October 2006
Volume 11, Issue 2

MRC NEWSLETTER

Maintenance & Reliability Center
The University of Tennessee
"where industry & academia meet"

Editor
Kim Kallstrom
kallstrom@frontiernet.net

UT Now Offering Two Great Graduate Study Programs in Maintenance and Reliability!

UT's College of Engineering (COE) has now added their own Master's Degree in Reliability and Maintainability to complement our existing UT-Monash Master's Degree in Maintenance Management and Reliability Engineering. Addition of this new program offers a broader group of courses with different subject matter and perspective. Depending on your personal situation, you should find that one of these is right for you. Some highlights of each are listed below.

UT-Monash

- Off-campus delivery with paper copy course material
- Assignments and communication by e-mail
- Web-enhanced (bulletin board) supplements
- Minimal Residential School (in Knoxville) requirements
- Equipment/process application based (many assignments in current workplace)
- Very practical approach
- Courses run March – October

Inside this issue:

UT-College of Engineering

- Off-Campus Delivery via internet (synchronous system with audio)
- Class sessions are archived
- Assignments and communication by e-mail
- No residential requirements
- Equipment and process based (vs. product quality/reliability)
- Fairly classical and theoretical engineering (math, statistics, etc.)
- Courses run normal semesters - Fall, Spring, Summer (sometimes)

Director's Corner

Tom Byerley
MRC Director

The pace continues hot and heavy here at the MRC as the year rolls on. Summer (academically speaking) has ended and the fall hustle and bustle on campus has started. Our 29 interns have finished up their summer work assignments and returned to campus. They have had some great experiences and several of them shared with us at our recent Members' meeting.

Our new Master's Degree in Reliability and Maintainability Engineering is in the final phases of approval by all the appropriate committees and is being placed into the university catalog. We have already had several inquiries about this program – even without any advertising to date. Be sure and read about it elsewhere in this newsletter – or ask us about it by phone or e-mail.

We are also extending our agreement with Monash University to deliver their Master's Degree in Maintenance Management and Reliability Engineering. We have worked with them for seven years with tremendous results and just completed the annual Residential School at the end of August. You can see pictures and read about the program elsewhere in this newsletter.

Kim Kallstrom has already created and sent out our Call for Papers for MARCON 2007 I really encourage you to take a shot at writing and delivering a paper at the conference. The quality of the conference continues to soar upward and it is a great opportunity for all of you. Plus, we have decided to provide complimentary registration for those individuals selected as presenters this year. So, check out the Call and send us some abstracts for review.

I trust that you are noticing the improved quality of our newsletter Kim is working hard to chase down more technical and meaty articles to help you in your understanding of what works in the modern maintenance and reliability world.

I want to mention that Linda Stooksbury is still recovering from knee replacement surgery. She is making progress and hopes to return to the office in early to mid October. Meanwhile, please keep her in your thoughts as she goes through her therapy.

Finally, I urge all of you to stay in touch and involved with the MRC. This is a very special organization, built upon the strength of our members and their companies. As we move into fall, and the last quarter of the year (with planning and budgets and all the other things that brings), we are here to serve you and help you meet your goals and objectives.

Tom

University Adding Master of Science Program in Reliability and Maintainability Engineering

The University of Tennessee is in the final stages of approving a Master of Science program in Reliability and Maintainability Engineering (RME). Although the program has to pass a final vote by the University, the College of Engineering anticipates having final approval for the new program by late fall.

The RME program will be offered through an interdepartmental program, the first of its kind in the College of Engineering. Students will have the option of completing the program on campus or via the internet using a synchronous, interactive delivery mode in which distance students attend class with the local students. Thesis and non-thesis (project) options will be available, both of which will require completion of a minimum of 30 semester hours. The course work will consist of a combination of RME core and elective courses; courses in statistics; and courses in engineering, business management or a related field.

The proposed admission requirements for the RME program are as follows:

> Applicants for admission to the MS program in Reliability and Maintainability Engineering are expected to have earned a bachelor's degree from an accredited undergraduate program in engineering or physics. Students from other appropriate disciplines (e.g. chemistry, mathematics, etc.) can be admitted but additional engineering courses may be required. Entering students must have, as a minimum, competency in mathematics through ordinary differential equations.

The RME program will provide traditional students and working professionals with the opportunity to learn the theoretical and practical aspects of Reliability and Maintainability Engineering. The specific goals of the RME program are:

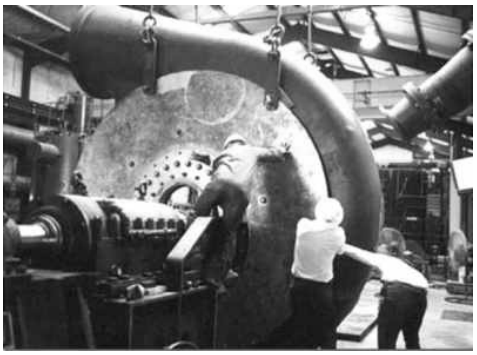
- To educate and produce graduates with the ability to understand and apply the techniques, skills, and modern engineering tools necessary for professional practice in reliability and maintainability engineering.
- To contribute to the economic development of the state by training highly qualified graduates in the field to support industry and government.

More information about the RME program will be available as soon as final approval is obtained. Watch the MRC website and future issues of this newsletter for more details. Feel free to contact Dr. Wes Hines directly for updates (jhines2@utk.edu).

The Art of Maintaining Stand-by Pumps

By: Ken Reed, System Improvements, Inc.

I want to maintain the highest possible reliability of 2 parallel centrifugal pumps. One is the operating pump, and the other is a stand-by pump, required only as a back-up in case the running pump fails. What is the best run-time strategy to maximize the reliability of these pumps?



My first thought was, "50:50, of course!" That way the wear and tear on the pumps is spread out over both pumps, doubling the effective lifetime of the equipment. Seems reasonable to me.

Unfortunately, if you are using this strategy, there is a good chance you are significantly accelerating the wear on the pumps, resulting in increased downtime!!

One assumption that has to be made: The pumps are using mechanical seals. Pumps with packing glands normally are wetted by the working fluid. These pumps may require a more frequent cycle schedule for packing maintenance. This strategy is normally defined by the manufacturer, and is essential to prevent damage to the packing. One major failure mode for packed pump glands is start-up with dry seals. Therefore, a frequent pump shift strategy makes perfect sense for pumps with packing. Unfortunately, this strategy has often been carried over to pumps with mechanical seals, with little thought as to why we should be following that strategy.

So why is a 50:50 run strategy bad for mechanically sealed pumps?

First, the major wear and failure mode when considering a mechanical seal is the wear incurred when starting or stopping the pump, not wear while running. A properly-maintained mechanical seal sees very little wear while it is operating. However, starting and stopping the pumps solely for equal run time puts enormous stresses on the seals. This introduces new failure modes that are not normally present in a secured standby pump.

Finally, with perfectly even wear, both pumps (theoretically) will fail at about the same time. This means that, when one pump fails, the other pump should be expected to fail during its next run cycle. Not the ideal situation for an emergency standby pump!

It seems then that the fewer start-stop cycles, the better. Ideally, as far as mechanical seal wear goes, the stand-by pump should never be started, maintaining it in pristine condition, ready to take over on the loss of the duty pump. Therefore, why not use a 100:0 run cycle. In other words, *never* start the stand-by pump!

Although this may be good for the mechanical seals, this strategy fails to address other failure modes that are unique to a stand-by pump. You no longer have confidence that these failure modes (fail to start, failure to reach full capacity) are not present.

A good compromise is closer to a 90:10 ratio. For example, run the duty pump for about 8 weeks, and then run the standby pump for a day or two. Then SHIFT BACK TO THE DUTY PUMP. This has several advantages:

- You have confidence the stand-by pump will run when needed.
- You can prove it will reach full load capacity.
- The shift can be scheduled around your normal PdM periodicities. For example, conduct thermal and vibration analysis of the standby pump at the scheduled 2-month PdM requirement, killing 2 birds with one stone.
- Most people shift pumps weekly, which is a total of 104 starts or stops for the 2 pumps over the course of a year. The 90:10 strategy at a bi-monthly interval lowers the number of start/stop cycles to only 10 or 12.

Some facilities have actually color coded their pumps. The duty pump is green, and the standby pump is red. This eliminates another problem often seen on the production floor: operators do not report when a piece of equipment fails. For example, when the duty pump starts making those funny noises, the operators may immediately shift to the stand-by pump to maintain production, but then never report that there was a problem in the first place. With a color code program in place, when any operator sees the red pump running, he can now question why we are not in the "reliable" line-up. This makes it more likely that operators will immediately report failures of the duty pump.

This 90:10 philosophy may not "feel right", but there is plenty of data to back it up. Again, this assumes that the prevalent failure mode is seal failure. It also assumes that there are not other extenuating circumstances requiring pump shifting. For example, maybe you have a history of false brinelling of the standby pump bearings if the pump is idle for xx weeks. (Of course, this begs the question, “Is my baseplate design inadequate, allowing vibration transmission to the non-running equipment?”) Take a look at your pump-shifting strategy. Are you shifting pumps weekly because, “We’ve always done it this way”? You may find you are able to increase your equipment availability, reduce downtime, and limit repair costs, just by adjusting your pump switching schedule.

Ken Reed is the Senior Associate at System Improvements, Inc. in Knoxville, TN. He is the Program Manager for the Equifactor® Equipment Troubleshooting Module of the TapRooT® system. Any questions can be sent to ken@taproot.com. Visit the TapRooT® website at www.taproot.com for further information.

Warner Robins Air Logistics Center Receives Awards for Innovative C-5 Program

At MARCON in May, Doug Keene, Technical Director of the 402d Maintenance Wing at the Warner Robins Air Logistics Center (WR-ALC), gave an inspiring keynote presentation on the WR-ALC's efforts to reduce maintenance flow time for military aircraft. Specifically, Doug highlighted how, in concert with their Lean efforts, the WR-ALC has implemented Critical Chain Project Management (CCPM) in the C-5 Programmed Depot Maintenance Line to reduce the variability in aircraft flow. In just eight months, the program achieved amazing results:

- Aircraft flowdays were reduced by 35% - to 159 days to repair A Model aircraft and 151 days for B Model aircraft
- 44% reduction in work in process (WIP) – from 12.5 aircraft on station to 7
- Approximately $36.5 M/yr in additional revenue generated

The C-5 program is now gaining national attention and has been named the recipient of two very prestigious awards.

In May, the WR-ALC was awarded the 2006 Franz Edelman Award for Achievement in Operations Research (O.R.). Nicknamed the "Super Bowl of O.R.", the Edelman Award has been awarded by the Institute for Operations Research and the Management Sciences (INFORMS) for the last 35 years. WR-ALC received the coveted award for their radically different approach to managing the repair and overhaul activity of the C-5 aircraft using CCPM. Joining the WR-ALC's representatives on the stage to accept the award were Jan R. Williams, Dean of UT's College of Business, and Mandyam M. Srinivasan, a professor from the College of Business. The 402d Aircraft Maintenance Group's Deputy Chief, Bill Best, was first introduced to CCPM while completing UT's Aerospace MBA program. After Best convinced management at Warner Robins of the potential impact CCPM could have on the C-5 line, the Center teamed with UT's College of Business and Realization Technologies to implement the program.

From left to right: Mr. Bill Best - Deputy Director, 402d Aircraft Maintenance Group, Mr. Ken Percell - Executive Director, WR-ALC, Dr. Mandayam Srinivasan - Professor of Business at UT, Mr. Sridharan Chandrasekaran – Realization Technologies, Dr. Jan R Williams – Dean, UT's College of Business Administration, LTC Jeffery E. Elliot – Commander of 559th Aircraft Maintenance Squadron

In September, the C-5 program was honored for the second straight year as a Gold recipient of the Shingo Prize for Excellence in Manufacturing. Deemed the Nobel Prize for manufacturing by *Business Week*, the Shingo prize was established in 1988 and recognizes world-class performance for quality, cost and delivery through the use of Lean principles and techniques. Last year the prize was opened to the public sector for the first time, and the C-5 program became one of the first-ever public industries to receive the Shingo Prize and the first government industry to receive the gold level honor. This year, the WR-ALC also took home bronze-level honors for their F-15 Programmed Depot Maintenance Line and the 568th Fighter Avionics Squadron.

THE UNIVERSITY of TENNESSEE

Maintenance and Reliability Center

"Where industry and academia meet"

Call For Papers

MARCON 2007 **May 8-11, 2007** **Downtown Hilton Hotel, Knoxville, TN**

Like previous MARCON conferences, **MARCON 2007** will be a forum for all – practitioners, specialists, educators, students, and managers – to exchange information on new emerging technologies as well as on tried and proven methods and techniques in the area of maintenance and reliability engineering. Cutting edge research topics, case studies of real applications and the latest thinking in the managerial/financial aspects of the maintenance & reliability field come together in this multi-track, highly informative conference. **You are invited to provide a 300 – 500 word abstract for consideration by the Technical Review Committee for presentation at MARCON 2007.**

Why participate and present at MARCON?

- *Inspiring keynote addresses* such as those in 2006 by Paul Casto of Eastman Chemical and Doug Keene from the award-winning Warner Robins Air Logistics Center
- *Numerous papers* in three parallel tracks: Asset Management; Best Practices/Case Studies; New Technologies
- *Reliability tutorials; Lean Maintenance sessions; and more*
- *Speakers receive complimentary conference attendance*

Submission Requirements:

- 300—500 Word abstract
- Clear, descriptive title
- Author's name, e-mail
- address, phone & FAX number, company
- affiliation
- Agreement to attend and present the paper if selected
- Electronically sent to MRC by November 3, 2006

Critical Dates:

November 3, 2006	**Abstracts Due**
December 1, 2006	**Authors Notified of Selection**
April 2, 2007	**Manuscripts & Presentation Slides Due**
May 9-11, 2007	**Presentations at MARCON**

Abstracts should be transmitted electronically to mrc@utk.edu and marked Attention: MARCON Technical Program Chair. Successful authors will be sent manuscript and presentation preparation guidelines when notified of selection. Final manuscripts and presentation slides must be submitted electronically.

MARCON 2007 should prove to be greatly beneficial for your business, featuring keynote addresses and pre-conference workshops centered around bridging classic reliability and industrial maintenance. We welcome manuscripts that correspond to this theme as well as additional topics such as those suggested on the back of this call.

Maintenance and Reliability Center
The University of Tennessee
506 East Stadium Hall
Knoxville, TN 37996-0750 USA

For more details,
visit our website at
www.engr.utk.edu/mrc

Phone: 865-974-9625 • Fax: 865-974-4995 • E-mail: mrc@utk.edu

Focus on Staff – *Duane Dunlap*

This quarter we focus on Duane Dunlap. Duane is a Manufacturing Consultant for the MRC with over 40 years of industrial experience.

Duane Dunlap

Duane graduated from the University of Tennessee in 1963 with a B.S. in Mechanical Engineering. He went to work immediately for Alcoa's Tennessee Operations. He spent the next 36 years working for Alcoa in Tennessee, Iowa, and Pennsylvania as a mechanical engineer and environmental manager. Duane retired in 1999 from his position as Division Manager of Process Design and Reliability at the Alcoa Technical Center in Pittsburgh, PA. He has since been consulting at Alcoa, the University of Tennessee, and other companies.

While at Alcoa, Duane received an Alcoa Patent Award for controlling rolling mill vibration, and in 1990, he was the recipient of the Arthur Vining Davis Award (Alcoa Corporate Award for team excellence). Duane also held many special assignments while at Alcoa, including:

- Alcoa Corporate Manager for all maintenance and reliability research
- Alcoa Operating Committee Member – MIT's Leaders for Manufacturing Program
- Alcoa Operating Committee Member – Stanford's SIMA Manufacturing Program
- Alcoa Operating Committee Member – Rensselaer Polytechnic Institute's CMP Manufacturing Program
- Alcoa Operating Committee Member – University of Pittsburgh's Manufacturing Program
- Sponsor: Reliability Program – Arizona University
- Sponsor: MMO Reliability Program – University of Toronto

Since joining the MRC staff, Duane has proved to be an invaluable asset. He presently serves as the Project Leader of the British Petroleum and Baker Hughes INTEQ Assessment Team, and is a member of the Fluor Company Special Projects Team, and assists in many other activities for the MRC. He presents annually at the MRC's Boot Camp, which prepares interns for their summer positions. In addition, Duane is a member of the SMRP Best Practices Team and the Standards Team.

Besides his consulting and MRC activities, Duane also currently referees projects and publications for Materials and Manufacturing Ontario (MMO). MMO is a Canadian organization that funds Ontario industrial projects and makes connections between university research and the needs of Ontario industry.

Why Is Something So Simple So Hard?

There is a renewed interest in Root Cause Analysis (RCA) throughout industry. The Rapid Problem Solving concepts, the emphasis on reducing waste, the drive to reduce costs and the need to improve equipment availability all depend on the elimination of the causes of failures. All you have to do is ask 'Why?" five times. In principle it sounds very simple but in practice it is difficult.

In my attempts to gain a better understanding of this I have come to several conclusions. The first and most obvious is that in general the culture is one of restoring production as quickly as possible and not finding the root cause and eliminating it for good. By some this is referred to as the "White Horse Syndrome". It is exciting and much more interesting than trying to understand why a greasy mangled bearing failed. The second is that we have a difficult time when the "Whys?" point us in the direction of people. To understand this better let's look at the two approaches and look at an example of a Root Cause Analysis.

Fix it, get it running and move on to the next problem (opportunity):

- □ Increase number of spares so the component can be changed with a spare and the repair can take place in the shop, thereby increasing uptime of the equipment.
- □ Revise the component so it can be repaired more quickly.
- □ Replace the component with one that should perform better.

Root cause Analysis:

- □ Gather information WHY the failure occurred.
- □ After determining WHY the failure occurred ask "What caused the failure?".
- □ Having determined WHAT caused the failure ask "WHY?".
- □ Four or five iterations of this process will normally identify the root cause.
- □ Eliminating the Root Cause or source of the failure ensures that the failure will not have to be solved again.

Example Root Cause Analysis of a loss of flow to a tank:

Physical Causes

Why?

- □ The pump feeding the tank failed.

Why?

- □ It quit turning.

Why?

- □ The coupling failed.

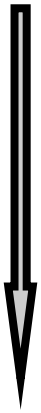
Why?

- □ Lack of Lubrication?
- □ Coupling Alignment?

"Investigate Further"

- □ Coupling failed because of lack of lubrication.

Driving To The Root Cause



Physical Cause

- ❑ **What you can see, feel, smell, taste or hear.**

Human Cause

- ❑ **This is where inappropriate human intervention takes place.**
- ❑ **Remember the person is only the point where the real Root Causes are deposited.**

Root Cause

- ❑ **Where eliminating this cause will prevent recurrence.**
- ❑ **These tend to be system or management issues.**

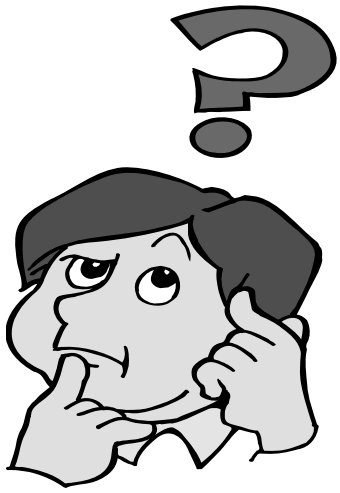
Human Causes

Why?

- □ Area person didn't lubricate the coupling.

Why?

- □ Lubrication fitting is hard to get to.



Root Causes

Why?

- □ There was a protective guard in the way.

Why?

- □ There were no access holes in the guard.

Why?

- □ The installation procedure used a generic guard drawing and didn't include a step to add access for lubrication of the coupling.

Why wasn't this step included?

- □ It was an oversight.

The corrective actions would include revising the drawing to include a step for adding lubrication access and checking to see how many similar installations that have the same problem designed in.

We could have easily stopped at the physical causes and changed out the coupling and moved on to the next problem. We also could have stayed with the physical causes because we started getting into the human causes and didn't want to take on any people issues. In the example, only by driving through the people issues did we really start to identify the true root cause. The true root causes are mainly system or management issues. People are only the receivers of the root cause not the root cause themselves. When I advise someone who is conducting a Root Cause Analysis I tell them that when the investigation starts to point to people they need to drive through the people issues and get to the real root causes. In any Root Cause investigation it needs to be stated clearly in the beginning that it is not a witch-hunt. The Root Cause Analysis Team needs to understand they will eventually get to people issues and this is a signal to press even harder as the real root causes are just a few "Whys" away.

I hope this simple model has some utility in shedding a little light on why we find Root Cause Analysis so difficult and possibly make this critical task easier.

About the Author—Dennis M. Whitty

Dennis has spent the last 28 years with Alcoa, Inc. as a Plant Engineer, Engineering Supervisor, Project Engineer, Maintenance Supervisor for craft training and nondestructive testing, Process Improvement Specialist, Reliability Manager for West Australia and most recently as a Reliability Consultant for several business units within Alcoa.

Maintenance & Reliability Center
The University of Tennessee
"*where industry & academia meet*"

Maintenance & Reliability Center
University of Tennessee
506 East Stadium Hall
Knoxville, TN 37996-0750

Phone: 865-974-9625
Fax: 865-974-4995

Email: mrc@utk.edu
tbyerley@utk.edu
lstooksb@utk.edu
rcollin8@utk.edu

We're on the Web!
www.engr.utk.edu/mrc

MRC 2006/2007 Calendar of Events

October 23 - 25	SMRP Annual Conference (Birmingham)
November 3	MARCON Abstracts Due
December 5-8	IMC Conference (Daytona Beach)
January	MRC Meeting (TBD)
January 30	Cutoff for UT-Monash Applications

IF YOU NO LONGER WISH TO RECEIVE MAILINGS FROM THE MRC, KINDLY PHONE, EMAIL OR MAIL US YOUR ADDRESS LABEL AND WE WILL REMOVE YOUR NAME FROM OUR MAILING LIST.

Publication Number R01-1302-079-002-07