Gerrit Teunissen, General Manager City Power, Johannesburg, South Africa

“How to justify and prioritise maintenance requirements throughout an organisation”
Presentation outline

- **Background: What is MAINTENANCE?**
- **Maintenance Costs**
- **Financial Perspective**
- **Maintenance Methodologies**
- **Maintenance mix**
- **Condition Monitoring Techniques**
- **Determination of Risk Value**
- **Failures averted due to Condition Monitoring**
- **Requirements for maintenance execution**
- **Closure**
What is MAINTENANCE?

1. General: Activities required to conserve as nearly, and as long, as possible the original condition of an asset or resource while compensating for normal wear and tear.

2. Accounting: Periodic cost incurred in activities that preserve an asset's operational status without extending its life. Maintenance is an expense that, unlike capital improvement (which extends an asset's life), is not capitalized.
What is MAINTENANCE?

3. 

**Engineering:** Actions necessary for retaining or restoring an **equipment**, **machine**, or **system** to the specified operable condition to **achieve** its maximum **useful life**. It includes **corrective maintenance** and **preventive maintenance**.
Maintenance Costs

Maintenance costs = Direct costs + Indirect costs

DIRECT
- Maintenance labour
- Spare parts
- Sub-contractor
- Transport

INDIRECT
- Loss of revenue (lost sales)
- Increased spares holding (higher inventory carry costs)
- Re-work
- Unnecessary work (Secondary damage, etc)
- Increased scrap
- Extra capacity (network, personal and material)
- Increased overtime
- Increased customer dissatisfaction
- NRS 048 & 047 non-compliance
- Disposal costs
- Safety (accidents, liabilities, etc)
- Increased insurance premiums
Maintenance methodologies

**Non-tactical**
- Breakdown (fire fighting)
- Ad-Hoc

**Tactical**
- Operate to Failure (OTF)
- Fixed interval based (Time or counter/meter)
- Condition-Based / Predictive
- Pro-active

**Opportunistic Maintenance**

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Maintenance mix

Operate-to-Failure
Fixed interval Maintenance
Condition-Based Maintenance
Pro-active Improvement

Low
Med
High

Cost

OEE

Optimum Maint. Mix

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Condition Monitoring Root Map

Prevention

Mitigation of Potential Failures for Reliability & Quality Power

Containment

Network Protection System
Remote Control and Monitoring Capability
Systemized Contingency Operation Plan
Operational Readiness and Fast Response
Business Continuity Management
Generators Mobilisation

Asset Security and Protection
Asset Replacement Programme
Systemized Contingency Operation Plan
Quality Management System
Condition Based Maintenance Programme
Condition Monitoring Programme

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**Determination of the Risk Value**

<table>
<thead>
<tr>
<th>Risk Level</th>
<th>Consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Red = Extreme</strong></td>
<td><strong>Safety:</strong> Describe Negligible through to Disaster events</td>
</tr>
<tr>
<td><strong>Amber = High</strong></td>
<td><strong>Environmental:</strong> Describe Negligible through to Disaster events</td>
</tr>
<tr>
<td><strong>Yellow = Medium</strong></td>
<td><strong>Reputation:</strong> Describe Negligible through to Disaster events</td>
</tr>
<tr>
<td><strong>Green = Low</strong></td>
<td><strong>Financial:</strong> Describe Negligible through to Disaster costs</td>
</tr>
<tr>
<td><strong>Blue = Slight</strong></td>
<td><strong>Other:</strong> Describe Negligible through to Disaster events</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Likelihood of Event</th>
<th>Event Count per Year</th>
<th>Negligible</th>
<th>Minor</th>
<th>Important</th>
<th>Major</th>
<th>Severe</th>
<th>Disaster</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certain</td>
<td>10</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Almost Certain</td>
<td>1</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Possible</td>
<td>0.1 (once in 10 yrs)</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Rare</td>
<td>0.01 (once in 100 yrs)</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Very Rare</td>
<td>0.001 (once in 1000 yrs)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>
## Condition Monitoring Techniques

<table>
<thead>
<tr>
<th>Condition Monitoring Systems</th>
<th>What they detect</th>
<th>Applied to</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Scanning</td>
<td>Overheating</td>
<td>Equipment</td>
</tr>
<tr>
<td>Dissolved Gas Analysis</td>
<td>Abnormal oil contents</td>
<td>Equipment &amp; cables</td>
</tr>
<tr>
<td>Oil Pressure Monitoring</td>
<td>Low pressure</td>
<td>Cables</td>
</tr>
<tr>
<td>Distributed Temperature Sensing</td>
<td>Hot spots</td>
<td>Cables</td>
</tr>
<tr>
<td>Very Low Frequency Test</td>
<td>Low insulation</td>
<td>Cables</td>
</tr>
<tr>
<td>Partial Discharge Monitoring</td>
<td>Minute current leakage</td>
<td>Equipment &amp; cables</td>
</tr>
<tr>
<td>Operating Mechanism Monitoring</td>
<td>Abnormal operation</td>
<td>Equipment</td>
</tr>
</tbody>
</table>
FAILURES AVERTED DUE TO CONDITION MONITORING

POTENTIAL FAILURE FOUND AT A SUBSTATION IN 88/11kV YARD ON TRANSMISSION

LOOSE CONNECTION CAUSED EXCESSIVE HEAT TERMINATION REPLACED

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FAILURES AVERTED DUE TO CONDITION MONITORING

POTENTIAL FAILURE FOUND AT A SUBSTATION

MANY PREVIOUS FAULTS – MOSTLY FROM CABLE TERMINATION FAULTS
PANEL NOT BEEN CLEANED ADEQUATELY LEADING SECONDARY FAULTS

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FAILURES AVERTED DUE TO CONDITION MONITORING

POTENTIAL FAILURE FOUND AT A SUBSTATION

COMPOUND FILLED TERMINATION REPLACED WITH HEAT SHRINK
INDEQUATE CLEARENCES AND CORE CROSSED

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CONDITION MONITORING TECHNIQUES TO UTILIZED

- Ultrasonic, TEV monitors and Infrared camera – substations and overhead lines – on going
- Dissolved Gas Analysing and online monitors for transformers – on going
- Off load Partial Discharge (PD) diagnostic for cable systems – being investigated
- Live PD detection for GIS and AIS switchgear – being investigated
- Leakage current monitors for surge arresters – being investigated
FAILURES AVERTED DUE TO CONDITION MONITORING

POTENTIAL FAILURE FOUND AT A SUBSTATION

PARTIAL DISCHARGE DETECTED ON VT AND REPLACEMENT CT’S NOT INSTALLED CORRECTLY OEM DESIGN PROBLEM AND POOR WORKMANSHIP
Requirements to ensure maintenance of an acceptable standard is performed

**Funding:** Sufficient funding should be made available – international benchmark: 5 to 7% of asset replacement value on an annual basis

**Skills:** The “Right Skills at the Right time doing the Right thing Right”

**Material availability:** Making sure the correct parts are available and are used – no short cuts!
Other factors to be considered

- **History:** Keep a data base of maintenance performed – this will give a cost overview as well as compliance to OHS act
- **Down time:** What impact will down time have? Can the work be done after hours?
- **Maintenance Tactic:** Have the maintenance work in a task list format – this will ensure standards are met within a specified timeframe
Conclusion

Thanks for listening and sweat the assets but don’t drive them into the ground(red).