Carlo Scodanibbio presents:

**Lean Maintenance**

**Lean Plant Management**

”We are what we repeatedly do. Excellence, therefore, is not an act, but a habit”

A training event organised by

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**What is Maintenance?**

“the work of keeping something in proper condition; upkeep”

Maintenance is the management, control, execution and quality of those activities which ensure optimum levels of availability and overall performance of plant are achieved to meet business objectives.

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Nothing lasts forever
## Approaches to Maintenance

### Main Types of Maintenance Operations

- **Reactive Maintenance**
- **Preventive Maintenance**
- **Predictive Maintenance**
- **Reliability Centred Maintenance**
- **Others**

### Study 2000

- >55% Reactive
- 31% Preventive
- 12% Predictive
- 2% Other

### Reactive Maintenance

**Advantages**
- Low cost (until equipment fails)
- Less Maintenance Manpower

**Disadvantages**
- Increased and incremental cost due to unpredicted downtime of equipment
- Increased labour cost, especially if overtime is needed
- Cost (possibly very high) involved with repair or replacement of equipment
- Possible chain reaction: secondary equipment or process damage consequent to equipment failure
- Inefficient use of resources (in the long run)
about RISK & RELIABILITY

FMEA
(Failure Mode and Effect Analysis)

FMECA
(Failure Modes, Effects and Criticality Analysis)

about RISK & RELIABILITY

FTA
(Fault Tree Analysis)
RBI has been applied in industries such as oil/gas industry, power generation, refineries, petrochemical plants and pipelines.

RBI can be applied for static equipment such as pipe-work, pressure and atmospheric vessels, heat exchangers/coolers, filters and other static equipment.

RBI is used in calculating both the consequences of possible failures and the likelihood with which those failures are expected to occur. The product of consequences and likelihood is used to identify which equipment poses the greatest risk and therefore warrants the most inspection attention in order to manage that risk effectively.

RBI makes use of a broad range of technologies including consequence modelling, reliability and failure frequency analysis and limit-state approaches to provide industry with a risk-based method for evaluating and developing inspection plans.
IPF – INSTRUMENT PROTECTIVE FUNCTIONS

**definitions:**

Developed originally by Shell, the IPF methodology refers specifically to automated responses to abnormal situations as detected by instrumentation (typically alarm and trip functions).

The process entails the execution of a risk assessment for each protective function by a multidisciplinary team, accomplished by consideration of the instrument failure probability and the associated consequences.

The result of the classification enables specification of the most appropriate implementation and maintenance strategies for the IPF.

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SHUTDOWN (TURNAROUND) MAINTENANCE & (PLANNED) OUTAGE MAINTENANCE

**definitions:**

**Shut Down:** scheduled down-period for a plant for scheduled maintenance for an extended period of time

"Turnaround" is intended to encompass all types of industrial projects for existing process plants including I&Ts (Inspection & Testing), shutdowns, planned outages, debottlenecking projects, revamps, catalyst regeneration, etc. where an operating plant must be shut down until the work is completed and then restarted - thus "turning around" the unit/plant.

The terms: “shut down” and “turnaround” have, in practice, the same meaning. However, turnaround maintenance may imply works which are not only of maintenance nature (for instance, plant revamping may be much more than just pure scheduled maintenance).
**FORCED (UNPLANNED) OUTAGE MAINTENANCE**

**Outage**: an "out-of-service" condition of a plant (or part of it) that is unwanted, unplanned and unpredicted

**Forced Outage Maintenance** is maintenance directed to bring back the concerned Plant to a "in-service" status as fast and reliably as possible

An unplanned outage can be dealt with:
- in the absence of any plan = **panic management**
- with a sufficiently or, preferably, well structured plan to manage the (any potential type of) outage

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**new performing systems**

**VAM**

Value Adding Management

Systematic search for systematic improvement and values

**LM**

Lean Manufacturing

TQM

Total Quality Management

TPM

Total Productive Maintenance

**the direction**

**world-class manufacturing operations**
TPM
TOTAL PRODUCTIVE MAINTENANCE

equipment: OK
surrounding waste

movie time
efficiency, effectiveness, losses

OVERALL EQUIPMENT EFFECTIVENESS - PRESS X - MONITORING CHART

<table>
<thead>
<tr>
<th>Date 1</th>
<th>Date 2</th>
<th>Date 3</th>
<th>Date 4</th>
<th>Date 5</th>
<th>Date 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>50</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

OEE

LOSSES AND EQUIPMENT EFFECTIVENESS

<table>
<thead>
<tr>
<th>AVAILABLE TIME</th>
<th>PLANNED DOWNTIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>(during a given period: day, week, month..)</td>
<td>Breakdowns in production schedule</td>
</tr>
<tr>
<td>ACTIVE TIME</td>
<td>Planned Maintenance</td>
</tr>
<tr>
<td>(during which, equipment is actually available for operations)</td>
<td>Production Interruptions</td>
</tr>
<tr>
<td>OPERATING TIME</td>
<td>Losses 1-2</td>
</tr>
<tr>
<td>(during which, equipment is actually in operation)</td>
<td>Planned Startups</td>
</tr>
<tr>
<td>NET OPERATING TIME</td>
<td>Losses 3-4</td>
</tr>
<tr>
<td>(during which, equipment is operated under stable conditions)</td>
<td>Planned Setups</td>
</tr>
<tr>
<td>REWORKING TIME</td>
<td>Losses 5-6</td>
</tr>
<tr>
<td>(during which, equipment is operated at a stable speed or rate)</td>
<td>Planned Downtime</td>
</tr>
<tr>
<td>VALUABLE OPERATING TIME</td>
<td>Planned Downtime</td>
</tr>
<tr>
<td>(during which, acceptable products are produced)</td>
<td>Planned Downtime</td>
</tr>
</tbody>
</table>
LOSSES AND EQUIPMENT EFFECTIVENESS

continuous process equipment & some construction equipment

similarly:

\[ \text{OEE} = \frac{\text{OR} \times \text{PR} \times \text{OR}}{\text{ACTIVE TIME}} \]

\[ = \frac{\text{VALUABLE OPERATING TIME}}{\text{ACTIVE TIME}} \]

\[ = \text{OEE} \]

exercise?????

...oh, yes!!!
homework????

...oh, yes!!!

Associating the Six Sigma Methodology with the TPM approach
EQUIPMENT
“RANKING”

chronic losses

TAKING THE TPM WAY....

chronic losses

losses
THE GENERAL TPM APPROACH FOR REDUCING AND ELIMINATING CHRONIC LOSSES

5 Approaches or combination, as applicable:

a) IDENTIFYING AND ESTABLISHING OPTIMAL OPERATING CONDITIONS

b) RESTORING THE EQUIPMENT TO ORIGINAL/OPTIMAL OPERATING CONDITIONS

c) PREVENTING DETERIORATION

d) INCREASING EQUIPMENT RELIABILITY

e) ELIMINATING (ALL) SMALL DEFECTS
The P-M ANALYSIS

exercise????

...oh, yes!!!
WHEN CHRONIC LOSSES (ESPECIALLY QUALITY LOSSES) ARE NOT ORIGINATED BY (HIDDEN) DEFECTS IN THE EQUIPMENT BUT RATHER BY INADEQUATE METHODS, A P-M ANALYSIS MIGHT BE INAPPROPRIATE.

THE PROPER APPROACH IS THROUGH TOTAL PROBLEM SOLVING TECHNIQUES LIKE TPS AND CEDAC.
PREVENTIVE MAINTENANCE

AUTONOMOUS MAINTENANCE

The new relationship between Maintenance and Production

MAINTENANCE ACTIVITIES

IMPROVEMENT ACTIVITIES

MAINTENANCE ACTIVITIES

--- > Prevent Breakdowns and repair faulty equipment. Combination of:

• Autonomous Maintenance
• Preventive Maintenance (daily-periodic)
• Predictive Maintenance
• Corrective Maintenance (sporadic, ad hoc)

IMPROVEMENT ACTIVITIES

--- > Extend Equipment Life - reduce Maintenance time - avoid the need for Maintenance.

Combination of:

• Reliability Improvement
• Maintainability Improvement
• Maintenance Prevention
• Maintenance-free Design

COMMON TARGET: MAX OEE

basically by means of:

➢ DETERIORATION PREVENTION
➢ DETERIORATION MEASUREMENT
➢ RESTORATION OF OPTIMAL CONDITION
**MAINTAINABILITY IMPROVEMENT**

improving equipment maintainability increases the efficiency of maintenance work and reduces repairs time

**Maintenance PREVENTION**

Maintenance Prevention targets at eliminating/reducing the need for Maintenance

It is a TPM goal to reduce the need for maintenance (especially costly Preventive Maintenance) and, where possible, eliminate that need altogether.

the marriage TPM/RCM contributes substantially to the target
HOW TO GO INTO A TPM PROGRAM

assignment????

...oh, yes!!!
MEASURING TPM EFFECTIVENESS

TPM STATUS:
SELF-EVALUATION

Radius
1. DOWNTIME & OTHER LOSSES
2. BREAKDOWN LOSSES
3. QUALITY DEFECTS & YIELD LOSSES
4. EDUCATION & TRAINING
5. OPERATION & AUTOMAINTENANCE
6. PREVENTIVE MAINTENANCE
7. ADVANCED TPM
8. PLANT MANGMT, ECONOMICS, SPARE PARTS MANGMT.
"...everyone has a favourite horror story about large production losses caused when an essential part was missing in a store full of unnecessary materials and spares...."
## Reducing Overall Costs of Maintaining Equipment

### Targets and Strategies:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>Review Periodic Maintenance intervals</td>
</tr>
<tr>
<td>b.</td>
<td>When appropriate, switch from outside contracting to in-house facilities</td>
</tr>
<tr>
<td>c.</td>
<td>Audit Spare Parts Management</td>
</tr>
<tr>
<td>d.</td>
<td>Identify idle equipment and use it effectively (f.i: in Cell Production activities)</td>
</tr>
<tr>
<td>e.</td>
<td>Reduce energy use and service resources waste</td>
</tr>
<tr>
<td>f.</td>
<td>Eliminate Equipment Losses</td>
</tr>
</tbody>
</table>
MEASURING MAINTENANCE EFFECTIVENESS

- OVERALL EQUIPMENT EFFECTIVENESS (OEE)
- OPERATIVITY RATE (OR)
- MEAN TIME BETWEEN FAILURES (MTBF)

case study

A non-TPM factory
A non-TPM factory

TRADITIONAL PROJECT MANAGEMENT
PLANNING
PROGRAMMING
SCHEDULING
CONTROLLING

LIFECYCLE OF PROJECT WITH POOR PLANNING

Project initiation
Wild enthusiasm
Disillusionment
Wild chaos
Search for the guilty
Punishment of the innocent
Promotion of non-participants
Definition of the requirements (Planning)
CONTROL

ADEQUATE PLANNING

EASIER + MORE EFFECTIVE CONTROL

CONTROLLING PROJECTS

<table>
<thead>
<tr>
<th>yesterday</th>
<th>today - tomorrow</th>
</tr>
</thead>
<tbody>
<tr>
<td>giving orders</td>
<td>objectives definition by mutual consent</td>
</tr>
<tr>
<td>being at the head</td>
<td>clear definition of tasks at all levels</td>
</tr>
<tr>
<td>directing</td>
<td>planning &amp; scheduling on the basis of necessary and really available resources</td>
</tr>
<tr>
<td>supervising</td>
<td>Progresses, Costs and Quality Measurement Methods based on a clear, precise, pre-defined system, known by all relevant members of the project team, and agreed upon by mutual consent</td>
</tr>
<tr>
<td>inspecting</td>
<td>At all levels:</td>
</tr>
<tr>
<td>controlling</td>
<td>&gt; continuous monitoring of actual results versus estimates and budgets</td>
</tr>
<tr>
<td></td>
<td>&gt; adequate and timely re-scheduling</td>
</tr>
<tr>
<td></td>
<td>&gt; regular re-assessment of time and cost “to completion” in a continuous projection process</td>
</tr>
</tbody>
</table>
….then the world changed….

why enterprises don’t “perform”...

….the root causes of poor performance date back to over 2 centuries ago…..

….we have gone into the 21st century, with enterprises designed in the 18th and 19th centuries to perform well in the 20th…..
WORLD-CLASS PERFORMANCE

the world-class enterprise operates “per process”

VAM
VALUE ADDING MANAGEMENT
LEAN MANUFACTURING and FLOW PRODUCTION

**continuous flow**

The target:

**pipeline flow**
LOT (BATCH) PRODUCTION vs. FLOW PRODUCTION

fake flow production
the “conveyor” method
“batch production” vs. “one-piece flow”

LEAN THINKING

what is it?
...are **Lean Thinking** and **Flow Process** principles and techniques suited to all industries?

The answer is always: **yes!!**
introducing:

LEAN
PROJECT MANAGEMENT
basics

movie time
Lean Project Management
foreword
any correlation between what you have seen and your work of every day?

<table>
<thead>
<tr>
<th>Any similitude?</th>
<th>Check list:</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ Moving</td>
<td>✓ Meetings – “spot” meetings in the passage...</td>
</tr>
<tr>
<td>✓ Filing</td>
<td>✓ Giving instructions – Receiving instructions</td>
</tr>
<tr>
<td>✓ Answering</td>
<td>✓ Doing things “in case” – or “why not?”</td>
</tr>
<tr>
<td>✓ Attending...</td>
<td>✓ Ordering things – Setting-up things – Making sure...</td>
</tr>
<tr>
<td>✓ Reporting</td>
<td>✓ Checking – Inspecting - Supervising</td>
</tr>
<tr>
<td>✓ Preparing</td>
<td>✓ Talking – Clarifying – Explaining – Illustrating...</td>
</tr>
<tr>
<td>✓ Waiting</td>
<td>✓ Chatting - Phoning – Taking “this” call...</td>
</tr>
<tr>
<td>✓ Observing</td>
<td>✓ Putting pressure – Chasing - Expediting – Dealing...</td>
</tr>
<tr>
<td></td>
<td>✓ Managing – Authorising, approving – Getting right...</td>
</tr>
</tbody>
</table>

Does all this create value for your clients?
taking the lean way

specific tools/techniques for:

the PPC and its intelligent use

the “Last Planner” approach
Lean Project Management in Multi-Project situations

the TOC approach

movie time

can construction become different?
look at this!!
movie time

a world-class project-driven enterprise

Lean Maintenance

what is it?
Lean Maintenance is the systematic deployment of Lean principles in all maintenance-related activities in Maintenance of all kinds.
CONCURRENT (SIMULTANEOUS) ENGINEERING

TRADITIONAL OVER-THE-WALL ENGINEERING
...another “Terminator” of Adam Smith theories....

Lean Plant Management

what is it?
Lean Maintenance & Lean Plant Management

A course presented by Carlo Scodanibbio

Organised by

CREDITS: the documentary material of this course is based on papers and works of

K. Arai

M. Baldini

N. Bodek

W.F. Christopher

J. Conti

E. del Turco
Lean Maintenance & Lean Plant Management

“a cultural revolution”