Creating a Precision Lubrication Work Plan
With everything we already have to do Every Day …

Why Bother Committing to Yet Another Time and Money Consuming Initiative
Capitalism is 'Darwinian'

Globalization of capitalism, and increased communications capacity, has provided low-cost labor markets with easy access to:

- Capital for development
- Technology
- New Methods and Practices
- Foreign markets (which means us!)

The expected consequence is:

- increased competitive (pricing) pressures
- increased pressure to differentiate products and quality
- increased risk of failure
Global Commodity Producers Must Choose…

to be either a
Market Survivor,
or
Market Dominator!

What are the behavioral differences between survivors and dominators?
Capacity from the Current Assets

What systemic changes in maintenance process and practices could eliminate or severely reduce scheduled and unscheduled downtime?
Commodities Market Survivor Profile

- The best companies
  - Focus on the denominator – plant capacity
    - Use ‘best practices’ to provide capacity without additional capital investment
  - Re-engineer plant methods and practices to remove process variability
    - Attack and eliminate the root cause of variability and loss
  - Use shop floor innovations to drive out production cost
Factors that Contribute to Downtime

Most Losses are not equipment related

- Product Changeovers
- Product Quality Defects
- Raw Material Delivery
- Raw Material Quality
- Market Demand
- Energy Curtailments

Machine Condition and Maintenance Practices

- 60% to 90%
- 10% to 40%

Non-Equipment Related Losses

MCP Consulting (Britain) in Conjunction with British Dept. of Trade and Industry
Precision Alignment and Balance are Critical

Deep Groove and Cylindrical Element Bearings – No Tolerance for Misalignment, Axial and Radial Loads Influence Rate of Lifecycle Decay

Percentage of Standard Life

Misalignment (angular minutes)

ISO Quality Grade for Rotating Components

Source: SKF Bearing Manual

Precision Lubrication is Critical

25% of earth’s crust is made of silica laden rock. Silica has a harder MOHs rating than machine tool steel, particularly in the 'silt sized' (≤5 microns) particle range.
Dominant Maintenance Strategies

What are Root Causes that Lead to Failure?

Things to remember:

1. There are always more than one root cause. *Pursue Precision Machine Condition!*

2. Pareto Rule: 20% of the factors produce 80% of the failures.

3. Lubricant Degradation occurs in 44.9% of instances (SKF)

4. Corrosion, Contamination and Insufficient lubrication occurs in 59.9% of instances.
Defects (Failure Modes) Affect Reliability

A plant with 6,500 work orders per year must eliminate 10,000 defects (root causes) to reduce the incident rate by 50%.

Source: RM Group-Knoxville & Winston Ledet, Ledet Enterprises. Humble Texas
Maintenance Future of Successful Industrial Companies

Condition Control!!

- KNOW the monitoring/diagnostic technology
- Believe what the technology tells you
- Plan the work – long term view in mind
- Know the machinery – understand the inherent failure modes and machine criticality
- Know the processes – understand where the ‘root causes‘ are introduced
- Get the right people on the bus – highly skilled, technology savvy, highly motivated
Mining - Hydraulic Shovel Study Results

Hitachi 2500 Shovel - $99,901 annualized savings

- 4 premature pump failures 27 months ($20,000 per exchange, $34,000 per event production losses )
- Plus: 42 hose failures, severe oil oxidation at 2,250 hours, sever servo value failures, 39 hours downtime for repair.

Effect of Precise Lubrication State

- 1.94 years into changes
- Achieved 15/12/9, (from 22/20/17); oil lifecycle to 17,000 hrs (from 4,000).
- Eliminated 4 pump replacements and several servo valve failures.
- Increased productivity of the excavating operation

Ref: AV Lubricants, Hypro Filtration, Mobil Oil Case Study
It has been said that Industry rides on a 10 μm (Micron) Film of Oil.

If only we were so lucky!

Element Bearings = .5 - 1.5 μm
Plain Bearings = 3.0 - 10.0 μm
Controlling Component Failure

A properly devised and executed machine care program provides a continuous coating that cushions and seals components to prevent wear and corrosion.
Lost Oil Film Integrity Produces

- Loss of productive time
  - Unscheduled repairs
  - Scheduled repairs
- Loss of machine repeatability
  - Lost product quality control
- Increased Risk of Injury
- Higher Product Cost / Ton
What does ‘Optimum Results’ Mean?

- Reduction in replacement of lubricated machine parts
  - (25% minimum, 50% target @ 3 years)
- Elimination of labor associated with those mechanical repairs
  - (100% target)
- Reduced contract labor for planned outages, unplanned outages
  - (25% target)
- Increased Net Production Output
  - (3% minimum, 6% target @ 3 years)
The ‘High-Value Proposition’

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Cornerstones of Machine Productivity

Precision Installation
Precision Alignment
Precision Lubrication
Precision Balance
Precision Alignment
Common Component Failure Modes

Lubricant-Based Failure Modes are

Measurable, Predictable

And

Avoidable
Lubrication Program Development

Step 1 – Measure: Benchmark, Gap Analysis, Plan Development

- Determine program effectiveness, establish an improvement plan

Step 2 – Define: Develop machine-specific relubrication practices

- Create practices that are optimized for criticality and operating environment

Step 3 – Assess: Conduct Fluid Forensics – Machine Condition Analysis

- The feedback loop, UE (grease) and sump (oil) surveillance

Step 4 – Capital Improvement: Make necessary capital improvements

- Upgrades for machine lubrication service fixtures, lubricant storage & handling, automation, feedback

Step 5 – Educate: Conduct Skill Development

- Conduct certification/non-certification & operator training to deliver precision lubrication work practices
Composite Score - Avg 5.1
Typical Goals and Objectives

- Establish reliability objectives
  - Bearing replacement reduction
    - 40% year 1; 40% year 2; 20% year 3
  - Hydraulic value and pump replacement
    - 50% year 1, 25% year 2
  - Gear drive lifecycle extension by 50%
  - Lubricant consumption reduction
    - 20% year 1, 20% year 2, and hold there
#2 – Review Assets for Lubricant and Planning ‘Best Fit’

As is:

<table>
<thead>
<tr>
<th>Data Source</th>
<th>Bearing Lookup</th>
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<tbody>
<tr>
<td>Bearing Number</td>
<td>22220</td>
</tr>
<tr>
<td>Bearing Type</td>
<td>Spherical</td>
</tr>
<tr>
<td>Bore</td>
<td>100 mm</td>
</tr>
<tr>
<td>Outer Dia.</td>
<td>180 mm</td>
</tr>
<tr>
<td>Width</td>
<td>46 mm</td>
</tr>
<tr>
<td>Shaft Speed</td>
<td>1785 rpm</td>
</tr>
<tr>
<td>Bearing Temp</td>
<td>125 °F</td>
</tr>
</tbody>
</table>

Service Factors:
- Temperature: Housing below 150 F
- Contamination: Light, non abrasive dust
- Moisture: Occasional water on housing
- Vibration: 2 to 4 ips (5 to 10 mm/s)
- Position: Horizontal bore centerline

Viscosity:
- @ 40C: 46 cSt
- @ 100C: 46 cSt

Lubrication Interval:
- 2 days

As should be:

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Viscosity:
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- @ 100C: 10 cSt

Lubrication Interval:
- 2 days

* Should be lubricated with an automatic method
* Lube volume was scaled by 25%
Optimizing the Lubrication Plan

A few challenges to be met:

1. RCL is a detail-intensive machine care process
   - Need a plan for collecting and managing the details
   - Need a system for managing and tracking at the COMPONENT (not the ASSET) level

2. Plan should focus on Machine First, Lubricant Second
   - Reliability Priority to meet production demands
   - Component type, size, speed, load
   - Environmental challenges
   - Annual Labor Requirement – based on measurement
Step 1 – Mapping. Example – Mill, Machine Tend Side
Site Mapping and Route Definition – Jointly Defined
System Components to Consider

Lube Tasks for a Simple Process Pump

Motor Bearings, IB & OB
Coupling
Pump Body
Lubrication Program Details

- **A SINGLE Critical Conveyor, Lubrication Tasks / Year**
  - Motor (2 bearings x 2 tasks / year) = 4
  - High Speed Coupling (1 ea. x 2 tasks / year) = 2
  - Reducer Level Check (1 x 52 tasks / year) = 52
  - Reducer Grease Seal (2 ea. x 4 tasks / year) = 8
  - Reducer Oil Sample (1 ea. x 4 tasks / year) = 4
  - Side-stream Sump Filtration (12 times / year) = 12
  - Oil Change is based on condition (none / year) = 0
  - Low Speed Coupling (1 ea. x 2 tasks / year) = 2
  - Head Pulley Bearings (2 ea. x 12 tasks / year) = 24
  - Tail Pulley Bearings (2 ea. x 12 tasks / year) = 24
  - Take up roll bearings (6 ea. x 12 tasks / year) = 72
  - Assume all other bearings are sealed

Net Lubrication Tasks per Year = **204**
Reliability-Centered Lubrication

Site-Wide Machine Requirements Survey

- Record Machine Name & Number.
- Log each component by type.
- Log meaningful nameplate and design details.
- Log environmental influences
## Reliability-Centered Lubrication

### Train Elements by Type

- **(Ex.: Electric Motor)**

<table>
<thead>
<tr>
<th>Items</th>
<th>Make</th>
<th>Model</th>
<th>No.</th>
<th>Component Type</th>
<th>Make</th>
<th>Model</th>
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<tbody>
<tr>
<td>Drive Train - Conveyor A1</td>
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<tr>
<td>Motor</td>
<td>GE</td>
<td>5KS511SN3260HB</td>
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<td>SKF</td>
<td>90BCO3JP3 75BCO3JP3</td>
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<td>1080T</td>
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<tr>
<td>Gear Reducer</td>
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<td>2145 Y2B</td>
<td>1</td>
<td>1 Sump</td>
<td>Falk</td>
<td>Type K</td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td>2 Seal</td>
<td>Falk</td>
<td>Type K</td>
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<tr>
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<td></td>
<td></td>
<td></td>
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<td>Falk</td>
<td>PRT 65</td>
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<td>Falk</td>
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<td>1</td>
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<td>Head Pulley</td>
<td></td>
<td></td>
<td></td>
<td>2 Bearing</td>
<td>SKF</td>
<td>22234CCK/W33 22234CCK/W34 22230C/W35 22230C/W36</td>
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<td></td>
<td></td>
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<tr>
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<td></td>
<td>SKF</td>
<td>90BCO3JP3 75BCO3JP3</td>
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<td>Cont. Conv 78AH650-66G</td>
<td>192 3</td>
<td>Bearing</td>
<td>Timken LM</td>
<td>11949</td>
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<tr>
<td>Return Roller Bearings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Koyo</td>
<td>UCF208-24</td>
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### Component Make and Model

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</tr>
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</table>

### No. of each type of component

- **3**

### No. of Lubricated parts for each component

- **3**

### Part Make and Model

- **Bearing**
  - **Koyo**
    - **UCF208-24**
Work Practices
Creation

Create a Machine Database

Balance Route work-load per employee, per each week
Without a QUALITY Plan to manage the details, and a RELENTLESS FOCUS on completing the Plan Every Week, the lubrication/basic care program will not deliver improved mechanical reliability.
After You’re Done - Make it Better

There is ALLWAYS from for Improvement

- Review schedule compliance weekly
  - 90% or better weekly compliance (or re-do routes)

- Review OA Results Bi-Weekly
  - Contamination Control in Limits – 85% of results
  - Oil Health Control in Limits – 95% of results

- Reinforcement through Training
  - Compensation growth based on Knowledge vs Yrs. of Employment

- Quarterly Review Against Reliability Goals
Focus On Meaningful Results

One of the smallest cost items in the budget directly influences 35% of total maintenance cost.
Final Thoughts

- There is a very strong relationship between the quality of the lubrication program, and replacement of lubricated machine parts.

- Machine lubrication is the ‘be$t buy’ in maintenance department cost control:
  - It gives you extraordinary leverage!

- You have to have the means and the discipline to manage a very large amount of detail!
Thank You and Questions?
Backup
AMRRI Reliability Support Services

Lubrication Program - Work Planning, Development and Deployment

- Lubrication development and management products to design and build effective lubrication practices, including: LubeCoach, LubeCoach Pro, Sample Interval Calculator, NPV Calculator, etc.

Engineering and Technician Training

- Certification (ICML MLT and MLA – all levels)
- ‘Newbie’ Hand’s-On training (for operators and new hires)
- LUBE-IT Lubrication Management Program build and operate training.

Fluid Forensics – Lubricant-Based Machine Monitoring Services

- Oil samples data is re-analyzed, action items are identified, reported and discussed with management. Intent is to IMPROVE machine performance, avoid simply making oil changes.

Continuous Lubricant Surveillance and Diagnostic Technology

- Viscosity, Moisture, Temperature, Particle Count, Ferrous Content, Lubricant Health
Available Reliability Support Services

On-site Manual Analysis Technology
- Spectro Systems on-site lab equipment

Lubrication Storage and Handling Improvements
- Greenfield facility design, space rejuvenation design
- Drum and Bulk Storage and Preparation for Use – prefiltration systems

On-Site Program Management and Staff Coaching
- Lubrication program management expertise to support via periodic or ongoing support

Special Consulting Projects
- Lubricant Consolidation Review and Recommendation, Logistics Analysis, Special Concerns Diagnosis and Recommendations

Condition Monitoring Technology – SPM HD Continuous Surveillance
- Low rotating speeds (<50 RPM), journal bearings – any speed
Case Study – BHP Aluminum Rolling Mill

![Graph showing Fluid Rating, Mill Output Speed, and Bearing Failure over years]

<table>
<thead>
<tr>
<th></th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
<th>Year 6</th>
<th>Year 7</th>
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<td>6</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td># Bearing Failures</td>
<td>12</td>
<td>9</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Mill Speed (m/S)</td>
<td>46</td>
<td>46</td>
<td>103</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
</tr>
</tbody>
</table>

Ref: Diagnetics Case Study
Case Study – Nippon Steel

Action Plan:
- Cleanliness Targets
- Sampling Ports
- Improved Filters and Breathers
- Cleanliness Targets
- Onsite Particle

Achievements:
- 75% reduction in oil consumption
- 80% reduction in hydraulic repairs
- 50% reduction in bearing purchases

Years

Program Implementation

Pump Replacement Frequency (% of Total)

Percentage of New Installations and Fractional Defective
Case Study – Kawasaki Steel

Action Plan:
1. Set Cleanliness Targets
2. Installed Off-Line Filters
3. Onsite Particle Counter
Thanks for your interest.

For more Machine Lubrication & Oil Analysis Education and/or Certification Courses
Please reach out to us at AMRRI.com

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