16 major production losses

- Materials (weight)
- Dies/Jigs/Tools

Man (Man-hour)

- Total Man-hour
  - Loading Worker hours
  - Net Working hours
  - Effective Worker hours
  - Value-Added Worker hours

Machine

- Total Available Time
  - Loading Time
  - Operating Time
  - Net Operating Time
  - Value-Operating Time

Man (Man-hour) and Machine

- Effective Energy
- Input Energy

- Products (weight)
- Utilization

Excluding man-hours (Supported by other department)

- 9) Operation Waiting (Material shortage) losses
- 10) Motion losses
- 11) Organization losses
- 12) Walking & Carrying losses
- 13) Inspection & Adjustment losses

- 14) Energy losses
- 15) Yield losses
- 16) Dies/Jigs/Tools Utilization losses

- Scheduled Downtime
  - 8) SD (Shutdown) losses
- (Unscheduled) Downtime losses
  - 1) Major stops (Failure) losses
  - 2) Setting up & adjustment losses
  - 3) Die/Tool change losses
  - 4) Start-up losses
  - 5) Minor stoppage losses
  - 6) Speed losses
  - 7) Defect/Rework losses

Defect losses

- Performance losses

- Input Energy

- Utilization

- Effective Energy

- Products (weight)

- Utilization

- Effective Energy

- Products (weight)
Definition of equipment loss

- **Equipment failure (Breakdowns) loss**
  Time loss that results from sporadic (unscheduled) plant stoppage where plant or equipment ceases to function as specified.

  The failure can be classified into two types, one is the function-stoppage type and the other is the function-deterioration type. The function-stoppage type failure is the one which occurs unexpectedly, while the function-deterioration type failure is the one in which the equipment function decreases.

- **Changeover (Setup & adjustment) loss**
  This loss is usually caused by a stoppage due to set-up change. The set-up change time is the period during which the production is stoppage to prepare for subsequent Production. The factor which spends the most time is "adjustment".

- **Cutting tools & jig change loss**
  The cutting tools change loss is caused by the line stoppage for replacing the grinding wheel, cutter, bit etc. which might be broken or worn due to long service.

- **Minor stoppage & idling loss**
  The minor stoppage loss differs from failure and is the one in which temporary trouble causes the equipment to stop or idle. It might be called a "minor trouble."

  For example, idling of a line caused by a low supply of work in the chute due to clogging, and temporary line stops caused when the sensor detects a non-conforming product are examples of minor stoppage loss. These losses can be eliminated and the line returned to normal operation so long as the clogged work is removed. The losses are quite different from natural equipment failure losses.
Definition of equipment loss (cont’d)

- **Speed loss**
  The speed loss is the loss caused by the difference between the designed speed and the actual working speed.

  For example, when the line was operated at the designed speed, it was found that the line caused poor quality or mechanical trouble in the line. In that case, the line had to be run at a slower speed than the designed one. This loss from this situation is called a speed loss.

- **Defect & rework loss**
  This is the loss caused when defects are found and have to be reworked. In general, the defects are likely to be considered as waste which should be disposed of. But since even the reworked products need wasted manpower to repair them, this must be considered as the loss.

- **Start-up loss**
  The start-up loss is the one that occurs until the start-up, running-in and machining conditions of the equipment have been stabilized.

Scheduled downtime

  - **SD (shutdown) loss**
    This loss is referred to as line shut-down loss, which is caused by stopping the equipment for periodical maintenance/inspection, and for scheduled shutdown for legal inspection during the production stage.
Equipment 6 major losses

Controllable losses in plant

DOWNTIME

Unscheduled Downtime

Scheduled Downtime

| 5) Defects | 4) (Reduced Speed | 3) Minor Stoppages |
| 6) Start up | Unrecordable downtime | Recordable downtime |
| 1) Major stops = Breakdowns |
| 2) Setup & Adjustment |

Lunch/Breaks

Training

Production control

Scheduled Maintenance
# Major Stops & Equipment Failures

| Major stops = Unscheduled stops over 10 minutes | Equipment Failures (Breakdowns) | • Parts broken need to be replaced.  
• Machine function stops |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjustment</td>
<td>No need to be replaced.</td>
<td></td>
</tr>
<tr>
<td>Spills</td>
<td>Cleaning</td>
<td></td>
</tr>
<tr>
<td>Electric power stops etc.</td>
<td>Any utility stops</td>
<td></td>
</tr>
<tr>
<td>No material</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6 major machine losses & Overall Equipment Efficiency

- **Total Available Time (Working Hour)**
  - **Loading time**
  - **Operating time**
    - **Net operating time**
      - **Performance loss**
      - **Defect loss**
  - **Value operating time**
    - Defects & rework
    - Start up

**Example**

**Availability**

\[
\text{Availability} = \frac{\text{Loading time} - \text{downtime}}{\text{Loading time}} \times 100
\]

- **Example**
  \[
  \text{Availability} = \frac{460 \text{ mins} - 60 \text{ mins}}{460 \text{ mins}} \times 100 = 87\%
  \]

**Performance rate**

\[
\text{Performance rate} = \frac{\text{Standard cycle time}}{\text{Actual cycle time} \times \text{Product units}} \times \frac{\text{Loading time} - \text{downtime}}{\text{Actual cycle time}} \times 100
\]

- **Example**
  \[
  \text{Performance rate} = \left( \frac{0.5 \text{ min/unit}}{0.8 \text{ min/unit}} \times \frac{400 \text{ units}}{400 \text{ min}} \right) \times 100 = 50\%
  \]

**Quality product rate**

\[
\text{Quality product rate} = \frac{\text{Product units} - \text{Defect units}}{\text{Product units}} \times 100
\]

- **Example**
  \[
  \text{Quality product rate} = \frac{400 \text{ units} - 8 \text{ units}}{400 \text{ units}} \times 100 = 98\%
  \]

**Overall Equipment Efficiency**

\[
0.87 \times 0.5 \times 0.98 \times 100 = 42.6\%
\]
Overall Equipment Efficiency

• What is OEE?
  – To identify 6 major machine losses.

• How important is OEE data?
  – OEE is not only evaluation tool but also identify room (opportunity) to improve.

• How to use OEE?
  – Focus on gap between 100% level and Actual level.

“Overall equipment efficiency” is used as an indicator of how well equipment (man-machine system) is used in batch / lot production.

The overall equipment efficiency is obtained in relation to losses that can impede equipment effectiveness. The magnitude of stoppage loss is expressed as availability, that of performance loss as performance rate, and that of defect loss as quality products rate ratio. The products rate ratio. The product of the three rations is called “overall equipment efficiency”.

\[
\text{OEE(\%)} = \text{Availability} \times \text{Performance Rate} \times \text{Quality Products Rate}
\]
OEE Analysis Flowchart & Data Source

- **Availability**
  - Breakdowns
  - Model Change & Adjustments

- **Performance**
  - Chokko-Tei
  - Cycle Time

- **Quality**
  - Scrap & Rework
  - Start Up

**Reports**
- *Breakdown Report*
- *Downtime Report*
- *Comments Report*
- *Production Analysis*
- *Comments Report*
- *Comments Report*
- *P-Chart*
- *Rejects Report*

Example; MCCA, NC.
# Data Source

<table>
<thead>
<tr>
<th></th>
<th>Data Source</th>
<th>Freq. Summary</th>
<th>Unit</th>
</tr>
</thead>
</table>
| Major stop & Equipment Failures | • Production Report  
• Maintenance log (Downtime log)                                            | Shift & Daily    | Occurrence & Time       |
| Changeover                     | • Production Report                                                       | Shift & Daily    | Time (Start to End)     |
| Minor stop                     | • Production Report                                                       | Shift & Daily    | Occurrence              |
| Speed                          | • Production Report  
• SOP (Standard Operation Procedures)                                         | Shift & Daily    | Time (Minutes/piece)    |
| Defects & Rework               | • Quality Report (Scrap / Rework)  
• Production Report                                                            | Shifty & Daily   | Piece %                 |
| Start up                       | • Production Report                                                       | Shift & Daily    | Time (Start to End)     |
Number of Major stops – Equipment Failures

Common Indicators (AM & PM)

Overall Equipment Efficiency
- Performance
- Availability
- Quality

Major stops
- Changeover

Downtime/Incident
- MTBF/MTTR
- PM Completion Rate
- Planned Maintenance

Autonomous Maintenance

Adjustment Material shortage

Must separate Chronic & Sporadic events

# of Equipment Failures

# of Tag
One Point lesson
Activity time
8 big losses in process plant

1) Scheduled Shutdown (Maintenance) loss
2) Production adjustment (shutdown loss)
3) Equipment failure loss
4) Process Failure loss
5) Regular Production loss
6) Irregular Production loss
7) Defect loss
8) Reprocessed loss

Calendar hours (24 hours X 365 days)

Working hours

Operating hours

Net Operating hours

Value Operating hours

Source; TPM Encyclopedia (JIPM –2002)
## Definitions and Examples of 8 big losses in process plant

<table>
<thead>
<tr>
<th>Loss</th>
<th>Definition</th>
<th>Unit</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Planed Maintenance loss</td>
<td>Shutdown loss which is caused by the shutdown of the plant for its planned annual maintenance and periodic plant adjustment</td>
<td>Hour (Day)</td>
<td>Shutdown works, periodic maintenance, legal inspection, autonomous inspection, general repair works and others.</td>
</tr>
<tr>
<td>2) Production Adjustment loss</td>
<td>Adjustment time loss which is caused by the production plan to adjust the supply and demand balance.</td>
<td>Hour (Day)</td>
<td>Shutdown for production adjustment, inventory adjustment and other reasons.</td>
</tr>
<tr>
<td>3) Equipment Failure loss</td>
<td>Loss which is caused by sporadic shutdown of the facility or equipment due to malfunctions.</td>
<td>Hour</td>
<td>Pump failure, motor seizure, bearing damage, shaft breakage and other causes.</td>
</tr>
<tr>
<td>4) Process Failure loss</td>
<td>Loss which is generated in the process by plant shutdown due to improper chemical or physical properties of the substances to be handled, some other improper equipment operation or external factors.</td>
<td>Hour</td>
<td>Leak, spilling, clogging, corrosion, erosion, scattered dust and chips, operational error.</td>
</tr>
<tr>
<td>5) Regular Production loss</td>
<td>Loss which is caused by plant start-up, stopping and switchover.</td>
<td>Rate down, Hour</td>
<td>Start-up after starting, ending before stopping, production rate down in model change.</td>
</tr>
<tr>
<td>6) Irregular Production loss</td>
<td>Performance loss which is caused by reducing the production rate due to plant malfunction or abnormality.</td>
<td>Rate down</td>
<td>Low-load operation, low-speed operation, and operation below standard production rate.</td>
</tr>
<tr>
<td>7) Process Defect loss</td>
<td>Loss which are generated by producing defective products or imperfection. Loss which is defined as a loss deserving 2-rank down-grading.</td>
<td>Hour, Ton, Amount</td>
<td>Material and time loss caused by producing products which are off quality standard.</td>
</tr>
<tr>
<td>8) Reprocessed loss</td>
<td>Loss which is caused by reworking.</td>
<td>Hour, Ton, Amount</td>
<td>Defective units in final process are recycled to upstream processes for reworking to have them accepted.</td>
</tr>
</tbody>
</table>
Overall Production Efficiency

1. Calculating Overall Production Efficiency:

   \[ \text{Overall Production Efficiency} = \text{Availability} \times \text{Performance rate} \times \text{Quality Defect rate} \times 100(\%) \]

2. Availability Calculation:

   \[ \text{Availability} = \frac{\text{Calendar hours} - (1)(2)(3)(4)}{\text{Calendar hours}} \times 100 \]

3. Performance Rate Calculation:

   \[ \text{Performance rate} = \frac{\text{Actual Average Production Quantity (t/h)}}{\text{Theoretical Production Quantity}} \times 100(\%) \]

4. Quality Defect Rate Calculation:

   \[ \text{Quality Defect rate} = \frac{\text{Production Quantity (Ton) - (7)(8)}}{\text{Production (Ton)}} \times 100(\%) \]

5. Breakdown of Losses:

   - 1) Scheduled shutdown
   - 2) Production adjustment
   - 3) Equipment failure
   - 4) Process failure
   - 5) Regular production loss
   - 6) Irregular production loss
   - 7) Process defect loss
   - 8) Reprocessed loss
Theoretical production unit 1000 ton/day

Regular production loss = A+B = 1000 + 1000 = 2000 ton
Irregular production loss = C+D+E = 600 + 1500 +500 =2600 ton

Actual average production quantity = (1000 X 100 - (2000 + 2600) )/ 100 days = 954 t /day
Performance rate = 954 / 1000 (t/day) = 95.4 %
# Daily Data log (Example – Form)

## Data Collection Sheet

<table>
<thead>
<tr>
<th>Time</th>
<th>Products #</th>
<th>Cycle Time</th>
<th>Output</th>
<th>Rejects</th>
<th>Meeting</th>
<th>TPM</th>
<th>Material Shortage</th>
<th>Scheduled Maintenance</th>
<th>Breakdown</th>
<th>Setup</th>
<th>Adjustment</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM 6:00</td>
<td>Model X</td>
<td>05</td>
<td>18</td>
<td>2</td>
<td>10</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AM 7:00</td>
<td>Model X</td>
<td>05</td>
<td>16</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AM 8:00</td>
<td>Model X</td>
<td>05</td>
<td>15</td>
<td>5</td>
<td>10</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AM 9:00</td>
<td>Model Y</td>
<td>05</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AM 10:00</td>
<td>Model Y</td>
<td>05</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM 1:00</td>
<td></td>
<td>05</td>
<td>30</td>
<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

\[ \text{Loading Time} = \text{Working Hour} - (\text{Meeting} + \text{TPM} + \text{Material shortage} + \text{Scheduled maintenance}) \]

\[ \text{Down Time} = \text{Breakdown} + \text{Setup} + \text{Adjustment} \]

\[ \text{Availability} = \frac{\text{Loading Time}}{\text{Down Time}} \]

\[ \text{Operating Time} = \text{Loading Time} - \text{Down Time} \]

\[ \text{Performance Rate} = \frac{\text{Design Cycle Time} \times \text{Output}}{\text{Operating Time}} \]

\[ \text{Quality Product Rate} = \frac{\text{Output} - \text{Rejects}}{\text{Output}} \]

\[ \text{OEE} = \text{C} \times \text{E} \times \text{F} \]

---

**A**: Loading Time = Working Hour - (Meeting + TPM + Material shortage + Scheduled maintenance)

**B**: Down Time = Breakdown + Setup + Adjustment

**C**: Availability = Loading Time / (Down Time + Loading Time)

**D**: Operating Time = Loading Time - Down Time

**E**: Performance Rate = Design Cycle Time × Output / Operating Time

**F**: Quality Product Rate = (Output - Rejects) / Output

\[ \text{OEE} = \text{C} \times \text{E} \times \text{F} \]
1) Track Breakdown occurrence by Daily Occurrence chart.

2) Summarize Breakdowns Occurrence by Monthly Summary.

3) Cascade Target

4) Track Accumulated Occurrences