Are you getting a full return on your assets?

- How do you compare to world-class performers?
- What has the greatest impact on shareholder value for you: asset effectiveness, or reduced costs?
- How do you deliver actual, lasting improvements?
- How can you improve the reliability and safety of your operation?
- Where are hidden improvement opportunities; how worthy are they?

How can you optimize assets to improve your financial return?
Benchmarking

“Benchmarking is a continuous process for evaluating the practices and metrics of a maintenance organization, comparing to those companies recognized as leaders, aiming to identify and incorporate the improvement opportunities regarding cost reduction and production performance.”
## Benchmarking

<table>
<thead>
<tr>
<th>IT ISN’T</th>
<th>IT IS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Just a search of performance indicators from other companies for comparing to those from your own Company</td>
<td>Primarily to identify the best practices adopted in word-class Companies, which leverage them to high level performance and leading position, and implement such practices in your own Company.</td>
</tr>
<tr>
<td>A punctual event</td>
<td>A continuous process</td>
</tr>
<tr>
<td>Copy and imitation</td>
<td>A learning process; a pragmatic search of new ideas</td>
</tr>
<tr>
<td>Easy</td>
<td>A process that takes time, work and requires discipline</td>
</tr>
<tr>
<td>Just a new fashion</td>
<td>A powerful tool that delivers useful information for a sustainable improvement of the maintenance organization</td>
</tr>
</tbody>
</table>
Benchmarking - Objectives

- To know the strengths and weaknesses of your process
- To know your competitors
- To know the best practices, new ideas and to incorporate them
- To acquire superior performance
ACTIONS FOR A SUPERIOR PERFORMANCE

LOOKING FOR REFERENCE PRACTICES (BEST IN CLASS)

DEFINE WAYS FOR REDUCING THE GAP (BEST KNOWLEDGE, BEST PRACTICES, BEST PROCESSES)

LOOKING FOR REFERENCE METRICS (BEST IN CLASS)

GAP CALCULATION (DIFFERENCE: ACTUAL x REFERENCE METRICS)

· HOW MUCH? WHERE? WHEN?

MANAGEMENT COMMITMENT

EMPLOYEES PARTICIPATION

ACTIONS FOR A SUPERIOR PERFORMANCE
Critical Success Factors in Maintenance

The effectiveness of Asset Management Process within World-class companies is closely connected to:

- **PEOPLE** (qualification, culture, attitude)
- **MANAGEMENT SYSTEMS** (organization, standards)
- **TECNOLGY** (to improve the way of execution and also avoid the execution)
Maintenance Evaluation & Benchmarking

ABB Approach

Carlos Henrique Arruda

ABB
ABO’s approach to industrial asset optimization involves an integrated step-by-step process. Comprehensive benchmarking gives a clear picture of current overall plant effectiveness.

After partnership structure has been agreed, workplace efficiency & effectiveness is first improved using state of the art management methods and systems concerning both maintenance and production operations.

Achieving world-class maintenance standards involves putting in place industry-specific improvement tools and methodologies.

The last step in the ongoing improvement process involves technological innovation and/or process improvements which enhance the production performance of an already efficient and reliable plant.
Measurable Customer Benefits

- Significant reduction in maintenance costs
- Measurable improvements in productivity (OEE)

ABB Full Service®
ABB Full Service®

Totally dedicated to Industrial Maintenance

- We are present in more than 100 countries around the world
- The annual turnover of Service is BUSD 3,5
- The total number of Service employees is about 17,000
- We have over 150 Full Service Partnership Agreements
ABB Full Service®: Metals & Minerals

- CMS, Chile
- BlueScope Steel, Australia
- Hydro Aluminium, Australia
- Kunda Nordic Cement, Estonia
- Mondo Minerals, Finland (3 sites)
- Boliden Harjavalta, Finland
- Outokumpu Poricopper, Finland
- OMG Harjavalta Nickel, Finland
- JaRo, Finland
- ABB Motors, Finland
- ABB Industry, Finland
- ABB Motors, Estonia
- DMS, South Africa
- MMC, South Africa
- Columbus Steel, South Africa
- Outokumpu Stainless, Sweden
- Alcan, UK
The performance of the maintenance organization can be expressed by two main ratios:

- Maintenance Effectiveness
- Maintenance Practices

**INPUT**

- Personnel
- Material
- Contracted Services
- Overhead

**OUTPUT**

- Availability
- Speed
- Quality
- Reliability
- Energy & Utilities efficiency

**Asset Management Process (practices)**

**Direct Cost**

**Recurring Cost (Unreliability Cost / Production Losses)**
Methodologies - Detailed Assessment

QUALITATIVE ANALYSIS

QUANTITATIVE ANALYSIS

BOTTOM-UP

TOP-DOWN
Qualitative Analysis

- Maintenance Management
  - 24 sections
    (According to EFQM-model)

- Maintenance System
  - 7 sections
    (Asset Registry, Works Orders, Planning and Scheduling, System Performance, Business Processes (IT), IT (System Features), Inventory and Procurement)

- Reliability Engineering
  - 4 sections (Reliability Planning, Maintenance Plans, Root Cause Analysis, Precision Maintenance)

- Asset Conditions
  - 1 section
<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 0.9</td>
<td><strong>Innocence</strong>: It means an <em>unknowing</em> level, where there is no idea of what implies the characteristic or criteria of “Best Practices”.</td>
</tr>
<tr>
<td>1 - 1.9</td>
<td><strong>Awareness</strong>: It means a level where the characteristics and the benefits resulting of the implementation of the “Best Practices” <em>are known</em>.</td>
</tr>
<tr>
<td>2 - 2.9</td>
<td><strong>Understanding</strong>: It represents a level where the characteristics and criteria of “Best Practices” <em>are understood</em>, and some benefits are being achieved based upon initial steps of implementation.</td>
</tr>
<tr>
<td>3 - 3.9</td>
<td><strong>Competence</strong>: It means that <em>are well known</em> the criteria, characteristics and benefits already implemented in the company and there is a <em>good control</em> of the “Best Practices”, enough to spread them throughout the whole organization.</td>
</tr>
<tr>
<td>4 - 5</td>
<td><strong>Excellence</strong>: The level of competency on the “Best Practices” is comparable to world-class companies and <em>quantifiable</em> and auditable benefits were achieved as result of those practices.</td>
</tr>
</tbody>
</table>

Converted to percentage for Spider Web graph
## Gaps Analysis related to the Practices

### Example:

<table>
<thead>
<tr>
<th>Practice</th>
<th>Innocence</th>
<th>Awareness</th>
<th>Understanding</th>
<th>Competence</th>
<th>Excellence</th>
</tr>
</thead>
<tbody>
<tr>
<td>How do the Key Performance Indicators (KPI’s) are used?</td>
<td>KPI’s not defined.</td>
<td>KPI’s and its targets had been clearly defined.</td>
<td>The meaning of the KPI’s starting to be understood (influence factors and the consequence of its values).</td>
<td>The KPI’s are fully understood and managed.</td>
<td>The KPI’s take part of the management process of the plant.</td>
</tr>
<tr>
<td></td>
<td>Comparison of the plant performance against to the other similar ones has not been performed.</td>
<td>They had been used, but are not clearly understood for everyone.</td>
<td>The Benchmarking process has been started.</td>
<td></td>
<td>It has been achieved a World-class level.</td>
</tr>
</tbody>
</table>
ABB Deliverables: Areas for Improvement

The studied site

Benchmarking against 75% level of our Full Service sites

Leadership
- Role of maintenance
- Building relationship
- Cost Management

Business Results
- Profitability
- Effectiveness & efficiency

People Results
- Competence & motivation
- Safety & environment

Maint & Prod Mgmnt
- Strategy development & implementation
- Knowledge exchange & networking

People Management
- Competence management
- Motivation management

Client Results
- Client satisfaction
- Client value

Resource Management
- HSE mgmnt
- Finance & cost mgmnt
- Information mgmnt
- Material mgmnt
- Contractor mgmnt
- Facilities, tools, etc

Maintenance Functions
- Partnership
- Maintenance concept
- Maintenance operations
- Plant performance improvements
- Shutdown mgmnt

III ENCUENTRO DE MANTENEDORES DE PLANTAS MINERAS
III MINING PLANT MAINTENANCE MEETING

MAPLA 2006

6 al 8 de Septiembre de 2006, Viña del Mar, Chile.
Quantitative Analysis

- **Financial Data**
  - Personnel cost
  - Material and spare parts
  - Contracted services
  - Other costs (financial costs, etc)
  - Maintenance overhead

- **Maintenance & Supply Data**
  - Number of maintenance employees
  - Number of work-orders
  - Spare part stock
  - Consumables
  - Wastes treatment expenses

- **Productivity Data**
  - OEE analysis
  - MPR
  - Other Losses
OEE - Overall Equipment Effectiveness

Calendar time (A)

Working time (B) → Shutdown losses

Operating time (C) → Major stoppage losses

Net Operating time (D) → Performance losses

Effective Operating time (E) → Defect losses

“EIGHT BIG LOSSES”

1. Shutdown
2. Production adjustment
3. Equipment failure
4. Process failure
5. Reduced Speed
6. Abnormal production
7. Quality defect
8. Reprocessing

Availability Factor (A) → Performance Factor (P) → Quality Factor (Q)

Overall Equipment Effectiveness = Availability Factor x Performance Rate x Quality Rate
ABB Deliverables: Productivity analysis

Annual Available Operating Time
- 8784 Hrs
  - Xmas: 240 Hrs
  - Rebuilds: 168 Hrs
  - Commercial Shutdowns: 1748 Hrs

Available Production Time
- 6628 Hrs
  - Planned Shuts: 204.6 Hrs
  - Technical Downtime: 113.2 Hrs
  - Total Papermaking: 429.3 Hrs
  - Others: 6.34 Hrs
  - Clothing: 22.8 Hrs

Process Downtime: 770.27 Hrs

Gross Operating Time
- 5851.73 Hrs
  - Speed Loss: 531.53 Hrs

Net Operating Time
- 5320.2 Hrs

Valueable Operating Time
- 4817.25 Hrs

Planning Factor 75.5%
- Availability 88.3%
- Production Rate 90.8%
- Quality 90.5%

Manufacturing OEE = 72.6%
Business OEE = 54.8%
ABB Deliverables: Ratios & Figures

Maintenance Effectiveness

Maintenance Practices
ABB Deliverables: Comparison

Percentage of equipment having preventive or predictive tasks:

- BM: 80%
- Alizay Paper industry: 40.1%
- All industries: 80%

Percentage of hours worked that have been planned:

- BM: 80%
- Alizay Paper industry: 0%
- All industries: 80%

Percentage of hours worked on PM or PdM:

- BM: 40 - 50%
- Alizay Paper industry: 26.9%
- All industries: 40 - 50%

No of weeks backlog for the maintenance crew:

- BM: 2 - 3 weeks
- Alizay Paper industry: NA
- All industries: 2 - 3 weeks
ABB Deliverables: Value Proposition (example)

Operations Development

- Development of Production Efficiency: 3 550 M€/ 5 years
- Increase of Cost Efficiency (maintenance): 15 850 M€/ 5 years
- Indirect factors influencing the Efficiency: Only intangible values identified

<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>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OEE</strong></td>
<td>0 k€</td>
<td>580 k€</td>
<td>1 850 k€</td>
<td>2 940 k€</td>
<td>3 550 k€</td>
</tr>
<tr>
<td><strong>Maintenance cost</strong></td>
<td>1 100 k€</td>
<td>2 720 k€</td>
<td>6 270 k€</td>
<td>10 280 k€</td>
<td>15 850 k€</td>
</tr>
</tbody>
</table>

Cumulative Improvement potential: 19 400 k€
THE ORGANIZATIONAL MODEL IN TEAMS

“A small group of employees which responsibility is to self manager their own routine tasks, as well as to plan, control and implement improvements in their work processes“.
Best Practices # 1

THE ORGANIZATIONAL MODEL IN TEAMS

- Operation / maintenance teams per industrial unit / plant
- Individual and team targets
- Authority, responsibility and control
- Skills and performance based remuneration
- Centralized technical support
- Extensively training (on the job and within the team in cascade)
Differences: Traditional x Team Structure

TEAM ORGANIZATION

TRADITIONAL ORGANIZATIONAL STRUCTURE

PLANT MANAGER

OTHERS

OPERATION

MAINTENANCE

MODEL BASED IN TEAMS PER PROCESS

PLANT MANAGER

SUPPLY TEAM

GENERAL SERVICES & ADM. TEAM

TECHNOLOGY TEAM

PRODUCTION TEAM PLANT 1

PRODUCTION TEAM PLANT 2

PRODUCTION TEAM PLANT 3

PRODUCTION TEAM PLANT 4

PRODUCTION TEAM PLANT 5

PRODUCTION TEAM PLANT 6
### Differences: Traditional x Team Structure

#### TRADITIONAL ORGANIZATION
- Hierarchical levels
- Chiefs
- Task based work
- Manager hole → to lead
- Hierarchical leadership
- Controlled information
- Individual recognition

#### TEAMS ORGANIZATION
- Flat structure
- Leaders
- Process based work
- Manager hole → to train
- Shared leadership
- Shared information
- Team recognition
Best Practices # 2

SERVICE PROVIDER LEAD TO PERFORMANCE AND PRODUCTIVITY

- Pay per Performance based Contracts
  - Production targets
  - Productivity improvement
  - Implemented cost cutting
- Service Provider = Strategic Partner
- No incentive for headcount increasing
- Work Progress & Performance Reporting
  - Achievement of planned dates
  - Productivity / Equipment performance
  - Costs of routine services and shutdowns
- A Sole service provider for all company, integrating subcontractors

Allows long term partnership contracting compatible with TEAM BASED STRUCTURE
Best Practices # 3

INTEGRATED
RELATION WITH
MATERIALS
SUPPLIERS

- Continuous Improvement program for suppliers
- Yearly targets of cost cutting
- Stock Management by supplier
  - Supply and storage functions under supplier responsibility
  - The stock belongs to the supplier
- Work Progress & Performance Reporting
- Formal supplier Certification Process
- Boost technical assistance by supplier
  - Technical training
  - Preventive / Predictive Maintenance
  - Standardization / alternative components
- Suppliers consolidated base
Best Practices # 4

TOP MANAGEMENT SUPPORT AND VISION

- Proactive and clear involvement in:
  - Continuous improvement team
  - Extensively training for continuous improvement, focused on the business performance needs
  - Recognition programs
  - Employees appraisal
  - HR Selection and recruitment processes
  - Carrier development
  - Compliance of SHE standards

- Incentive to external benchmarking surveys

- Reliability-driven thinking

- Dissemination of positive results

- Ostensive exposition of KPI’S and targets
Best Practices # 5

PROACTIVE PLANNING, SCHEDULING AND CONTROL

- Macro planning centralized
- Scheduling and execution decentralized
- Daily, weekly and monthly scheduling
- Whole services scheduling
- Proactive planning
- Formal backlog managing
- Compliance of maintenance plans / programming
- On line work request and work orders follow up
- Database and history of interventions
- Maintenance costs follow up and control
- SH&E considered as higher priority
Best Practices # 6

AGILE AND EFFECTIVE PROCESS FOR MATERIALS AND SERVICES PROCUREMENT

- Centralized process
- Prices previously adjusted standardized contracts
- Targets to minimize / rid quotation time for sundries
- Purchase contracts
- Consigned stocks
- Suppliers kitting
- Utilization of the suppliers capability, information and technology
- Self-service delivery for small value items
- Utilization of web tools to improve price competitiveness and decreasing of lead times
INTEGRATION OF THE BUSINESS PROCESSES

- Integrated processes
  - Procurement
  - Accounting
  - Warehouse
  - Payroll
  - Equipment performance control
  - Project management

- Management system focused in equipment reliability
  - Equipment historical analysis
  - Preventive / Predictive maintenance

- Full cost and manpower appropriation
Best Practices # 8

TURNAROUND MANAGEMENT

- Professional leadership
- Turnaround Management – full dedication
- 12 to 18 months of advance in planning activities
- Reliability Engineering has the main hole in deadline definition
- Emphasis in increasing the mean time between turnarounds
- Extensively training at each turnaround event
- Safety performance considered as basic requirement
Best Practices # 9

DISCIPLINE IN COMPLYING THE SH&E STANDARDS

- Written procedures and standards
- SH&E program involving subcontractors
- PPE & protection technology
- Systematic training
- Accidents and incidents analysis
- Planned observation tasks
- Daily dialog on SH&E issues (FLM’s)
- Emergency & Control Response
- Safety & Health Control
- Job Safety Analysis
- Systematic safety meetings
- Systematic auditing
- Management of Changes (MoC)
Best Practices # 10

PRODUCTION BASED ON RELIABILITY

- Team formally applied to predictive maintenance and reliability
- Systematic approach on prediction technologies
- Equipment and systems classification
- 100% of preventive plan under CMMS control
- Planned maintenance - 90% minimum
- Systematic auditing on preventive / predictive maintenance
- Skills on predicting the equipment performance over 12 month horizon
- Formal process of Root Failure Analysis
- Extensive application of reliability tools
- Systematic approach for production losses accounting / capture process
**Metric References: Manufacturing**

<table>
<thead>
<tr>
<th>Benchmark</th>
<th>Process Industries</th>
<th>Discrete Manufacturing</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance craftspeople per first-line supervisor</td>
<td>15</td>
<td>16</td>
<td>Indicator of how well first-line supervision is leveraged</td>
</tr>
<tr>
<td>Maintenance craftspeople per maintenance planner</td>
<td>28</td>
<td>25</td>
<td>Measure of the emphasis placed on maintenance planning and scheduling</td>
</tr>
<tr>
<td>Estimated plant replacement value ($MM) per maintenance craftsperson</td>
<td>$4.9</td>
<td>$4.5</td>
<td>Amount of assets maintained by each maintenance employee; indicator of maintenance labor effectiveness</td>
</tr>
<tr>
<td>Annual training days per maintenance craftsperson</td>
<td>9.3</td>
<td>9</td>
<td>Indicator of management commitment to employee development and functional excellence</td>
</tr>
<tr>
<td>Annual training days per maintenance supervisor</td>
<td>7.4</td>
<td>5</td>
<td>Indicator of management commitment to employee development and functional excellence</td>
</tr>
<tr>
<td>Total maintenance cost as percent of estimated plant replacement value</td>
<td>2.2%</td>
<td>2.5%</td>
<td>Indicator of maintenance cost-effectiveness; high values may indicate potential for cost reductions; low values may indicate milking of assets</td>
</tr>
</tbody>
</table>

Source: Plant Engineering : Values shown were established by the board of directors of the North American Maintenance Excellence Award as representative of superior maintenance operations. They are not intended as targets to be met or guidelines to be followed in maintenance evaluation.
## Metric References: Manufacturing

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<tr>
<th>Benchmark</th>
<th>Process Industries</th>
<th>Discrete Manufacturing</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unplanned (emergency) manhours as a percent of total maintenance manhours worked</td>
<td>7%</td>
<td>18%</td>
<td>Indicator of maintenance planning and control levels</td>
</tr>
<tr>
<td>PM/PdM manhours as a percent of total maintenance manhours worked</td>
<td>27%</td>
<td>39%</td>
<td>Indicator of commitment to proactive maintenance and assurance of equipment reliability</td>
</tr>
<tr>
<td>Planned repairs schedule compliance</td>
<td>87%</td>
<td>87%</td>
<td>Measure of performance in completing work as scheduled</td>
</tr>
<tr>
<td>Preventive maintenance schedule compliance</td>
<td>90%</td>
<td>90%</td>
<td>Measure of performance in completing preventive maintenance tasks as scheduled</td>
</tr>
<tr>
<td>Work order coverage as percent of manhours worked</td>
<td>100%</td>
<td>98%</td>
<td>Measure of maintenance documentation effectiveness. Affects ability to evaluate other factors</td>
</tr>
<tr>
<td>Storeroom annual inventory turnover</td>
<td>1.52</td>
<td>1.53</td>
<td>Indicator of storeroom management effectiveness and control; reflective of materials management policies</td>
</tr>
<tr>
<td>Storeroom investment as percent of plant estimated replacement value</td>
<td>1%</td>
<td>1%</td>
<td>General measure of stores inventory management</td>
</tr>
</tbody>
</table>

Source: Plant Engineering : Values shown were established by the board of directors of the North American Maintenance Excellence Award as representative of superior maintenance operations. They are not intended as targets to be met or guidelines to be followed in maintenance evaluation.
### GENERAL COST RATIOS

<table>
<thead>
<tr>
<th>Ratio</th>
<th>Typical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mtce cost/ERV</td>
<td>1.2% - 5%</td>
</tr>
<tr>
<td>Maintenance cost/ production cost</td>
<td>10% - 30%</td>
</tr>
<tr>
<td>Total mtce cost/ total sales</td>
<td>1.5% - 5%</td>
</tr>
<tr>
<td>Mtce materials cost/ maintenance cost</td>
<td>25% - 45%</td>
</tr>
<tr>
<td>ERV ($millions)/ technician</td>
<td>$3.2 - $9.0</td>
</tr>
</tbody>
</table>

### MAINTENANCE PERFORMANCE

<table>
<thead>
<tr>
<th>Performance</th>
<th>Typical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work order coverage</td>
<td>50% - 100%</td>
</tr>
<tr>
<td>Schedule compliance</td>
<td>35% - 90%</td>
</tr>
<tr>
<td>Preventive maintenance (plan compl)</td>
<td>60% - 100%</td>
</tr>
<tr>
<td>Unplanned work (emergencies)</td>
<td>5% - 35%</td>
</tr>
<tr>
<td>Overall equipment effectiveness</td>
<td>40% - 90%</td>
</tr>
<tr>
<td>Availability</td>
<td>85% - 99%</td>
</tr>
</tbody>
</table>
### Metric References: Petrochem

<table>
<thead>
<tr>
<th>LABOR/HUMAN RESOURCES</th>
<th>range</th>
</tr>
</thead>
<tbody>
<tr>
<td>OSHA injuries/200,000 hr</td>
<td>--</td>
</tr>
<tr>
<td>Technicians/supervisor</td>
<td>8 - 25</td>
</tr>
<tr>
<td>Technicians/support person</td>
<td>2 - 8</td>
</tr>
<tr>
<td>Technicians/planner</td>
<td>20 - 80</td>
</tr>
<tr>
<td>&quot;Wrench time&quot;/Total mtce man-hours</td>
<td>30% - 60%</td>
</tr>
<tr>
<td>Overtime</td>
<td>4 – 25%</td>
</tr>
<tr>
<td>Annual training days / mtce craftsperson</td>
<td>3,0 – 12,0</td>
</tr>
<tr>
<td>Annual training days / mtce supervisor</td>
<td>2,0 – 9,0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MATERIALS MANAGEMENT</th>
<th>range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stores value/ERV</td>
<td>0.3% - 2.0%</td>
</tr>
<tr>
<td>Stores turnover</td>
<td>0.3 – 2.5</td>
</tr>
<tr>
<td>Service level (stockouts)</td>
<td>0.5 – 4%</td>
</tr>
<tr>
<td>Stores inventory accuracy</td>
<td>85% - 100%</td>
</tr>
<tr>
<td>Stores disbursements/store personnel</td>
<td>$0.5 – 2.0M</td>
</tr>
</tbody>
</table>
Metric References: Pulp & Paper

**European Market/Integrated BSKP/BHKP Pulp Mills**

**Total annual maintenance costs**
- personnel costs incl. supervision: MEUR/a 0.7 - 6.7
- maintenance material costs: MEUR/a 2.0 - 5.3
- external services: MEUR/a 1.8 - 6.2
- **Total**: MEUR/a 8.3 - 15.9

**Total maintenance costs per ton produced**
- personnel costs incl. supervision: EUR/ADt 3 - 24
- maintenance material costs: EUR/ADt 7 - 16
- external services: EUR/ADt 5 - 30
- **Total**: EUR/ADt 27 - 57

% of total external services of total maintenance costs (excl. pulp mills with 100%)
- **%**: 20% - 68%

Own maintenance hours per ton at pulp mill (h/ADt)
- **h/ADt**: 0.4 - 0.8

% of total maintenance personnel (incl. supervision) of total pulp mill personnel
- **%**: 28% - 43%

---

**Partly Integrated and Market BSKP/BHKP Mills**

<table>
<thead>
<tr>
<th>Total Production Efficiency</th>
<th>PM Time Efficiency</th>
<th>Production Stability Digesters</th>
<th>Production Stability Recovery boilers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Europe</strong></td>
<td><strong>North America</strong></td>
<td><strong>Europe</strong></td>
<td><strong>North America</strong></td>
</tr>
<tr>
<td>Max</td>
<td>87</td>
<td>87</td>
<td>98</td>
</tr>
<tr>
<td>Min</td>
<td>78</td>
<td>79</td>
<td>90</td>
</tr>
</tbody>
</table>
# Metric References: Metals & Minerals

<table>
<thead>
<tr>
<th>GENERAL COST RATIOS</th>
<th>Typical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual maintenance cost / ERV</td>
<td>1.2% - 5%</td>
</tr>
<tr>
<td>ERV (MUSD) / technician</td>
<td>3.2 - 9.0</td>
</tr>
<tr>
<td>Maintenance cost / total sales</td>
<td>1.5% - 5%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MAINTENANCE PERFORMANCE</th>
<th>Typical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work order coverage</td>
<td>50% - 100%</td>
</tr>
<tr>
<td>Schedule compliance</td>
<td>35% - 90%</td>
</tr>
<tr>
<td>Preventive maintenance (plan compliance)</td>
<td>60% - 100%</td>
</tr>
<tr>
<td>Unplanned work (emergencies)</td>
<td>5% - 35%</td>
</tr>
<tr>
<td>Overall equipment effectiveness (continuous)</td>
<td>55% - 97%</td>
</tr>
<tr>
<td>Availability</td>
<td>85% - 98%</td>
</tr>
<tr>
<td>PM+PdM activities by operators</td>
<td>0% - 25%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LABOR/HUMAN RESOURCES</th>
<th>Typical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technicians / supervisor</td>
<td>8 - 25</td>
</tr>
<tr>
<td>Technicians / planner</td>
<td>20 - 80</td>
</tr>
<tr>
<td>&quot;Wrench time&quot; / total maintenance man-hours</td>
<td>30% - 60%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MATERIALS MANAGEMENT</th>
<th>Typical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stores value / ERV</td>
<td>0.3% - 2.0%</td>
</tr>
<tr>
<td>Stores turnover</td>
<td>0.2 - 2.5</td>
</tr>
<tr>
<td>Service level (stockouts)</td>
<td>0.5 - 4%</td>
</tr>
</tbody>
</table>