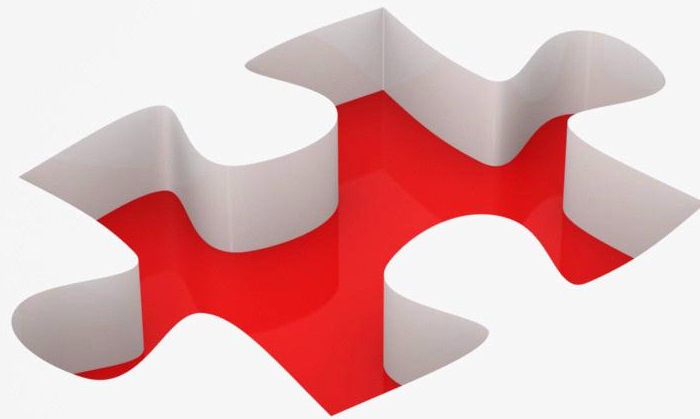


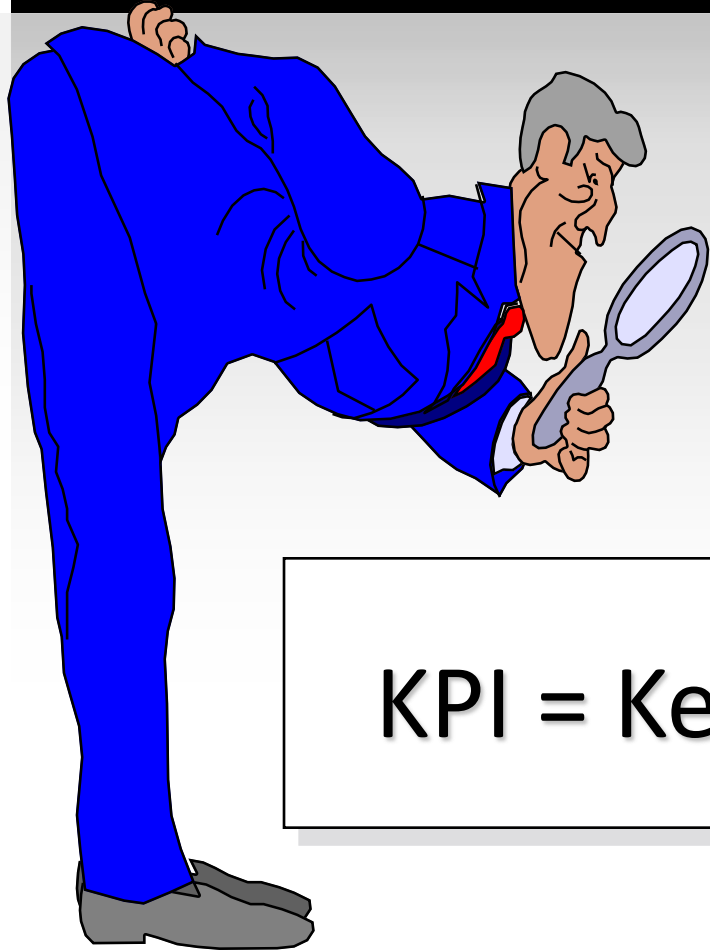
Tec – 709

Maintenance Engineering

Maintenance KPI



Prof: John Santana

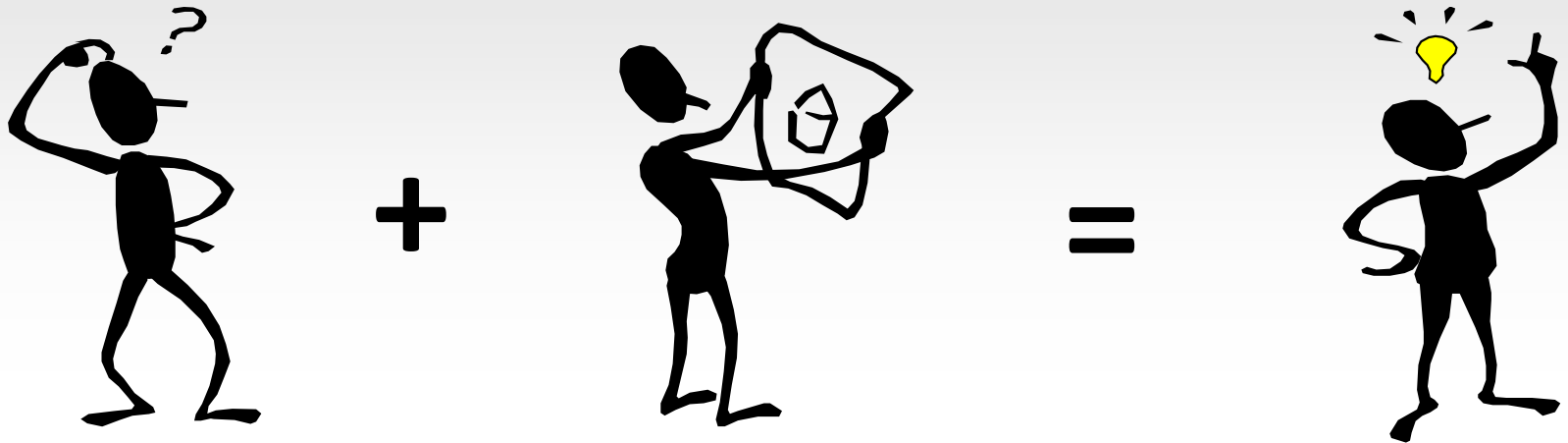


KPI = Key Performance Indicator



Objectives

- Improve personnel's understanding of KPIs and what they indicate.

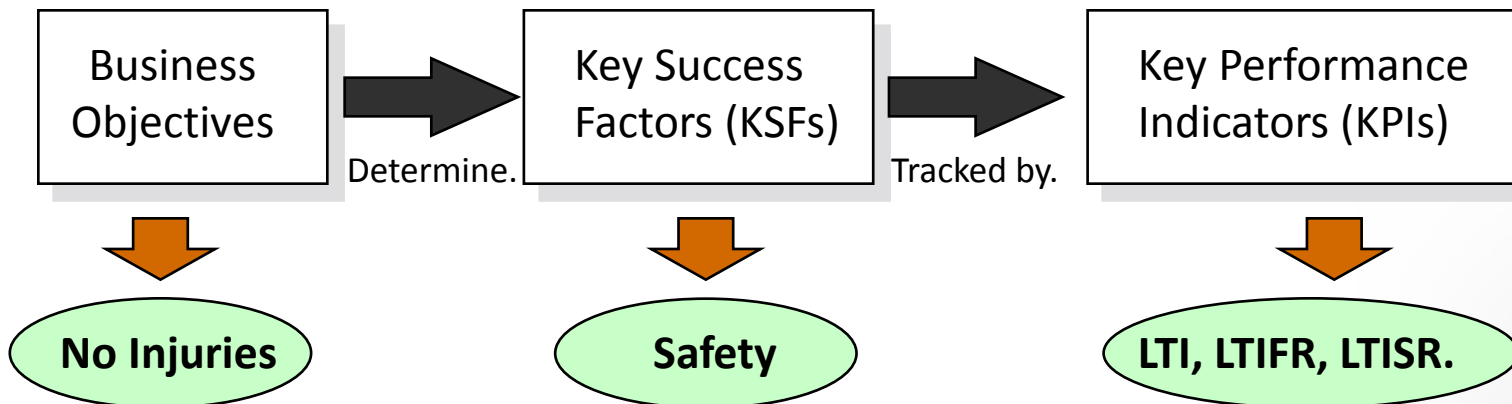


- Improve personnel's awareness of maintenance performance.

What is a KPI?

KPIs track performance against established key success factors.

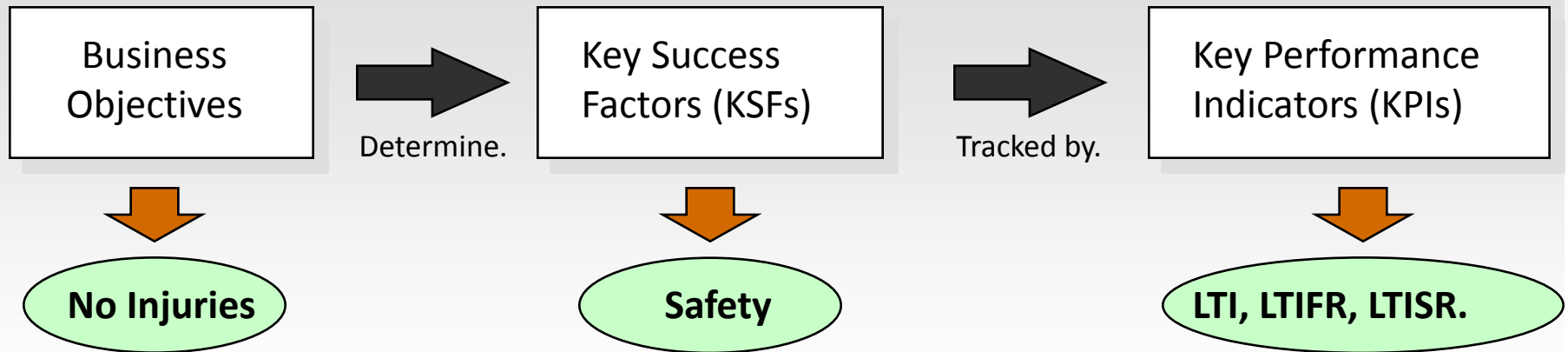
- KPIs are directly linked to the overall goals of the company.
- Business Objectives are defined at corporate, regional and site level. These goals determine **critical activities (Key Success Factors) that must be done well for a particular operation to succeed.**
- KPIs are utilised to track or measure actual performance against key success factors.
 - Key Success Factors (KSFs) only change if there is a fundamental shift in business objectives.
 - Key Performance Indicators (KPIs) change as objectives are met, or management focus shifts.



How do I interpret a KPI?

Interpretation of KPIs is KPI dependent.

KPIs do **NOT** give answers, rather they raise questions and direct attention.



- If **LTI, LTIFR or LTISR increase**, this indicates that the business objective, “No Injuries”, is **NOT** being fulfilled.
 - This should direct attention to the SAFETY key success factor.
 - Problems / Issues should be identified and resolved with a view to decreasing safety KPIs and therefore achieving the business objective.
- If **LTI, LTIFR or LTISR decrease**, this indicates that the business objective, “No Injuries”, is being fulfilled.
 - This indicates safety practices / mechanisms are proving successful.



What influence do I have on KPIs?

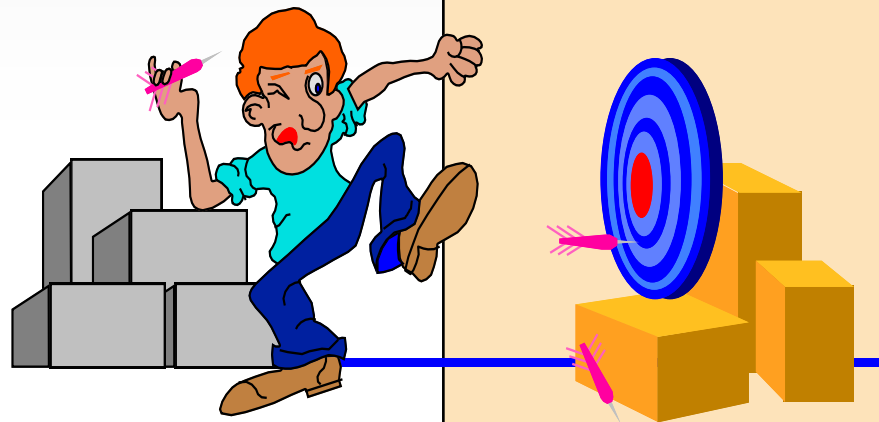
Every person on-site has an influence on certain KPIs and business objectives.

Senior Foremen

- LTIFR
- Incidents
- Property damage (\$)
- Cost / unit
- Cost / hour
- Cost of quality
- Maintenance effectiveness
- Maintenance efficiency
- Mean time between failure
- Mean time to repair

Crew

- LTIFR
- Incidents
- Property damage (\$)
- Mean time to repair



Maintenance KPIs

Seventeen (17) primary maintenance KPIs to be utilised.

- These KPIs will be utilised across the site's Maintenance Departments.

KPIs

- LTIFR (both production and maintenance)
- Maintenance Cost per Unit vs. Budget
- Maintenance Cost per Hour vs. Budget
- Cost of Quality
- Maintenance Effectiveness
- Maintenance Efficiency
- Mean Time Between Failure (MTBF)
- Mean Time to Repair (MTTR)
- Preventive Inspection Effectiveness
- Ratio of Preventive to Breakdown Maintenance
- Backlog
- % Scheduled Man Hours Planned
- % Schedule Compliance
- % Planning Effectiveness
- % Man Hours Available
- % Rework
- % Failures Investigated
- MIP Process Effectiveness



LTIFR

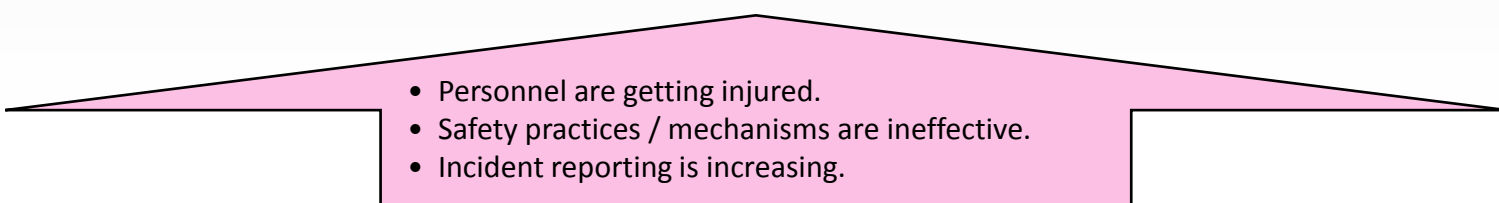
Lost Time Injury Frequency Rate

- LTIFR is a measure of overall safety performance, and indicates the frequency of Lost Time Injuries (LTIs).

Formula

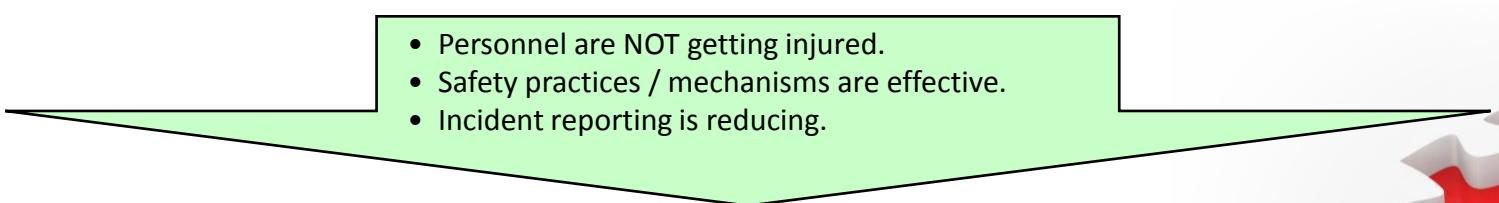
$$LTIFR = \left(\frac{\text{Number of Lost Time Injuries}}{\text{Total Man Hours}} \right) \times 1,000,000$$

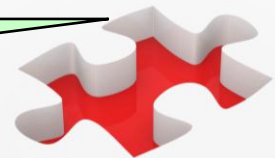
- **Total man hours** includes wages, staff and contractor hours associated with both production and maintenance operations.

- 
- Personnel are getting injured.
 - Safety practices / mechanisms are ineffective.
 - Incident reporting is increasing.

Interpretation

LTIFR < 5

- 
- Personnel are NOT getting injured.
 - Safety practices / mechanisms are effective.
 - Incident reporting is reducing.



Maintenance Cost per Unit vs. Budget

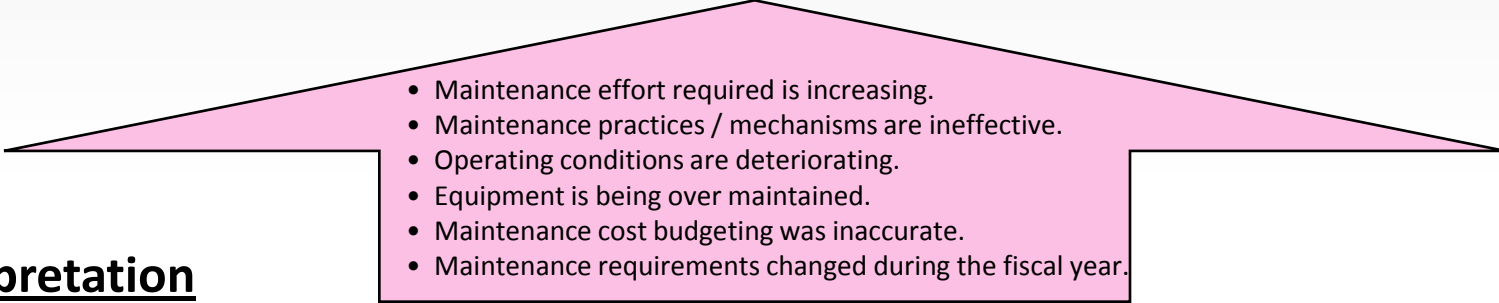
- A measure of the maintenance effort required for a piece of equipment (or plant) to generate a unit of production.

Formula

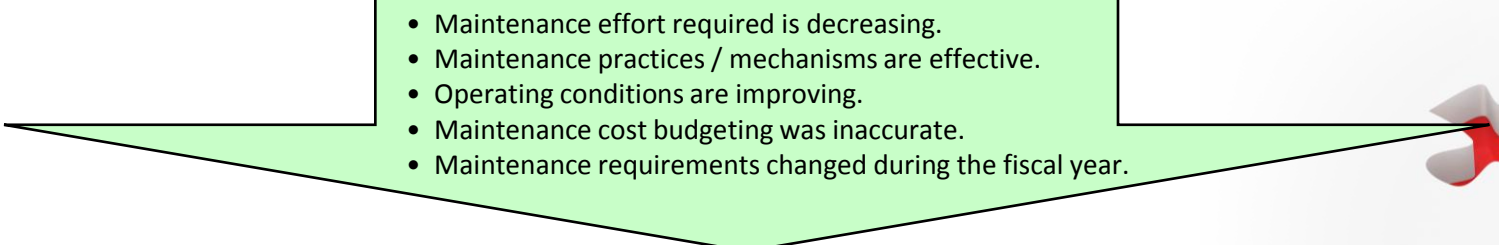
$$\text{Maintenance Cost per Unit} = \frac{\text{Total Maintenance Cost}}{\text{Unit of Production}}$$

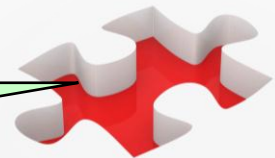
- **Total maintenance cost** includes total costed maintenance man hours, parts and any other costs associated with the maintenance effort (preventive and corrective).
- **Unit of production** will match the associated departments current unit.

Interpretation

- 
- Maintenance effort required is increasing.
 - Maintenance practices / mechanisms are ineffective.
 - Operating conditions are deteriorating.
 - Equipment is being over maintained.
 - Maintenance cost budgeting was inaccurate.
 - Maintenance requirements changed during the fiscal year.

Maintenance Cost per Unit vs. Budget

- 
- Maintenance effort required is decreasing.
 - Maintenance practices / mechanisms are effective.
 - Operating conditions are improving.
 - Maintenance cost budgeting was inaccurate.
 - Maintenance requirements changed during the fiscal year.



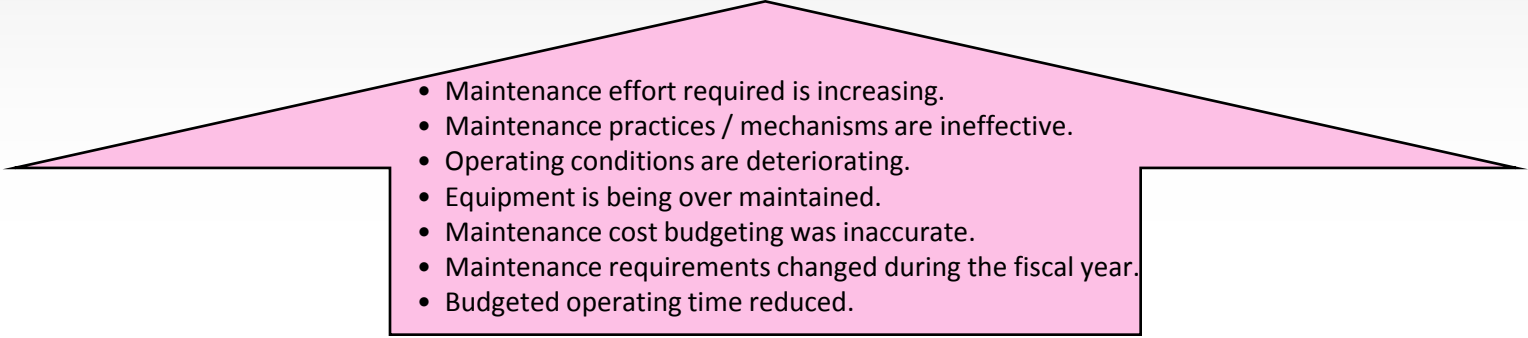
Maintenance Cost per Hour vs. Budget

- A measure of the maintenance effort required to generate production time from a piece of equipment (or plant).

Formula

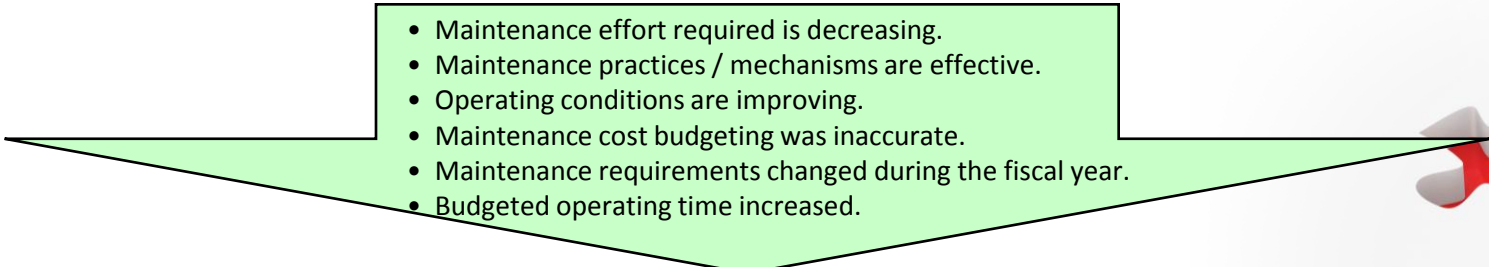
$$\text{Maintenance Cost per Hour} = \frac{\text{Total Maintenance Cost}}{\text{Operating Time}}$$

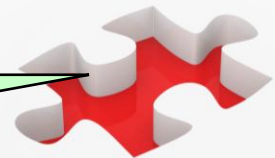
- **Total maintenance cost** includes total costed maintenance man hours, parts and any other costs associated with the maintenance effort (preventive and corrective).
- **Operating time** is productive time plus production delays.

- 
- Maintenance effort required is increasing.
 - Maintenance practices / mechanisms are ineffective.
 - Operating conditions are deteriorating.
 - Equipment is being over maintained.
 - Maintenance cost budgeting was inaccurate.
 - Maintenance requirements changed during the fiscal year.
 - Budgeted operating time reduced.

Interpretation

Maintenance Cost per Hour vs. Budget

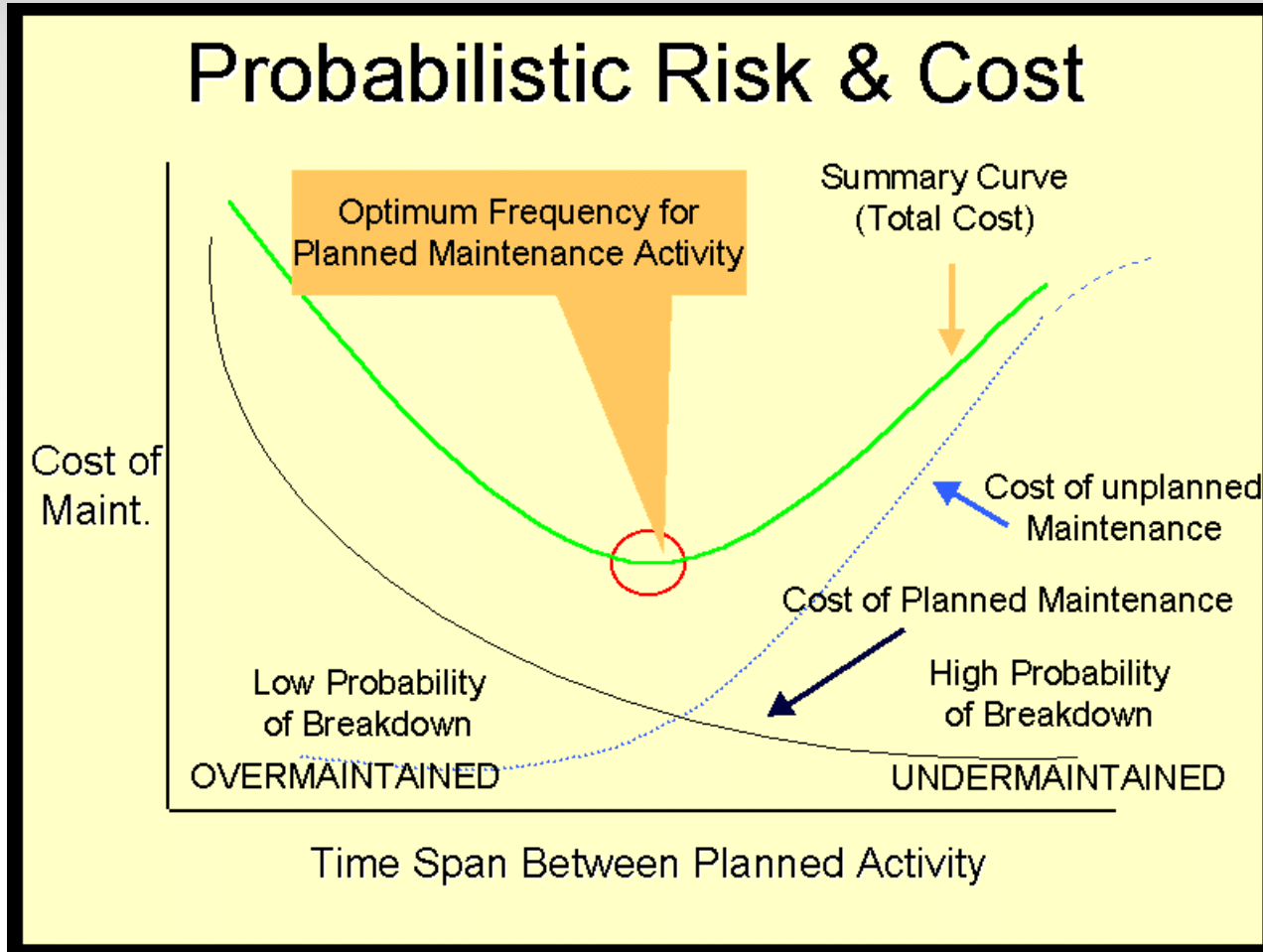
- 
- Maintenance effort required is decreasing.
 - Maintenance practices / mechanisms are effective.
 - Operating conditions are improving.
 - Maintenance cost budgeting was inaccurate.
 - Maintenance requirements changed during the fiscal year.
 - Budgeted operating time increased.



Cost of Quality

- A measure of preventive maintenance effect on corrective and total maintenance costs.

Concept



Cost of Quality (cont.)

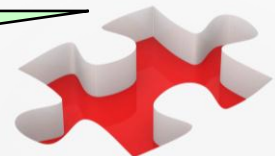
- **Total maintenance cost, or cost of quality**, is the sum of preventive and corrective maintenance costs.
- **Preventive maintenance cost** is the cost associated with maintenance carried out at predetermined intervals or other prescribed criteria intended to reduce the probability of failure or degradation of performance of equipment (or plant).
- **Corrective maintenance cost** is the cost associated with maintenance carried out on a defect which has caused equipment (or plant) to be taken out of service during scheduled operating time. Corrective maintenance can be either planned or unplanned.

Interpretation

- Preventive maintenance effort decreasing.
- Corrective maintenance effort increasing.
- Preventive maintenance effort excessive (beyond optimum)
- Maintenance practices / mechanisms are ineffective.

Cost of Quality

- Preventive maintenance effort is increasing.
- Corrective maintenance effort in decreasing.
- Preventive to corrective maintenance ratio optimised.
- Maintenance practices / mechanisms are effective.

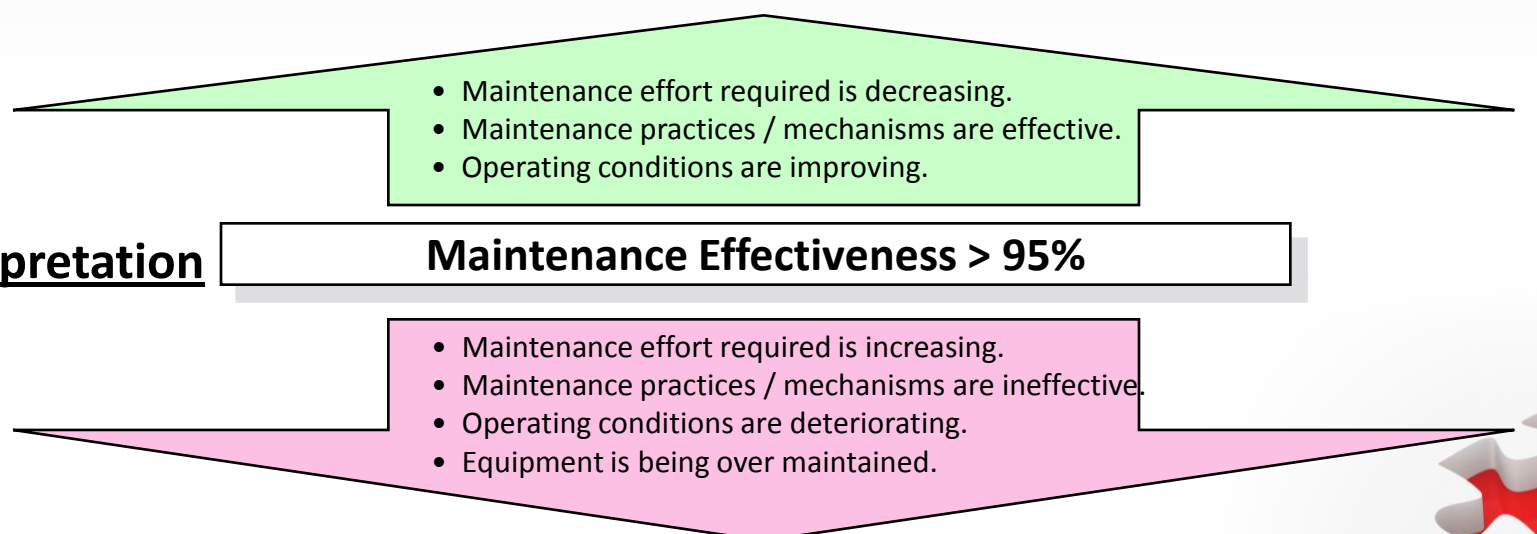


Maintenance Effectiveness

- A measure of the amount of maintenance downtime required to keep equipment (or plant) operating.

Formula Maintenance Effectiveness = $\left(\frac{\text{Operating Time}}{\text{Operating Time} + \text{Down Time}} \right) \times 100\%$

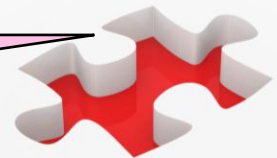
- **Operating time** is productive time plus production delays.
- **Down time** is the total time equipment (or plant) is down for maintenance work (preventive and corrective).

- 
- Maintenance effort required is decreasing.
• Maintenance practices / mechanisms are effective.
• Operating conditions are improving.

Interpretation

Maintenance Effectiveness > 95%

- Maintenance effort required is increasing.
• Maintenance practices / mechanisms are ineffective.
• Operating conditions are deteriorating.
• Equipment is being over maintained.



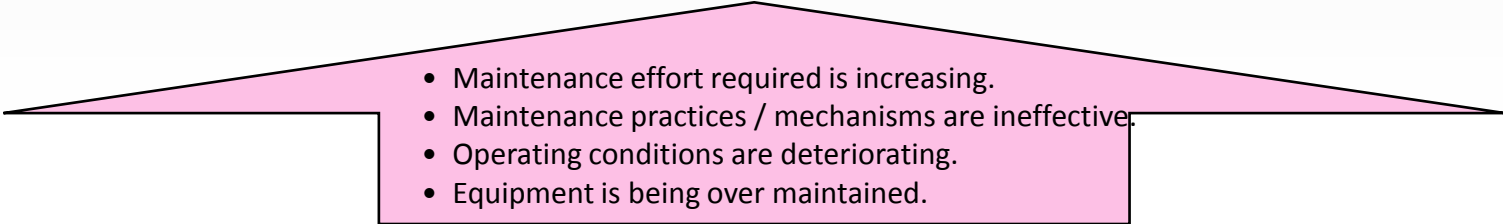
Maintenance Efficiency

- A measure of the maintenance effort required to deliver required performance levels from equipment (or plant).

Formula

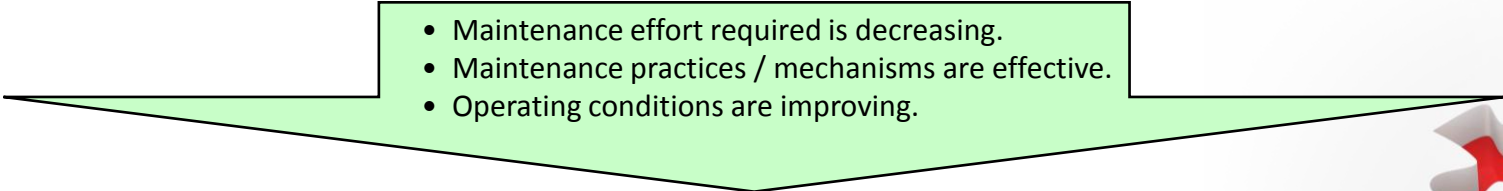
$$\text{Maintenance Efficiency} = \left(\frac{\text{Maintenance Man Hours}}{\text{Operating Time}} \right) \times 100\%$$

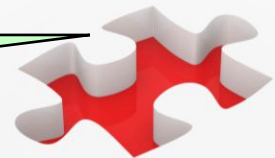
- **Maintenance man hours** is the actual maintenance man hours spent maintaining an item of equipment (or plant). Maintenance man hours includes maintenance wages, staff and contractor hours (preventive and corrective).
- **Operating time** is productive time plus production delays.

- 
- Maintenance effort required is increasing.
 - Maintenance practices / mechanisms are ineffective.
 - Operating conditions are deteriorating.
 - Equipment is being over maintained.

Interpretation

Maintenance Efficiency

- 
- Maintenance effort required is decreasing.
 - Maintenance practices / mechanisms are effective.
 - Operating conditions are improving.



MTBF

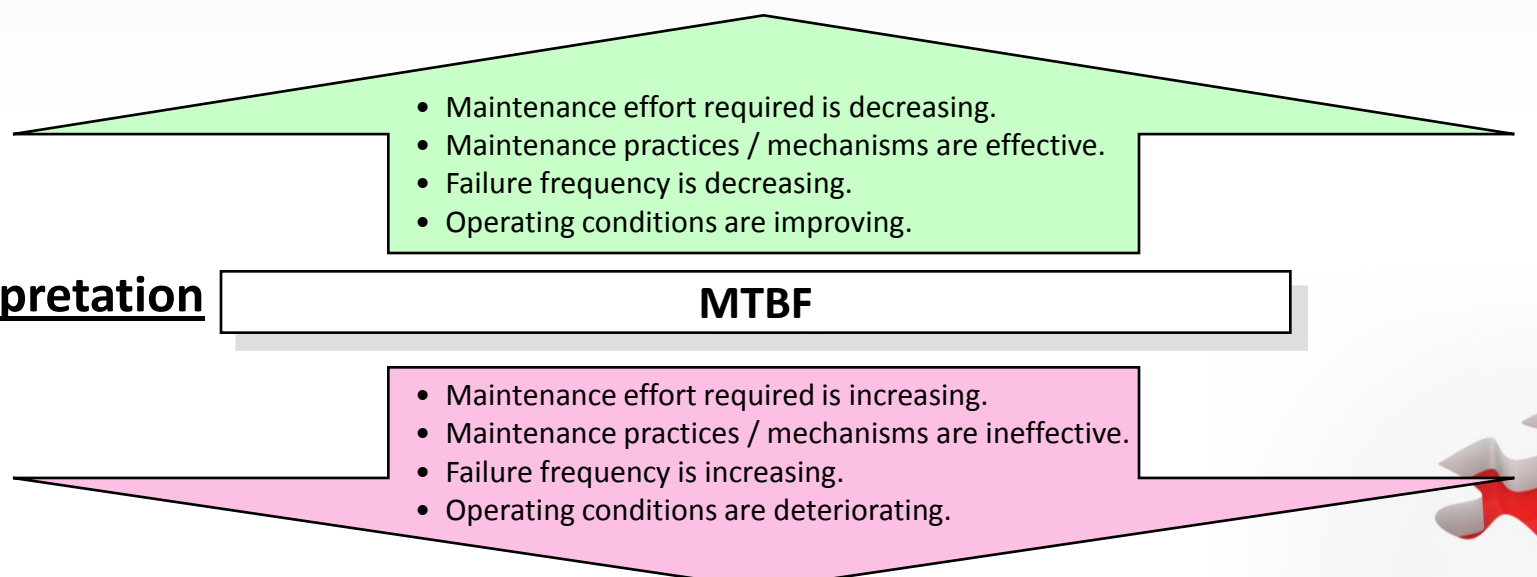
Mean Time Between Failure

- The average amount of operating time between consecutive breakdowns for an item of equipment (or plant).

Formula

$$\text{MTBF} = \frac{\text{Operating Time}}{\text{Number of Failures or Breakdown Events}}$$

- **Operating time** is productive time plus production delays.
- **Number of failures or breakdown events** is the number of failures on an item of equipment (or plant).

- 
- Maintenance effort required is decreasing.
 - Maintenance practices / mechanisms are effective.
 - Failure frequency is decreasing.
 - Operating conditions are improving.

Interpretation

MTBF

- Maintenance effort required is increasing.
- Maintenance practices / mechanisms are ineffective.
- Failure frequency is increasing.
- Operating conditions are deteriorating.



MTTR

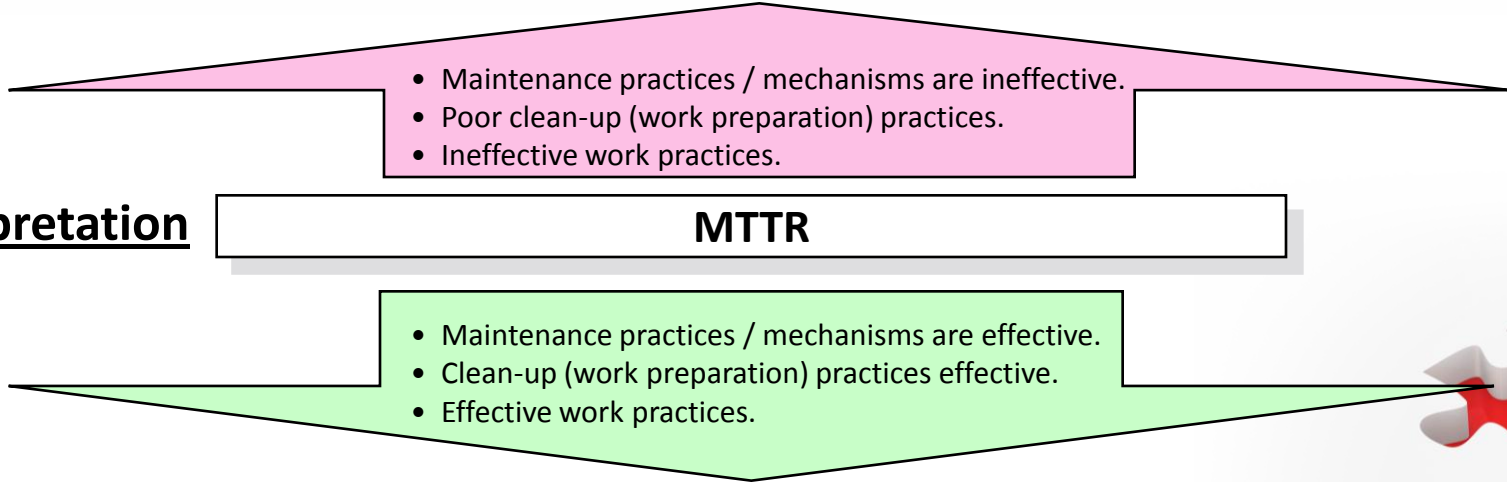
Mean Time To Repair

- The average maintenance time required to keep an item of equipment (or plant) operational.

Formula

$$\text{MTTR} = \frac{\text{Down Time}}{\text{Number of Failures or Breakdown Events}}$$

- **Down time** is the total time equipment (or plant) is down for maintenance work (preventive and corrective).
- **Number of failures or breakdown events** is the number of failures on an item of equipment (or plant).

- 
- Maintenance practices / mechanisms are ineffective.
 - Poor clean-up (work preparation) practices.
 - Ineffective work practices.

Interpretation

MTTR

- Maintenance practices / mechanisms are effective.
- Clean-up (work preparation) practices effective.
- Effective work practices.

Preventive Inspection Effectiveness

Ratio of Preventive Repair Man Hours to Preventive Inspection Man Hours.

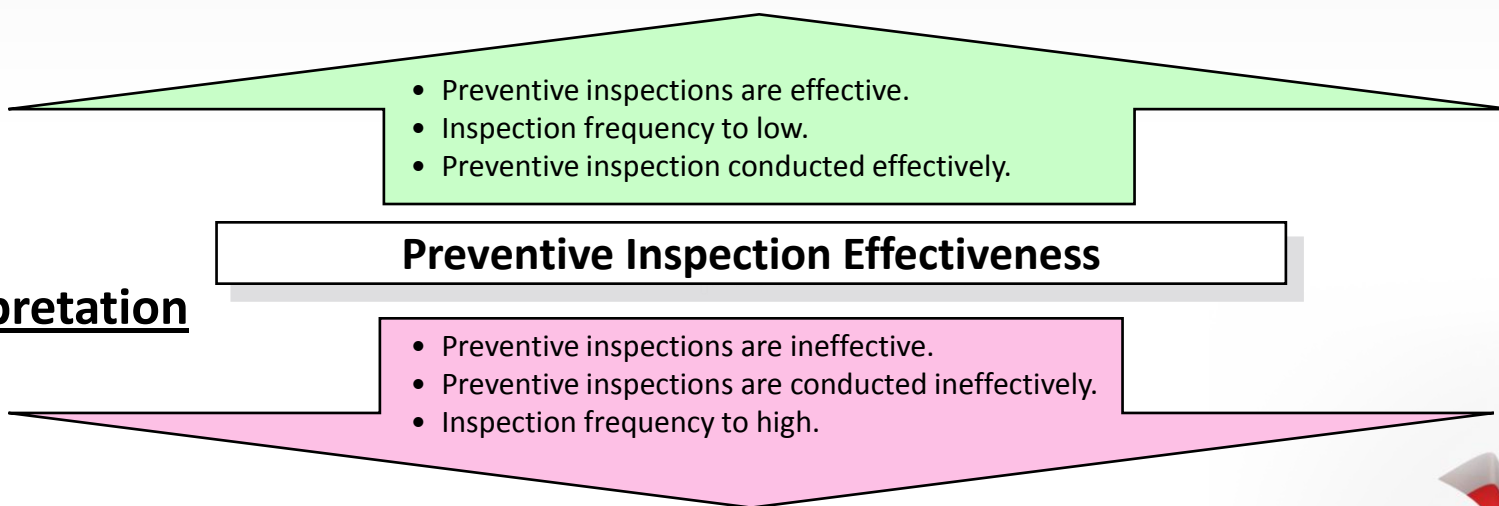
- A measure of preventive inspection effectiveness.

Formula

$$\text{Preventive Inspection Effectiveness} = \frac{\text{Preventive Repair Man Hours}}{\text{Preventive Inspection Man Hours}}$$

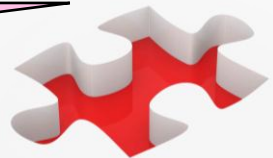
- **Preventive repair man hours** is maintenance that is performed as a result of a preventive inspection.
- **Preventive inspection man hours** is work performed that originates from equipment maintenance strategies; ie. planned services and inspections.

Interpretation

- 
- Preventive inspections are effective.
 - Inspection frequency to low.
 - Preventive inspection conducted effectively.

Preventive Inspection Effectiveness

- Preventive inspections are ineffective.
- Preventive inspections are conducted ineffectively.
- Inspection frequency to high.



Ratio of Preventive to Breakdown Maintenance

Ratio of Preventive Man Hours to Breakdown Man Hours.

- A measure of planning / scheduling process effectiveness and its influence on breakdown maintenance.

Formula

$$\text{Ratio of Preventive to Breakdown Maintenance} = \frac{\text{Preventive Repair Man Hours} + \text{Preventive Inspection Man Hours}}{\text{Breakdown Man Hours}}$$

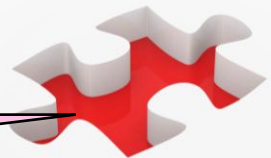
- **Preventive repair man hours** is maintenance that is performed as a result of a preventive inspection.
- **Preventive inspection man hours** is work performed that originates from equipment maintenance strategies; ie. planned services and inspections.
- **Breakdown man hours** is unplanned corrective maintenance that must occur due to a defect causing equipment (or plant) to be taken out of service during scheduled operating time (NOT corrective maintenance man hours).

- Over maintaining equipment.
- Preventive maintenance practices / strategies are too effective and should be optimised (optimise costs).

Interpretation

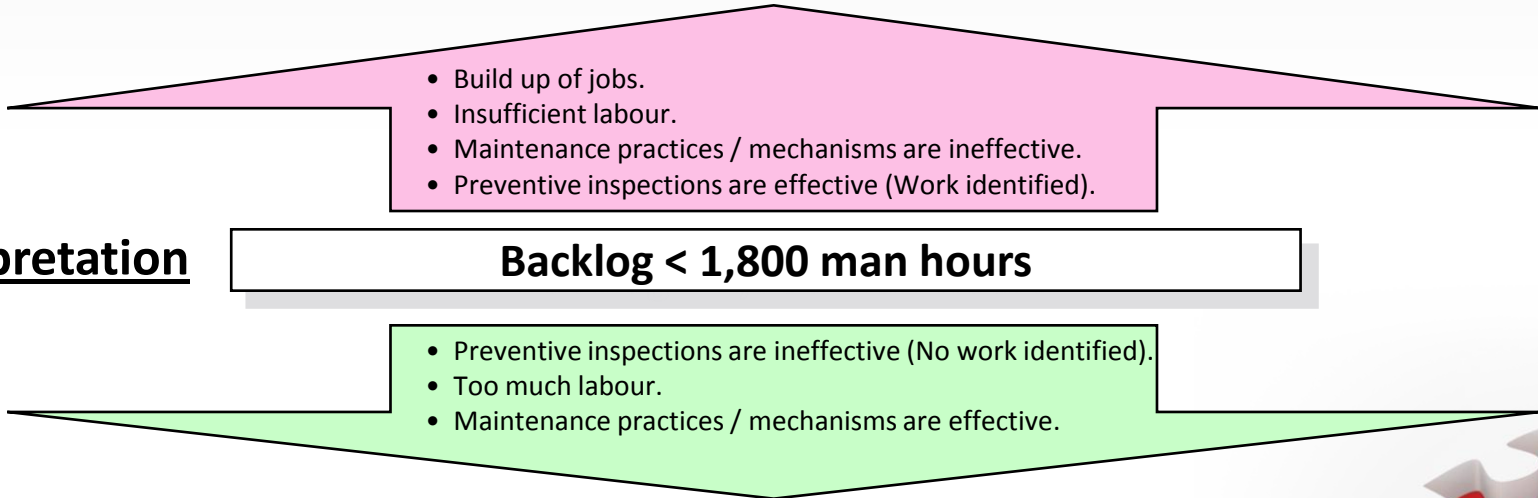
Ratio of Preventive to Breakdown Maintenance = 16

- Preventive inspections are ineffective.
- Faults not being reported.
- Preventive maintenance practices / strategies are ineffective.



Backlog

- All maintenance work identified to be done, but as yet incomplete. Indicates how much outstanding maintenance work exists compared to the resources available to complete the work.
- **Formula** $\text{Backlog} = \text{Total Maintenance Man Hours on Outstanding Work Orders}$
- **Total maintenance man hours on outstanding work orders** currently includes both backlog and forward log.

- 
- Build up of jobs.
 - Insufficient labour.
 - Maintenance practices / mechanisms are ineffective.
 - Preventive inspections are effective (Work identified).

Interpretation

Backlog < 1,800 man hours

- Preventive inspections are ineffective (No work identified).
- Too much labour.
- Maintenance practices / mechanisms are effective.



% Scheduled Man Hours Planned

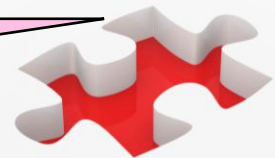
- The percentage of scheduled man hours that appear on the weekly schedule that have been planned. A measure of planning process effectiveness.
- **Formula**
$$\% \text{ Scheduled Man Hours Planned} = \left(\frac{\text{Planned Man Hours on Weekly Schedule}}{\text{Total Weekly Scheduled Man Hours}} \right) \times 100\%$$
- **Planned man hours on weekly schedule** is the total planned maintenance hours on the weekly maintenance schedule.
- **Total weekly scheduled man hours** is the total maintenance man hours scheduled for the week (NOT total maintenance man hours available).

-
- The diagram consists of a central white box with the text '% Scheduled Man Hours Planned > 80%'. Above this box is a green upward-pointing arrow containing a list of positive outcomes. Below the box is a pink downward-pointing arrow containing a list of negative outcomes. To the left of the central box is the word 'Interpretation' with a red arrow pointing to the central box. To the right of the pink arrow is a red puzzle piece icon.
- High level of planned work in backlog.
 - Minimal job delays.
 - Maintenance practices / mechanisms are effective.
 - Too much labour.

Interpretation

% Scheduled Man Hours Planned > 80%

- Priority work not being planned.
- Lack of planned work in backlog.
- Maintenance practices / mechanisms are ineffective.
- Insufficient labour.

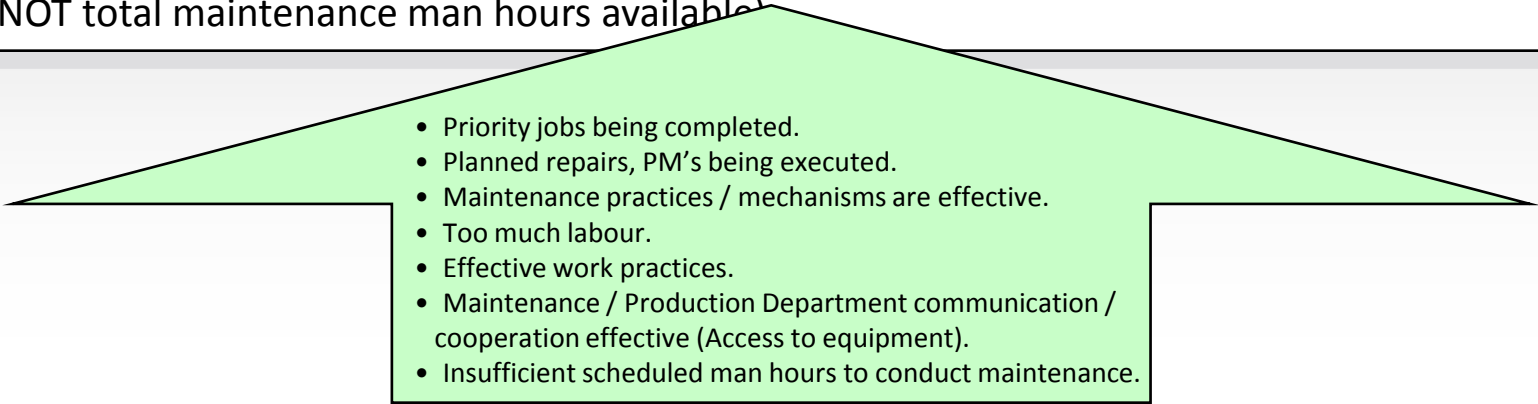


% Scheduled Compliance

- A measure of scheduling process compliance.

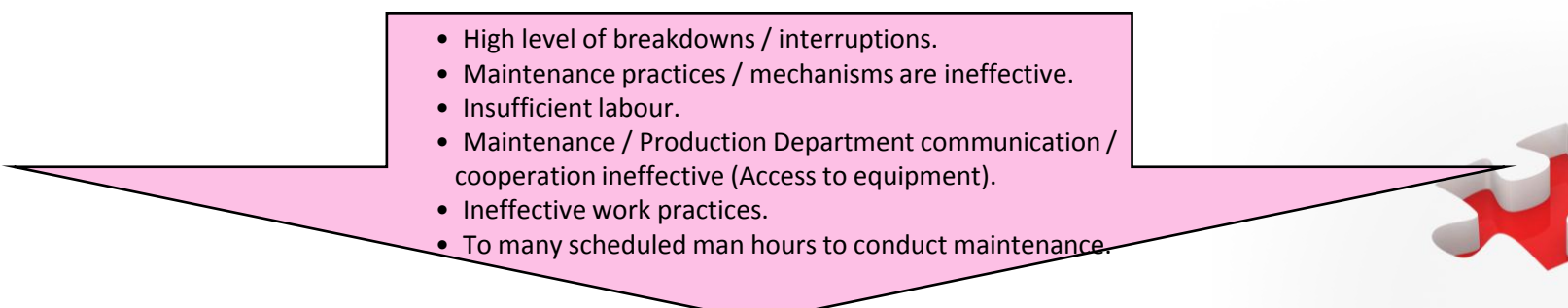
Formula % Scheduled Compliance = $\left(\frac{\text{Scheduled Man Hours Completed}}{\text{Total Weekly Scheduled Man Hours}} \right) \times 100\%$

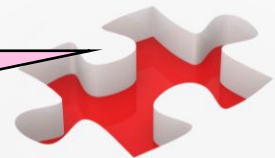
- **Scheduled man hours completed** is the actual man hours spent performing scheduled maintenance.
- **Total weekly scheduled man hours** is the total maintenance man hours scheduled for the week (NOT total maintenance man hours available)

- 
- Priority jobs being completed.
 - Planned repairs, PM's being executed.
 - Maintenance practices / mechanisms are effective.
 - Too much labour.
 - Effective work practices.
 - Maintenance / Production Department communication / cooperation effective (Access to equipment).
 - Insufficient scheduled man hours to conduct maintenance.

Interpretation

% Scheduled Compliance > 80%

- 
- High level of breakdowns / interruptions.
 - Maintenance practices / mechanisms are ineffective.
 - Insufficient labour.
 - Maintenance / Production Department communication / cooperation ineffective (Access to equipment).
 - Ineffective work practices.
 - Too many scheduled man hours to conduct maintenance.



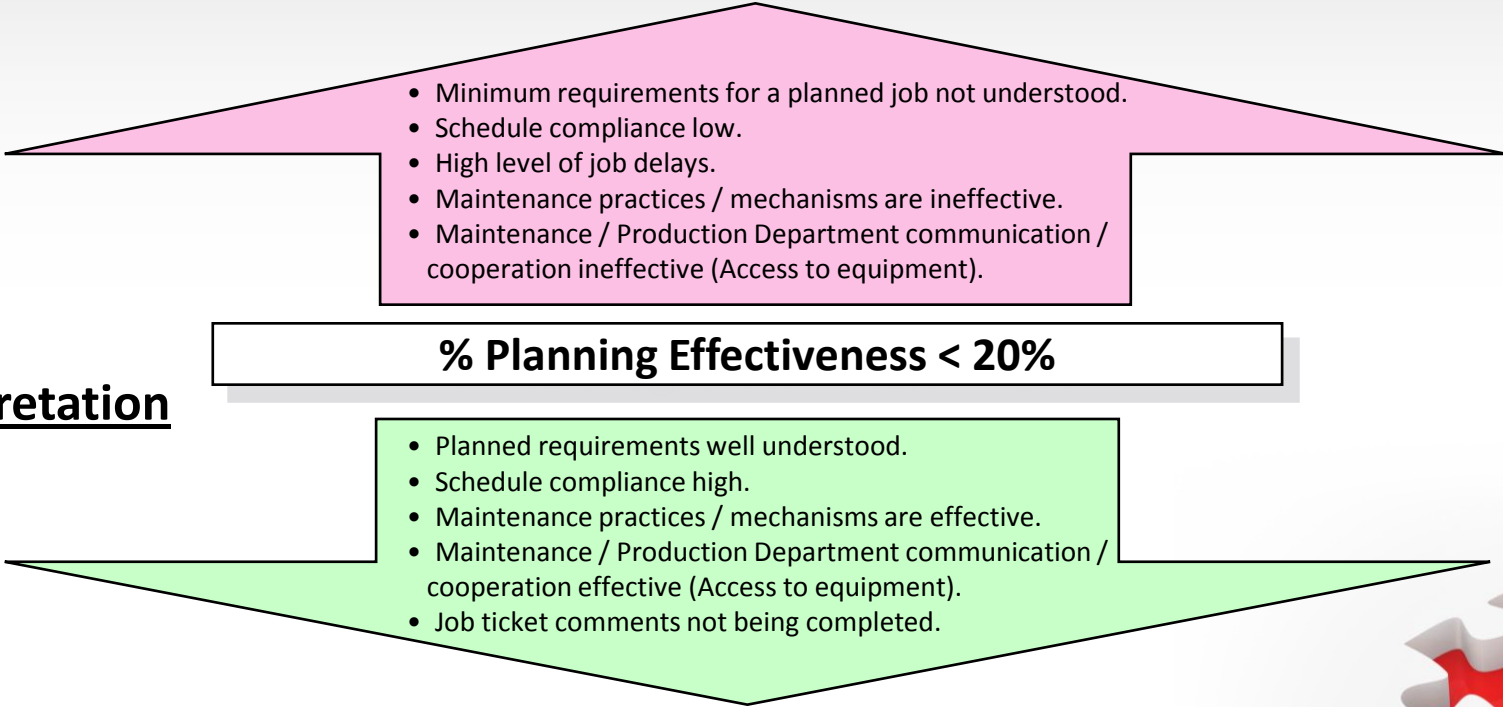
% Planning Effectiveness

- A measure of planning process compliance.

Formula

$$\% \text{ Planning Effectiveness} = \left(\frac{\text{Number of Scheduled Jobs Completed with Comments}}{\text{Total Number of Scheduled Jobs Completed}} \right) \times 100\%$$

- **Number of scheduled jobs completed with comments** is the number of scheduled jobs completed with comments on the job ticket identifying issues / problems with the planning process.

- 
- Minimum requirements for a planned job not understood.
 - Schedule compliance low.
 - High level of job delays.
 - Maintenance practices / mechanisms are ineffective.
 - Maintenance / Production Department communication / cooperation ineffective (Access to equipment).

% Planning Effectiveness < 20%

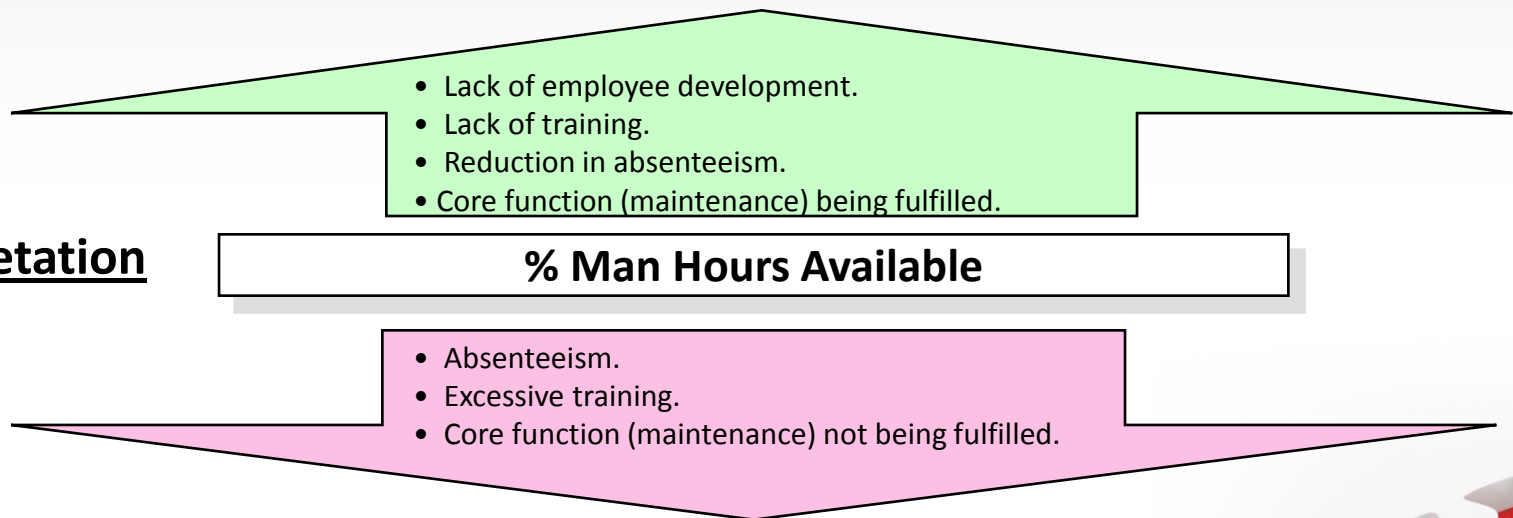
Interpretation

- Planned requirements well understood.
- Schedule compliance high.
- Maintenance practices / mechanisms are effective.
- Maintenance / Production Department communication / cooperation effective (Access to equipment).
- Job ticket comments not being completed.

% Man Hours Available

- Primarily a measure of attendance, but also a useful tool to track training and future manpower requirements. Indicates effective utilisation of man power.
- **Formula** % Man Hours Available = $\left(\frac{\text{Total Man Hours Paid} - \text{Absence from Work}}{\text{Total Man Hours Paid}} \right) \times 100\%$
- **Absence from work** is man hours associated with absenteeism, training and any other diversion from an employees primary function.

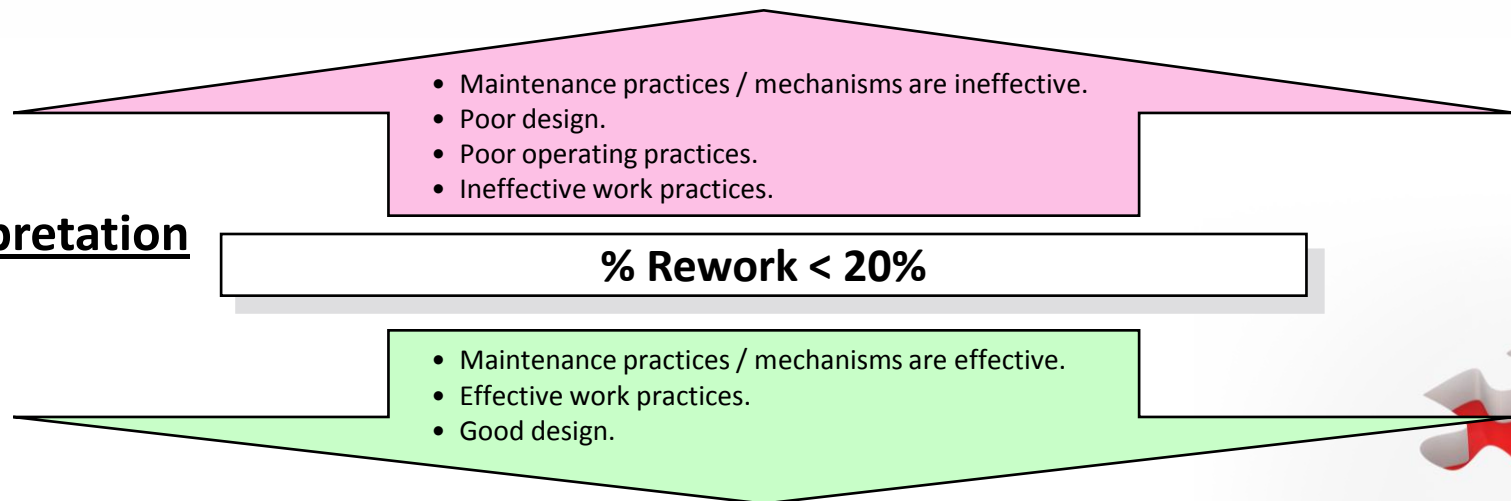
Interpretation



% Rework

- Maintenance action that is a repeat of a previous, ineffective effort. The work could have been ineffective due to poor workmanship, poor design, or improper procedures.
- **Formula**
$$\% \text{ Rework} = \left(\frac{\text{Rework Man Hours}}{\text{Maintenance Work Hours}} \right) \times 100\%$$
 - **Rework man hours** is man hours associated with a maintenance action that is a repeat of a previous, ineffective effort.
 - **Maintenance man hours** is the actual maintenance man hours spent maintaining an item of equipment (or plant). Maintenance man hours includes maintenance wages, staff and contractor hours (preventive and corrective).

Interpretation



% Failures Investigated

- Measure of the Maintenance Department's effort to continuously improve.

Formula % Failures Investigated = $\left(\frac{\text{Number of Corrective Job Tickets Investigated}}{\text{Total Number of Corrective Job Tickets}} \right) \times 100\%$

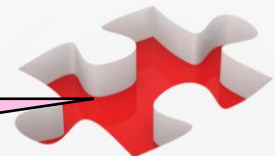
- **Number of corrective job tickets investigated** is the number of job tickets investigated, root cause found, and solutions investigated to prevent future occurrences. Job tickets that are associated with maintenance work performed on defects which caused equipment (or plant) to be taken out of service during scheduled operating time.
- **Total number of corrective job tickets** is the total number of job tickets associated with maintenance work performed on defects which caused equipment (or plant) to be taken out of service during scheduled operating time.

Interpretation

% Failures Investigated > 80%

- Improved equipment reliability.
- Continuously improving maintenance practices / mechanisms.

- Repetitive equipment failures.
- Repetitive job delays.
- Continuous improvement of maintenance practices / mechanisms is not occurring.



MIP Process Effectiveness

- Measure of the Maintenance Department's effort to continuously improve.

Concept

- **MIP process effectiveness** is a combination of the maintenance KPIs, schedule compliance, planning effectiveness and backlog.

Interpretation

MIP Process Effectiveness > 80%

- Maintenance effort is improving.
- Maintenance mechanisms / practices are improving.
- Improved equipment reliability.
- Backlog is decreasing.

- Maintenance effort is deteriorating.
- Maintenance mechanisms / practices are not improving.
- Equipment reliability is deteriorating.
- Backlog is increasing.



Summary

KPIs track performance against established key success factors.

Interpretation of KPIs is KPI dependent.

KPIs do NOT give answers, rather they raise questions and direct attention.

Every person on-site has an influence on certain KPIs and business objectives.

Seventeen (17) primary maintenance KPIs to be utilised.

–These KPIs will be utilised across the site's Maintenance Departments.



- Systems and mechanism implemented to address business objectives (key success factors) can always be improved.
 - A continuous improvement (CI) philosophy should be adopted.

