, and bring it back to its preeminence and the simplicity that it experienced at its inception.***

The Key Elements of RCM

The Three Phases of an RCM Based Preventive Maintenance Program



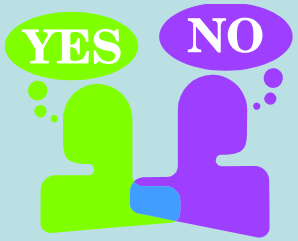
PHASE 1: IDENTIFY EQUIPMENT IMPORTANT TO PLANT SAFETY, GENERATION (or PRODUCTION), AND ASSET PROTECTION

PHASE 2: SPECIFY THE REQUISITE PM TASKS FOR THE EQUIPMENT IDENTIFIED IN PHASE 1.

TASK CATEGORIES

PHASE 3: PROPERLY EXECUTE THE TASKS SPECIFIED IN PHASE 2.

WHAT RCM IS AND WHAT IT IS NOT



- **This is a very important element in understanding RCM. A universal misconception exists regarding what RCM is and what it is not.**

WHAT RCM IS NOT

RCM IS NOT…..

- **A limited and selective process that picks and chooses the systems and/or the components to analyze such as that found in shortcut and streamlined versions of the process.**

- **A process that selectively analyzes only a few given systems or certain components that everyone, including the janitor, knows is a problem and that has a major effect on the operation of the plant or facility when it fails.**

- **A PM review of what is already being done on system ABC or component XYZ.**

- **Converting time directed maintenance tasks into condition directed predictive maintenance tasks.**

- **Performing an analysis on a piece part such as a bearing or a shaft for example.**

- **Establishing PM templates for PM tasks.**

WHAT RCM IS

RCM IS:

- Understanding the fundamentals and the limitations of redundancy.

- Understanding the differences between redundant, backup, and standby functions.

- Understanding hidden failures and hidden functions.

- Understanding hidden failures and hidden functions contained within in hidden systems.

- Understanding hidden failures contained in redundant, standby, and backup functions.

- Understanding how to test hidden functions.

- Understanding the “Canon Law” and the limitations of run-to-failure.

WHAT RCM IS

(continued)

- Understanding the cornerstones which include knowing when a single failure analysis is acceptable and when a multiple failure analysis is required.

- Understanding the importance of a “Living Program.”

- Understanding the limitations for defining “economic” consequences of failure.

- Understanding the differences between “Critical”, “Potentially Critical”, “Commitment”, “Economic”, and “Run-to-Failure" components.

AND LASTLY, BUT MOST IMPORTANTLY…..

IT IS NOT THE OBVIOUS THAT IS MOST IMPORTANT

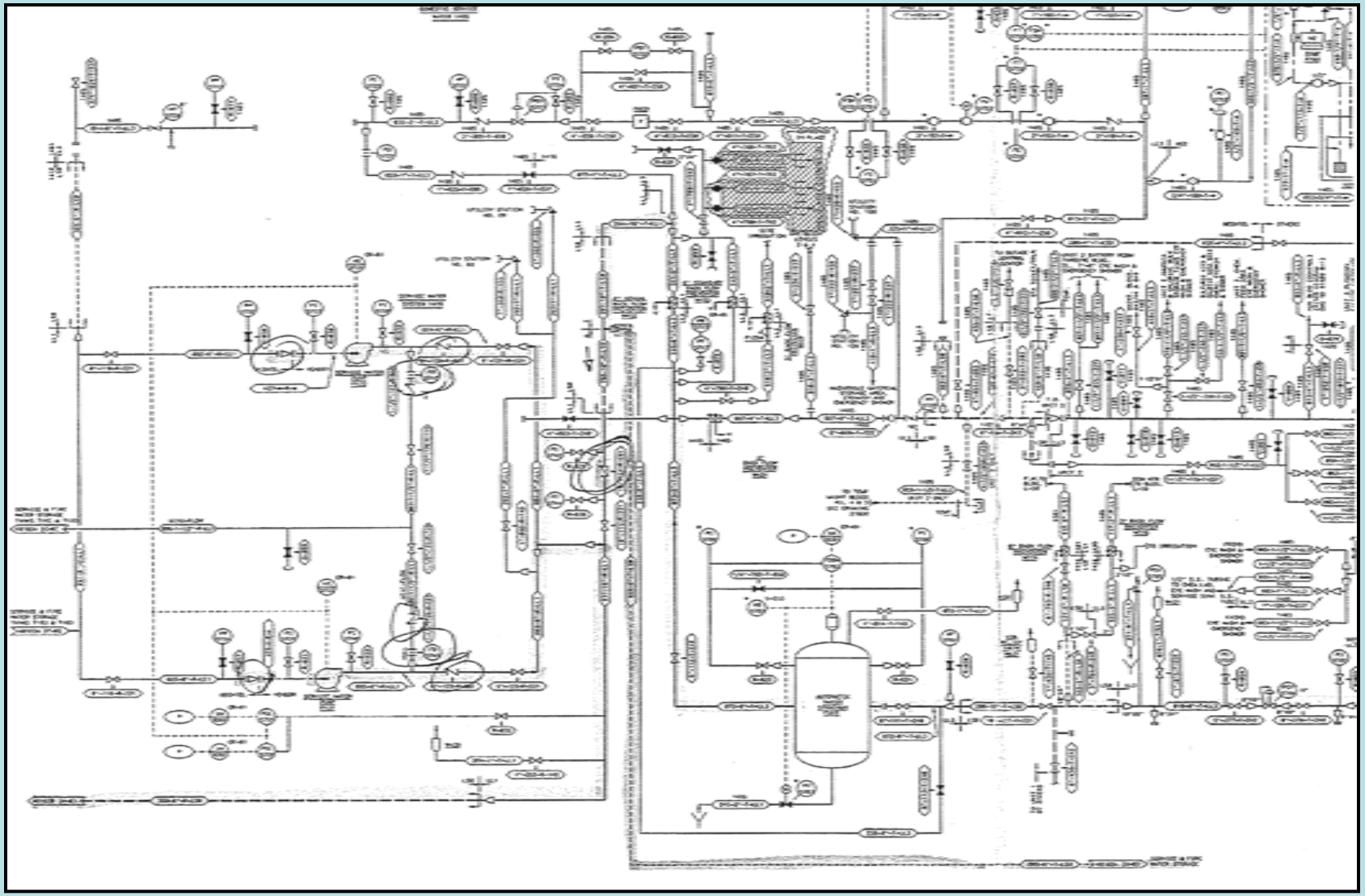
- **Remember, it is not the *"obvious"* that causes the greatest problems…. those issues and concerns are normally planned and budgeted for. It is the *"non-obvious innocuous"* components with unanalyzed failure modes and failure consequences that pose the greatest threat for causing a catastrophe or a disaster at your facility.**

Identifying the non-obvious consequences of failure is the real "Heart of RCM."

In fact, virtually every major disaster that was not the result of either an act nature, human error, sheer negligence, or downright incompetence was caused by Equipment Failures whose "*consequences of failure were unexpected and never analyzed, or that were incorrectly analyzed to be run-to-failure components.*"

Streamlined and shortcut RCM methods, 80/20 analyses, PM optimization (PMO) programs and other such shallow schemes are insufficiently robust to ascertain the non- obvious failure consequences and plant vulnerabilities that are key to preventing major unwanted disasters and catastrophes.

A TYPICAL PLANT SYSTEM SCHEMATIC



WHEN USING THE ARCHAIC RCM APPROACH FOR DEFINING FUNCTIONS AT THE SYSTEM AND SUB-SYSTEM LEVEL……..

- Where do you begin your analysis?
- Where do you begin to determine system and sub-system functions?
- How do you define what the functions are?
- How do you demarcate system and sub-system boundaries?
- How are the interfaces defined?
- How do you know if you captured all of the functions?
- What if some functions were inadvertently omitted?

This gives you some idea of why RCM programs are destined to failure from the start. This gives you some idea of why over 90% of all RCM programs result in failure.

This also gives you some idea of why the "old" RCM methods do not work.

I CREATED THE CONCEPT CALLED THE *"CONSEQUENCE OF FAILURE ANALYSIS" OR THE 'COFA'* VS. THE OLD *"FAILURE MODES AND EFFECTS ANALYSIS" REFERRED TO AS THE 'FMEA'.*

- **I created the *"COFA"* to simplify the entire RCM Decision Logic process.**

- **The *"COFA"* embraces the function of the component at the component level and not the function at the system and sub-system level.**

IN MY BOOK AND IN MY TRAINING, *FUNCTIONS ARE DEFINED AT THE COMPONENT LEVEL, NOT AT THE SYSTEM LEVEL.*

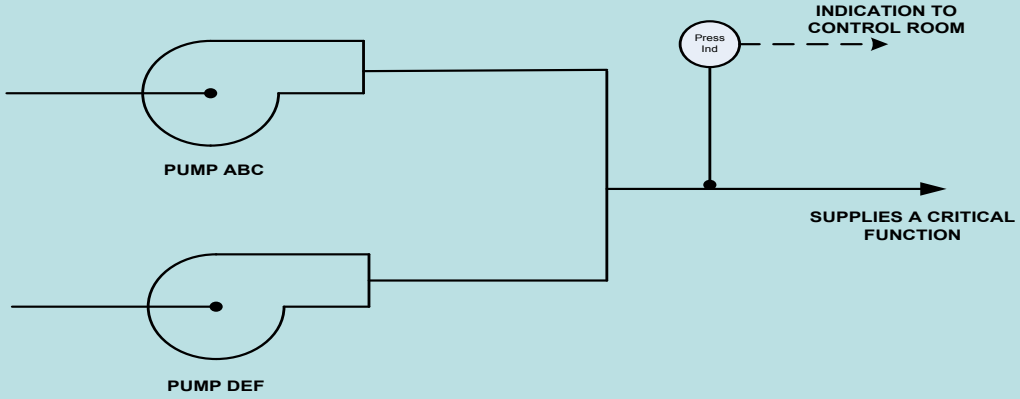
- **It is much easier to understand and implement for the layman.**
- **Eliminates the requirement for establishing boundaries and interfaces.**
- **The need for experienced RCM analysts and consultants is non-existent.**
- **The analysis can still be divided into a general system and sub-system format.**
- **There will be no left over "stray" components that fall through the cracks.**
- **It results in a greater accuracy of the analysis.**

Identifying functions by system and sub-system is not incorrect. It is just not easy to do so. It requires a huge administrative effort, more often than not it requires the assistance of an experienced RCM analyst and it can even result in less accuracy by unwittingly omitting important functions. On the other hand, identifying the functions of a component is quite easy and straightforward.

When considering the simplicity of addressing component functions and not system functions, thereby eliminating the time consuming effort of determining boundaries and interfaces and marking up P&ID's, etc, the entire analysis will undoubtedly take only a fraction of the time to complete.

A MULTIPLE FAILURE ANALYSIS

Condition: Both pumps are operating and either pump can supply the function by itself. If one pump fails it is hidden since the control room indication is downstream of both pumps.

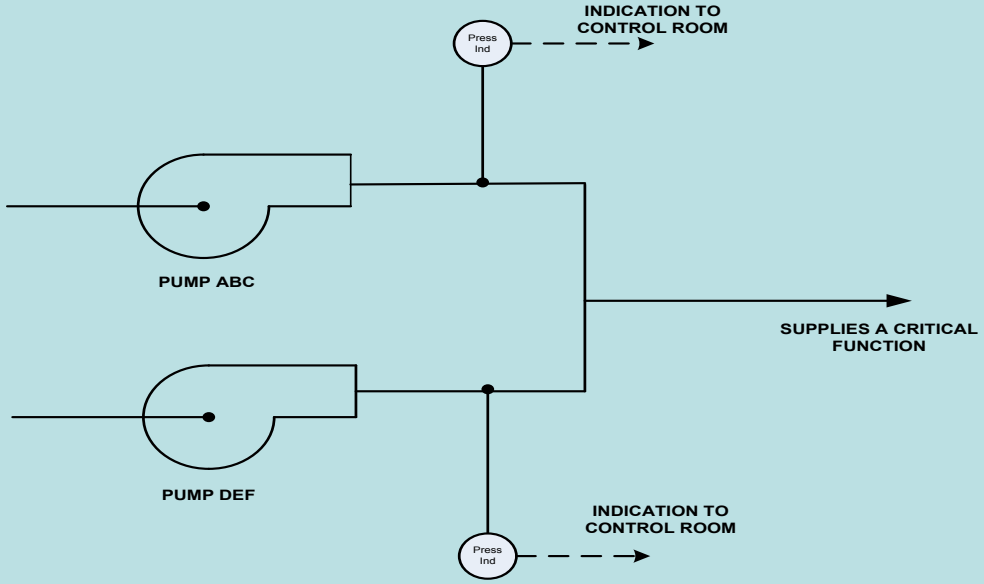


A SINGLE FAILURE ANALYSIS IS NOT ACCEPTABLE AND A MULTIPLE FAILURE ANALYSIS IS REQUIRED. IF PUMP ABC (OR DEF) FAILS IT WILL NOT BE EVIDENT AND WILL NOT HAVE AN IMMEDIATE UNWANTED CONSEQUENCE OF FAILURE. HOWEVER, IF BOTH PUMPS FAIL THERE WILL BE A SIGNIFICANT CONSEQUENCE OF FAILURE.

Figure 3-3

A "RUN-TO-FAILURE" ANALYSIS

Condition: Both pumps are operating and either pump can supply the function by itself. If one pump fails it is not hidden since there is control room indication for each individual pump.



With no safety, operational, or economic consequence as the result of a single pump failure, each pump is a run-to-failure component since the failure of each one is evident to the control room. Corrective maintenance must be performed in a timely manner when either pump fails.

Figure 3-4

A HIDDEN FAILURE

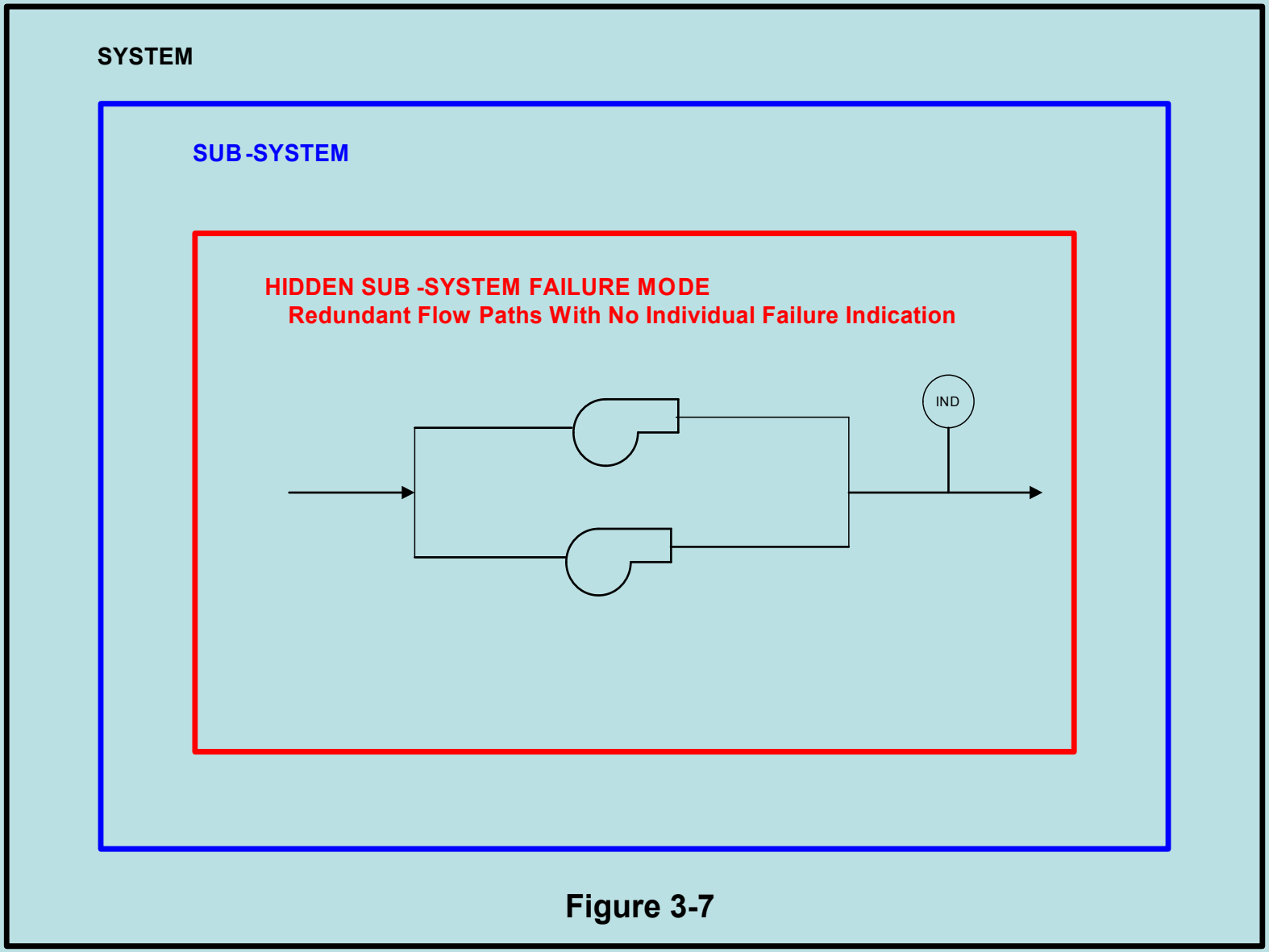


Figure 3-7

THE “MISSING LINK” OF RCM

I created the concept of the
“POTENTIALLY CRITICAL”
Component Classification
to solve the “Missing Link” of RCM.

THE CONCEPT OF "POTENTIALLY CRITICAL" COMPONENTS FOSTERS THE SIMPLE BUT INTRICATE UNDERSTANDING OF THE RCM PROCESS

- This concept is quite compelling.
- Previously, hidden failures with no immediate consequence of failure were defined identically to a failure with an immediate consequence.
- The absence of understanding this concept has led to major problems and disasters. (Remember the triple redundant main turbine explosion?)

- **A "Potentially Critical" Component is one whose immediate failure is *not evident* and is *not immediately* critical but has the "potential" to become critical either with a duration of time in and of itself, with an additional failure, or with an additional initiating event, at which time the consequence of the failure may unfortunately become quite evident (and critical).**

THE CONCEPT OF THE "CANON LAW" FOR RUN-TO-FAILURE

I created this concept to make the distinction very specific for when a component can be classified as RTF. I have termed this the "Canon Law" for run-to-failure and it reads as follows:

"A run-to-failure component is designated as such solely because it is understood to have no safety, operational, commitment, or economic consequence as the result of a single failure. Also, the occurrence of the failure must be evident to operations personnel.

As a result, there is no proactive preventive maintenance strategy to prevent failure. However, once failed, a RTF designated component does have a proactive corrective maintenance strategy commensurate with all other components based on the plant conditions at that time." *Neil Bloom*

Obviously, there will always be exceptions to every rule. In the case of the "Canon Law" the only exception would be for components that have no real function. For example, components that are there for convenience only or for a non-functional reason. Any real or true functional component that does not conform to the "Canon Law" for RTF should be questioned as to why it is even installed in the plant.

TRUE or FALSE?

1. If a component fails and nothing happens, i.e.. the system and the plant are totally unaffected by the failure, then by definition the component is run-to-failure.

2. Run-to-failure components are always less important than Critical components.

3. By definition, redundancy allows for a run-to-failure status.

4. A comprehensive definition of run-to-failure is: “PM’s are not required” or “failure of the component is allowed to occur.”

5. All components in a hidden standby safety system are also considered hidden and thereby classified as run-to-failure.

6. In present day RCM, a component whose failure has an immediate major unwanted consequence to the plant can be defined in the same category as a component whose failure has no immediate effect on the plant.

My RCM Philosophy

- ***My goal is not to embed myself into your organization for as long as possible. Instead, I provide a unique training experience whereby after only 3 days, your own people will have the requisite knowledge to implement a successful RCM based preventive maintenance program on their own.***

- ***I can achieve this goal because I know how to make RCM simple to understand and simple to implement. I consider myself to be fortunate in that the "lessons I learned" in over 35 years of being responsible for implementing RCM and preventive maintenance programs, both as a practitioner and as a member of Engineering and Maintenance Senior Management, afford me the unique opportunity and the know-how to be able to provide this knowledge to you and your DOE team.***

My RCM Philosophy

continued

- ***It is my firm belief that your own people, not myself, need to take ownership of your RCM program. The surest path for RCM <u>success</u> is to perform your own analyses in-house with your own people. The surest path to <u>failure</u> is to farm out your program to an outside 3rd party.***

- ***Before I leave your facility, your own people will be able to demonstrate, through a pilot study of your choosing that they can successfully implement your own program. Your results will be immediate. You will be able to implement your actual results immediately, before I leave. After my training, you won't need me anymore and that's exactly my goal. However, I always remain available via E-Mail or phone should there be any subsequent questions.***

WHAT I DID AT THE NEVADA TEST SITE

- *In only 3 days, a comprehensive training program was successfully completed. The training included a fundamental understanding of RCM and the principals and methodology I developed that make the entire process straightforward, simple, and less daunting to implement.*

- *In only 1 day, with the support from Technical Supervisor Bruce Norris and Station Director John Clymo, a pilot project was successfully commenced. Five major pieces of equipment were thoroughly analyzed including the new Mercury sub-station transformer.*

- *NTS Management learned how my RCM methodology enhances the synergy with DOE initiatives and DOE's fundamentally regulated governing criteria.*

There are many paths to improving reliability, but so far, no other process has proven to be as effective as the RCM methodology for establishing the best preventive maintenance program attainable.

Neil Bloom

I will be happy to entertain any questions you may have