

Root Cause Failure Analysis

Verso Paper Corporation

Chris Moore
Manufacturing Support Manager



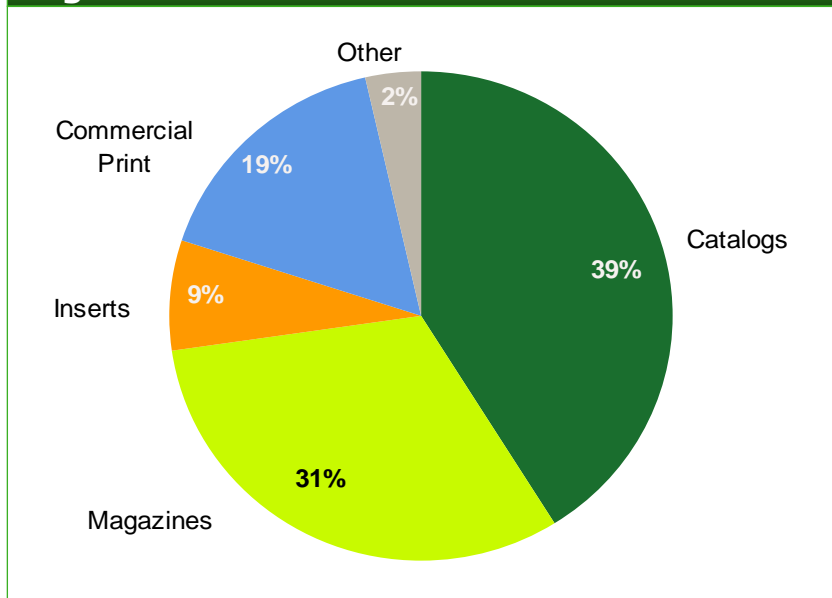
Verso simple.™

Verso Is One Of North America's Leading Manufacturers Of Coated Papers

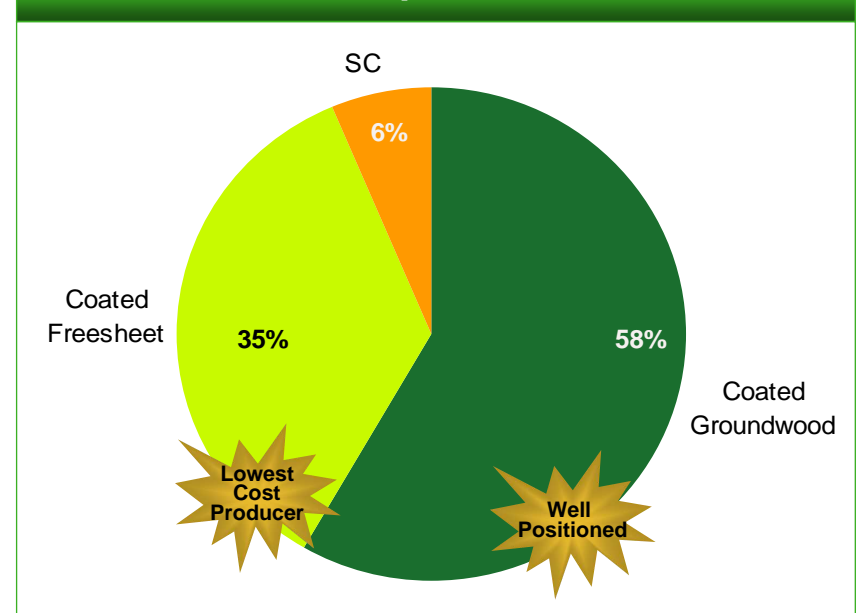
- Four paper mills with 1.8 million tons of total paper capacity
- 3000 Employees
- A market leader in its two key end-user segments



Market Leader in Two Key End-User Segments⁽¹⁾

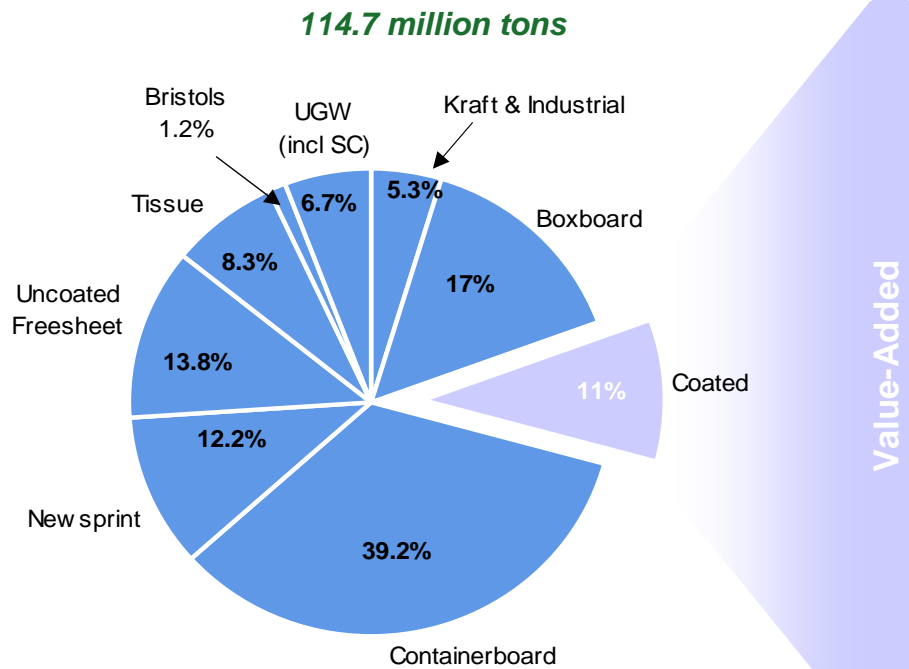


Focused on Three Paper Grades

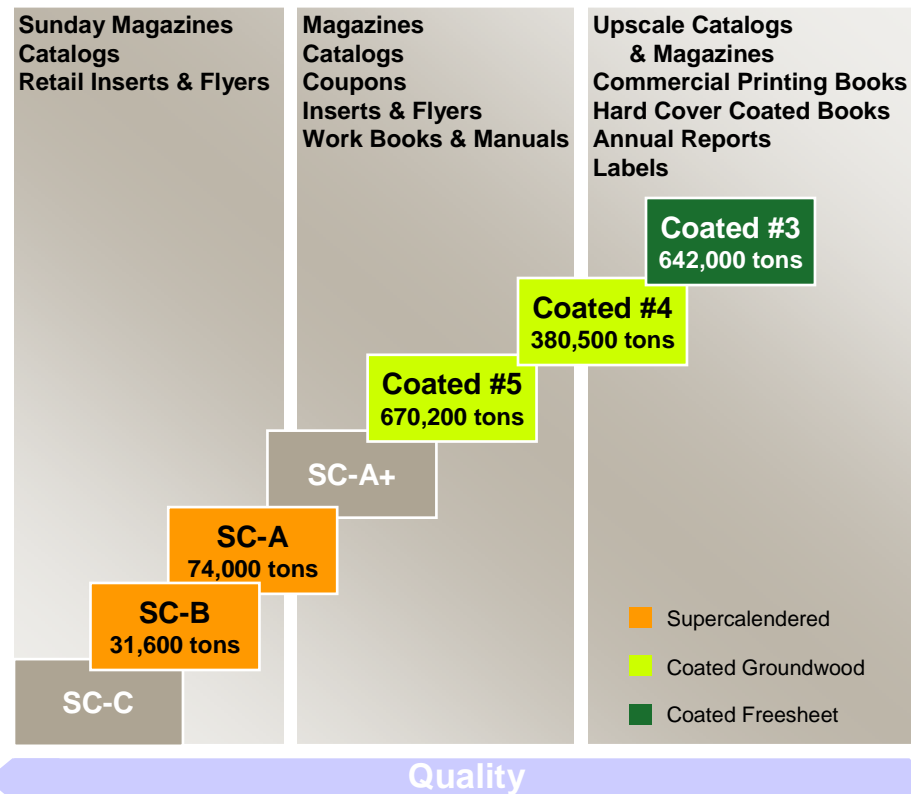


Focused Product Offering Targeting Catalog & Magazine Publishers

North American Paper Industry



Verso's Primary Product Offering



Source: RISI.
 Note: Total capacities pro forma for UPM Miramichi, NB shutdown of 495,000 tons of Coated Groundwood in 2007, NewPage shutdowns of 280,000 tons of Coated Groundwood and 60,000 tons of coated freesheet in 2008. Coated Freesheet also excludes 502,000 tons of IP coated bristols and includes a restart of 70,000 tons by Newton Falls Fine Paper in 2007.

- (1) Includes directory grades.
- (2) Uncoated freesheet excludes uncoated bristols.

Note: Product grades highlighted represent Verso products and current production capacity.

Verso is a Maine Company



Androscoggin Mill



- Opened for business in 1965.
- Employs almost 1,000 people operating five paper machines.
- Capable of producing more than 1,900 tons per day of coated groundwood and coated freesheet papers for offset and rotogravure printing on three coated machines.
- Also produces specialty grades and pulp on two other machines.

Bucksport Mill



- Opened for business in 1930.
- Employs more than 750 people operating four paper machines.
- Capable of producing more than 1,400 tons per day of coated groundwood and specialty papers.

Verso in Minnesota



- **Opened for business in 1906.**
- **Employs more than 470 people operating three paper machines.**
- **Capable of producing more than 800 tons per day of coated groundwood and supercalendered papers.**

Verso in Michigan



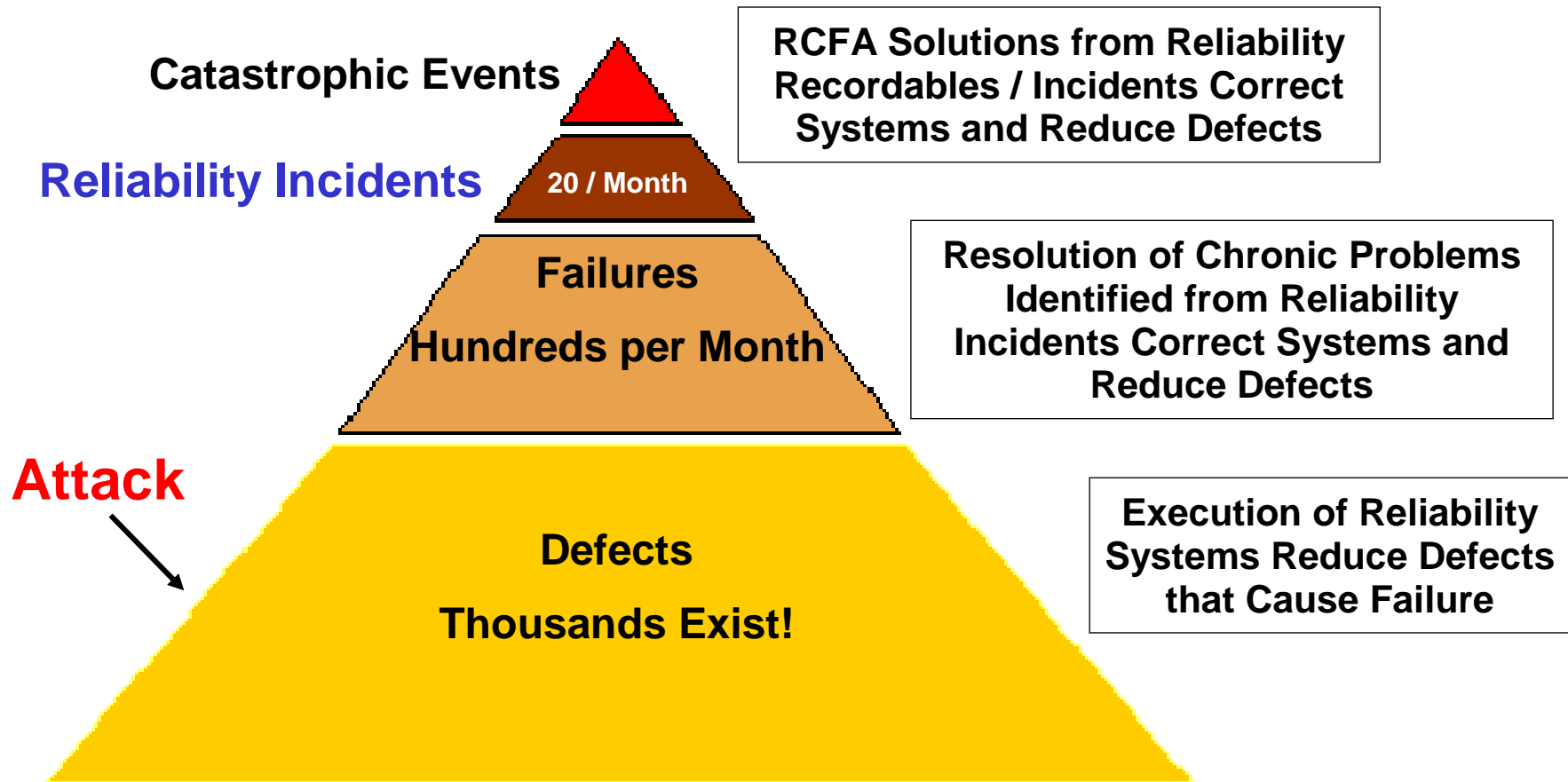
- **Pulp mill started up in 1985. Paper machine in 1990.**
- **Employs 460 people operating one coated freesheet paper and one northern hardwood pulp machine.**
- **Produces more than 1,100 tons of paper and 800 tons of market pulp per day.**

Reliability Incident Reporting

Measuring and Learning from Our Reliability Failures

Why?

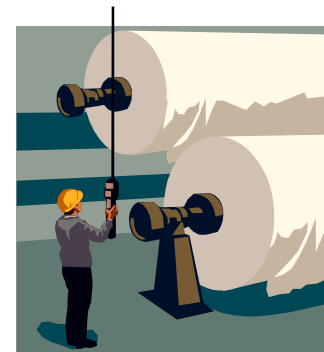
Because History Repeats Itself...Unless We Focus on the Facts and Prevent It!



More Reliability Defects = More Catastrophic Events

3 General Categories

1. **Technical (*physical*):** Equipment and Physical Causes [15%]
2. **Programmatic (*latent*):** Systems and Process Causes [60%]
3. **Personnel (*human*):** People Related Causes [25%]



What Leads to an RCFA?



- We track larger failures that cost over \$25k or 3+ hours of machine downtime (unplanned)
 - These events are termed Reliability Incidents (RI's)
 - We WILL do an RCFA on all RI's
- We still do RCFA's on items that may not reach these thresholds, so:
 - All RI's will have an RCFA, but not all RCFA's are RI's
- RI's are a major metric for both operations and maintenance
 - Scorecards for operations will have maintenance RI's on it and vice versa – we're all in this together!
- We track RI's in the Reliability Reporting database
- We compare mills against each other by using each mill's RAV as a denominator in determining metrics

RI Web Application



- Manual entry of reliability incidents
- All mill reliability incidents recorded since 2007 (additional information is available dating back to 2004)
- Recordable incidents are any incidents that have three (3) hours process or equipment downtime or \$25,000 financial impact
 - **Financial impact is cost of repair plus cost of lost operations**
 - **Cost of repair includes parts and labor**
- At the mill's discretion, all incidents can be entered into the database (different targets / thresholds)
- Accessible from any company PC
- It enables more consistent data storage and provide reporting functions
- Provides the framework to work through an RCFA
- Action Items / Corrective Actions are tracked through this system, and reports sent out as reminders of action due

The Birth of an RCFA



- A failure, or maybe even reduced optimization, occurs
- Typically, we have already worked through the event to get the equipment back online and operating optimally
- Later, an Operations Supervisor will enter an incident into the RI Database, filling in the required information such as what's and where's, as well, importantly, a list of people that could be interviewed (knowledgeable about the incident)
- An email will automatically be sent out notifying the pre-picked audience that a new RCFA has been created
- The operations manager for that area will then assign an RCFA Leader to that incident (maintenance or operations)

Incident Creation



Reliability Index - Microsoft Internet Explorer provided by Verso Paper (VIT 001-01A)

http://ridev/rindex.asp

Reliability Index

Reliability Incident Reporting

* Facility RI #

* Business Area Line

* Incident Start 00 Incident End 9/10/2009 Time 00:00 Downtime(hrs)

* Incident Title Crew Shift Failure Classification Avg Class

Incident Description

Recordable RCFA Chronic Certified Kill Best Practice

Trigger

Type of Failure Reason Prevention

Equip./Process Component

Repair Cost Operational Cost Financial Impact Safety Quality

Location of Failed Material

Conditions Influencing Failure

People to Interview

Team Members

Analysis Lead Analysis Completed Corrective Actions Completed

CreatedBy: None CreationDate: None LastUpdatedBy: None LastUpdateDate: None

Select RCFA Trigger (if applicable)



RCFA

Select an RCFA TRIGGER IF RCFA type is selected.

Note: The example shown shows additional triggers that the mill leadership has determined are causes for RCFA's

Reliability Incident Reporting

* Facility: Androscoggin

* Business: Finished Product Area: PM Line: 3 Paper Machine

* Incident Start: 07/13/2009 Time: 09:15 Incident End: 07/13/2009 Time: 14:30 Downtime(hrs): 5.25

* Incident Title: PM3 Fan Pump Motor Failure From Water Crew: X Shift: Day Failure Classification:

Incident Description: PM3 was scheduled to start up at 9am from a 24 hour outage. The Fan Pump ran during the boilout and also ran when threading up the paper machine. The sheet was already to the reel when the Fan Pump motor failed. When the junction box was opened, water ran out. A VIB condensate pump motor was also changed out earlier in the day with water in the motor junction box. The Seal Pit WW pump also had failed. Moisture and rust was noticed in the motor. The spare 150 HP motor for the fan pump was installed, but the motor failed a megger test after the

Recordable: Yes RCFA: Full RCFA Chronic: No Certified Kill: Best Practice:

Trigger:

- Type of Failure: 2 or more repeat failures in a year totalling more than \$10,000
- Equip./Process: 3 or more hours of unscheduled downtime
- Repair Cost: Any Fire Incident resulting in 3 or more hours of mill process downtime
- Location of Failed Material: Any failure with a cost impact of \$25,000 or greater
- Conditions Influencing Failure: Environmental Event (significant) or repeat environmental nonconformance
- People to Interview: Fire Incident with a cost impact of \$25,000 or greater
- Team Members: Incident likely to reoccur
- Analysis Lead: PM 2 - Greater than 40 tons of quality loss
- Analysis Completed: PM 3 - Greater than 40 tons of quality loss
- Preventive Action Completed: PM 4 - Greater than 36 tons of quality loss
- PM 5 - Greater than 34 tons of quality loss
- Repeat events totaling more than \$25,000

Prevention: Safety: Quality:



Enter Costs Related to Incident



- The Repair Cost of a reliability incident includes the repair or replacement costs of the equipment and/or the labor costs associated with the repairs. Also include overtime costs to get an accurate estimate.
- The Operational Cost is the cost of lost production / profit associated with equipment downtime or slowback, the loss of direct cost materials (fiber/raw materials/chemicals/energy) due to the failure, the incremental costs associated with the incident such as burning gas instead of bark, and/or any collateral damage caused by the failure. **Accounting provides the mill with the average cost of an hour's lost time to equipment, such as a paper machine.**
- The total Financial Impact is the Repair Cost plus the Operational Cost. This field is read-only and is a sum of the data entered into the other fields.

Type of Failure	Equip Failure Elec	Reason	Contamination	Prevention	Management Learning
Equip./Process	Motor	Component	Winding		
Repair Cost	4000	Operational Cost	32000	Financial Impact	36000
Location of Failed Material				Safety	
Conditions					

The RCFA Process



- When a failure occurs, we treat the area like a **Crime Scene**
- We take pictures, conduct interviews, and take notes on all the events that were simultaneously taking place
- When the RCFA Leader begins the process of identifying the root cause of the incident, all of this information is extremely critical
- The Leader may assemble a team to work on the issue, or he/she may conduct a solo investigation
- Rule of thumb – “The Faster the Better”



Failure Modes and Effects



1. Item Identification
2. Description of Failure Modes (ruptures, cracks, fractures, voids, short circuits, etc)
3. Cause of Failure (stress, errors, wear, mishandling, defective material)
4. Effects of Failure
5. Probability of Occurrence
6. Criticality of Failure (minor, major, critical, catastrophic)
7. Corrective Action/Preventive Measures

Techniques of Analysis



- Barrier Analysis
 - Events, programmatic problems, procedures
 - Used with Cause and Effect Analysis
- Basic Problem Solving
 - Necessary for equipment problems
 - Used for all analysis
 - Steps are: define the problem, use experts, analyze the problem, verify root causes
- Cause and Effect
 - Event analysis, complex system, or equipment technical problems
 - Helps sort and link causes and effects for use with other techniques
- Cause Tree Analysis
 - Event analysis
 - Programmatic events that include problems of omission or commission
- Change Analysis
 - Analysis of a component of system before repair or modification was performed
- Fault Tree Analysis (Logic Tree)
 - Logic diagramming to help establish cause and effect relationships

Techniques of Analysis



- Personnel Performance Analysis
 - People problems; requires people skills and understanding of human nature
- Programmatic Root Cause Analysis
 - Maintenance failures
 - Triggered by single event or “clusters”
 - Used on regularly scheduled audit
 - Four queries: Procedure/Documentation, Training, Quality Control, and Management
- Reliability Analysis
 - Develop logical and mathematical models of equipment and system performance
 - RCFA methodology, applicable to technical root cause analysis
- Systematic Approach to Repetitive Failures
 - “Cluster Analysis”: concentrations of chronic failures or other events seem to be occurring, leading to beginning point of investigation
- Technical Analysis
 - Physical or design failures
 - Scientific tools and engineering techniques

The RCFA Process



- The database leads the Analysis Leader through the process of identifying all of the possible causes
 - Machines, materials, methods, people
 - What are the failure modes for this equipment
- Once we identify this information, we begin to evaluate each piece based upon the evidence we collected at the Crime Scene, interviews we have conducted, and analysis of the equipment itself (either in-house or outside assistance such as a motor repair shop)
- The Leader, or the team, will work through all this until he/she believes they have identified the root cause. **It may take 2 days, it may take 2 months.**
- The Leader is also continually updating the RI Database with information, uploading pictures, entering analysis data, etc. so that we have a record of all the research for both this incident and potential future events

Analysis Workspace



RCFA Analysis Summary - Microsoft Internet Explorer provided by Verso Paper (VIT 001-01A)

http://rij/RCFAWorkspace.asp?RINumber=681795

RCFA Analysis Workspace

Failure Event - What brought this to your attention?

After a LOO curtailment, the Fan Pump motor failed on start-up. It had run earlier in the day and then failed when the windings shorted to ground.

Failure Modes - How has this event happened before?

When the motor junction box was removed, a significant amount of water ran out. Two other motors were also failed.

Proven Hypotheses - "How can" these modes happen?

The most likely cause was from high pressure hose water getting around the gaskets of the motor junction box. Other mills have experienced consensation with equipment that has been down for long periods of time.

Verification - Data that proves whether the hypothesis is valid

After the next few curtailments on 3/23, 4/27, and 5/20, we meggered critical SCA motors to ground to check for water contamination. Each time we measured infinity to ground which indicates no contamination. One the 3/23 outage, we also opened several motors to check for water and found none. This would indicate that the initial failure was due to hosing of motors.

[Save Changes to RCFA Analysis Workspace](#)

Use a structured problem solving approach to accurately determine the failure modes and their causes. Document your findings in the blocks below.

Analysis performed and summary data documented regarding the event, failure modes, proven hypothesis, and verification.

Document Causes



RCFA Causes - Microsoft Internet Explorer provided by Verso Paper (VIT 001-01A)

RCFA - Causes

Physical Causes			
<input type="checkbox"/> Defect in Manufacturing	<input type="checkbox"/> Material Selection Incorrect	<input type="checkbox"/> Unintended Operation	<input type="checkbox"/> Process Changes
<input type="checkbox"/> Damaged in Shipping	<input type="checkbox"/> Equipment Size/Spec	<input type="checkbox"/> Maintenance Oversight	<input type="checkbox"/> Measurement/Calibration Error
<input type="checkbox"/> Computer/Software Error	<input checked="" type="checkbox"/> Contamination	<input type="checkbox"/> Startup/Shutdown Failure	<input type="checkbox"/> Incorrect Parts
<input type="checkbox"/> Weather/Ambient Condition	<input type="checkbox"/> Power Failure Outside Area	<input type="checkbox"/> Operational Oversight	

Other Physical Causes

Human Causes

Contamination most likely due to water spray from hoses.

Latent Causes - List the most basic characteristics of the failure that can be identified and corrected.

<input type="checkbox"/> Training Deficiencies	<input type="checkbox"/> M.W.S. Deficiencies	<input type="checkbox"/> Communication Deficiencies	<input type="checkbox"/> Practice/Hands-on Experience
<input type="checkbox"/> Procedural Deficiencies	<input type="checkbox"/> Specification Deficiencies	<input type="checkbox"/> Enforcement of Policy	<input type="checkbox"/> Mgmt of Change

Other Latent Causes

[Save Changes to RCFA Analysis Summary - Causes](#)

After trials/assumptions or full analysis completed and causes found, update with Physical, Human and Latent Causes. Select all that apply.

Physical Root Causes



- **Defect in Manufacturing** – Materials or fabrication flaw from manufacturer / vendor
- **Damaged in Shipping** – Shipping to / from vendor & storeroom; to / from storeroom & jobsite
- **Computer/Software Error** – Failures due to computer systems
- **Weather / Ambient Condition** – Failures due to forces of nature
- **Material Selection Incorrect** – Chemical incompatibility, hardness, finish, operating temperature
- **Equipment Size / Specification** – Equipment and components originally sized above or below nominal design capacity.
- **Contamination** – External influence on components from process flow or surrounding conditions
- **Power Failure Outside Area** – Failure of electrical or steam power components from outside the area
- **Unintended Operation** – Equipment or process not operated within standard procedures or expectations. Cockpit error would fit here
- **Maintenance oversight** – Planning & Scheduling errors, improper assessment of equipment condition from Predictive Maintenance or Preventive Maintenance inspection, improper or no repair procedure used on equipment, equipment not returned to original tolerances or specifications
- **Startup Failure** – Improper start-up, shutdown of equipment
- **Process Changes** – Design of process has changed without consideration for effect on equipment
- **Measurement / Calibration Error** – Instrumentation readings not accurate, impacted operation
- **Incorrect Parts** – Parts supplied from manufacturer / vendor incorrect; materials supplied from storeroom incorrect

Latent Root Causes

- **Training Deficiencies** – Training not adequate to perform task or duty
- **Procedural Deficiencies** – Procedures not adequate to perform task or duty
- **MWS Deficiencies** – MWS systems not adequate to protect equipment or process. For example lack of PM, vibration analysis or other equipment care
- **Specification Deficiencies** – Specifications for equipment or process not adequate for purpose
- **Communication Deficiencies** – Poor communication contributed to problem
- **Enforcement of Policy** – Policies / procedures exist, but have not been enforced, so they were not used
- **Practice/Hands on Experience** – Individual was trained, but lacks recent hands on experience or practice to perform task
- **Management of Change** – A change was made to process, training or equipment that led to unintended problems

Document Causes

GOOD TO GREAT DEFINITIONS

Physical Roots – Component Causes

Human Roots – Human Actions

Latent Roots – Deficiencies in Management Systems

“Getting to the Latent Roots is the only way to eliminate reoccurrences.”

- From *Reliability Essentials Course*

RCFA Status



All – Lists all incidents that are RCFA type (open and closed)

Unassigned – RCFA incidents that have not been assigned an Analysis Lead

Analysis in Progress – Analysis Lead has been assigned, but Analysis has not been completed

Analysis Complete – Analysis Lead has submitted the RCFA and has the Analysis Complete. All of the corrective actions have not been implemented.

Analysis/Actions Complete – RCFA is completed

Actions in Next 7 Days – All RCFA's that have overdue or corrective actions to be done in the next week.

Overdue Action – List all RCFA's with overdue corrective action items

Reviewing the Conclusions



- Review of the Analysis findings begin once the Leader submits the incident as Analysis Complete
- Mill Lead Teams will review 1-2 incidents a week and provide feedback for improvement, as well their expertise
- We absolutely, positively reject more than 50% of these!!!!
 - This is not a rubber stamp process
 - Not all RI's are reviewed
 - Managers have identified an RI as critical
 - Personnel choices play a role (mentoring, history)
 - Believe the findings could be shared with other areas
- A Verso Reliability RCFA Team meets every two weeks for teleconferences / webex
 - Review as well, looking for systemic improvement and sharing of best practices, not necessarily for actual findings (although we do uncover opportunities within these meetings)

RCFA Executive Summary



Parameters Group Tree 1 / 4 100%

Main Report

RCFA Failure Incident Summary

Page 1 of 4
2/2/2011 6:07:17PM

RCFA#: 689635 **Androscoggin** RCFA Status: Analysis Complete/Actions Complete

Finished Products: PM 4 Paper Machine Recordable: Yes

Failure Date:	07-Jan-2010	Downtime hrs:	18.00	Trigger:	3 or more hours of unscheduled downtime
Cost of Failure:	\$ 30,000	Financial Impact:	\$ 126,450	Loc of Failed Material:	Pump Shop
Analysis Leader:	Charles Lavin	Team Members:			

Title: A4 Couch Roll Gearbox Failure

Failure Desc: At 1:27PM on Thursday January 7th an alarm for the couch roll gearbox was sounded, a call was made to ER to inspect the alarm. The ER employee inspected the gearbox and found the input shaft bearing failing with excessive heat and flames at motor coupling guard. He notified the wet end operator who shut down the paper machine. The gearbox was changed out. See attachments for photos, RCFA work sheet details.

People to Interview: Kevin Reed, Ben Cracolici, Tom Heywood, Todd Braga, Dale Lavorgna, Dan Anctil, Bob St. Pierre,

Failure Modes:

- 1) Leakage at pipe connections of reducer oil circulation system.
- 2) Leakage at input shaft or output shaft seal.
- 3) Leakage at quick disconnect installed at low side of circulation system.
- 4) Crack in gearcase house.
- 5) Oil drained out and not refilled.

Failure Event: Alarm at reducer oil circulation system. This alarms if oil flow is insufficient, or if oil temperature exceeds 180° F through the cooling and filtration loop that circulates oil via a Tuthill shaft mounted gear pump on the opposite drive end of the reducer input shaft. The CTC alarm when off 1:29 PM (1:27 PM DCS time). Once the high speed thrust bearing did not have proper oil level it started to fail. However, oil was still circulating through the cooling flow circuit and the flow switch and temperature switch were not in alarm. This continued until 11:57AM on 1/7/2010 at which time drive load at the couch and wire turn roll increased by about 15%. At 1:27PM there was a loss of flow alarm and Tom Heywood was called to check, he saw flames and very hot motor end of reducer.

Proven Hypotheses: | **Verification:**



Corrective Actions



Assign appropriate resource to corrective actions tasks.

The image shows a screenshot of a web application interface for adding corrective actions. The main form is titled "RCFA Corrective Action Items" and includes fields for Resource (Moore, Chris), Priority (High), Task (The replacement motor had bad leads internally from the junction box to the motor windings. Work with Lewis motor to check these for cracked insulation.), Due Date (08/20/2009), Completion Date (09/24/2009), and Work Order Nbr (123456789). A red box highlights the "Save Changes to Action" button. Below the form, there is a list of failure items with columns for Failure, People to Interview, Team Members, Analysis Lead, and Analysis Completed. An orange callout box with an arrow points to the "Save Changes to Action" button, stating: "When selecting 'Save Changes to Action,' resource will be notified via email automatically". To the right, an email notification is shown from Chris Moore, dated 09/15/2009 04:39 PM, with the subject "The following RCFA Corrective action item has been assigned to you:". The email body lists the task details: Task Description, Work Order (123456789), Priority (High), Due Date (08/20/2009), and Additional Information. A link is provided to review the failure incident and update the corrective action task.

RCFA Corrective Action Items

*Resource: Moore, Chris *Priority: High

*Task: The replacement motor had bad leads internally from the junction box to the motor windings. Work with Lewis motor to check these for cracked insulation.

*Due Date: 08/20/2009 Completion Date: 09/24/2009 (Date Format MM/DD/YYYY)

Work Order Nbr: 123456789

*Required Fields: **Save Changes to Action** Delete Action

When selecting "Save Changes to Action," resource will be notified via email automatically

The following RCFA Corrective action item has been assigned to you:

- **Task Description:** The replacement motor had bad leads internally from
- **Work Order:** 123456789
- **Priority:** High
- **Due Date:** 08/20/2009
- **Additional Information:**

[Click here to Review Failure Incident and Update Corrective Action Task](#)

The RCFA Process



- Corrective Actions Due reports come out weekly to track compliance
- Once we complete actions, we change the status of the RI to "Analysis & Actions Complete"
- Now we monitor and make sure we are achieving the results we expect
- Eventually, based on criteria that vary by department and type of equipment (especially criticality), we will list the item as a **Confirmed Kill**

How Do We Share Our Findings?



- Select if the Best Practices site was utilized for research regarding the incident, if information was added to the site regarding best practices / findings, if both options were done, or neither option was utilized.

Description: the junction box was opened, water ran out. A VIB condensate pump motor was also changed out earlier in the day with water in the motor junction box. The Seal Pit WW pump also had failed. Moisture and rust was noticed in the motor. The spare 150 HP motor for the fan pump was installed, but the motor failed a megger test after the

Recordable: Yes RCFA Full RCFA Chronic No Certified Kill Best Practice

Trigger

Type of Failure Reason Preventio

Equip./Process Component

Repair Cost Operational Cost Financial Impact Safety Quality

Location of Failed Material

Best Practice dropdown menu options: Site Research, Site Addition, Both, Neither

RCFA Training



- Large group training occurred in 2001 at our facilities, although some of our “Power” users went to a 1 week off-site training session
- However, over the years, as people have come and gone, we have NOT done a very good job of making sure we are providing formal, documented training
- Most people over the past 5 years are learning RCFA by hands-on application and/or coaching by individuals
- 2010, we started a formal, documented training sessions geared at different levels of users
 - Department by department
 - Low End users (may be involved in the process), Mid Level users (need to know Basic plus how to use the database), and High End Users (previous plus will be called upon to actually by an Analysis Leader)

Human Performance Errors



- **Internal:**

Lapse of memory, reflex, mindset, unawareness, overconfidence, tired, attitude, confusion, tunnel vision, pressure, lack of knowledge, unfamiliarity, lack of confidence, sickness, fear of failure, shortcuts

- **External:**

Uncorrected equipment problems, unusual plant conditions, simulation differs from plant, unlabeled equipment, verbal instructions, job planning and coordination, distractions, task interruptions, design modification

- **Performance Shaping Factors:**

Preoccupied with other tasks, misunderstood verbal communication, lack of communication, poor written information, poor equipment conditions, environmental conditions, work schedule, practices, and organization, resource and change management, training/qualifications, supervisory

Questions

