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## 1.0 TPM Definition

Total Productive Maintenance (TPM) is a concept to guarantee continuously high investment availability.

The target of this document is the advanced development of production equipments in co-operation with our machines suppliers utilizing TPM principles.

Planned and unplanned downtimes are minimized systematically.  
Recognition of the existing MAE condition by the operator is paramount. Maintenance and repair activities are fast and easy to accomplish.

## 2.0 Procedures, Cooperation and Responsibility

The details of the TPM appropriate MAE design need to be discussed already during the initial stages of the procurement process (requirement specification check).  
The production planner is responsible to incorporate the procedures in the respective project flow plan. The co-operation of the maintenance and production group has to be guaranteed.  
From the beginning the TPM Coordinator of the area / plant is to be included.

## 3.0 Application

This document outlines fundamental design directives for the TPM appropriate MAE design.  
The DIVISION/PLANT can use this document as a guide directly and adapt it to the respective projects.  
The contents of this Central TPM Specification are a component of the MAE order.  
The current Bosch Standards (Norm) apply.  
Repetition of target specifications and relevant standards in this document are deliberate.

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#### 4.0 General (N51MM20 Pkt.10)

- W-I-I matrix (Maintenance-Inspect-Service matrix) must exist. Contents such as Functional group, Assemblies, Components, Activity, Special Tools, Material used, Sequence/ Period, Responsible Person, Associated Documents (One Point Lesson, Standards, Rules etc) are specified. The document specifies internal (MAE must be stopped) or external activity (while machine is running). (N51MM20Pkt10)
- Instruction guides (One Point Lesson - OPL) must be created for complex assemblies / activities, critical start and stop processes. The operating personnel are to be trained on it.
- User manual, spare part lists, wear part lists, service and lubrication instructions exist. (N51MM20 Pkt.10)
- Spare part and wear part lists include Part numbers, part description, delivery time, manufacturer, vendor part numbers (original manufacturer). The list includes the quantity of included spare parts, as well as the recommended spare parts stock quantity for stocking the crib.
- The life cycle of components (wear parts, critical machine parts in function and procurement period, etc) are provided. (N51MM20 Pkt.10)
- Diagnostic systems are defined in the concept phase and adjusted. See also Bosch standard (N54 B1 Pkt. 4.4 and 4.5.)
- For wear parts, especially the ones touching the product, the drawings are to be provided.
- The components must be marked durably and align with the circuit diagram. The marking must be device specific, obvious and unmistakable.
- Monitoring and operating elements are accessible from the outside, visible and attached meaningfully. The monitoring activities must be able to take place while the machine is running. (N51MM23 Pkt.7.2)
- Elements necessary for maintenance are to be attached at a preferred machine side.
- To clean the machines no compressed air is intended to be used.
- The requirements for support installations (Hydraulics, pneumatics, etc) to have the ability to flex are defined and executed.
- Contamination source analysis needs to be performed. The resulting measures are to be corrected. (N51MM20 Pkt.10 Ord. 2)
- The ground clearance of the equipment (MAE) must be sufficient to allow for cleaning and inspection (guideline is 10 cm).
- Ground-level operating ability for the associates operating the equipment (MAE) is guaranteed.

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- Covers and guards are designed that maintenance, cleaning, inspection and preparing can be executed without problems. (N51MM20 Pkt.4.1, N51MM23 Pkt.8)
- All walls and panels are removable for service / maintenance. Opening of panels and walls using standard tools is possible.
- At minimum, horizontal aluminum profile (FMS) openings or keyways are to be covered, if aluminum construction is used.
- Storage and presentation of work piece, tools, change over parts, set up parts, gages and test equipment, cleaning devices which belong to the equipment (MAE), etc are organized meaningfully. (N51MM20 Pkt.1 and N62A 3.3)
- Chip disposal must be handled. Removal of the chips must be possible without shutting down the machine or the chip conveyor. Areas that can collect chips and dirt are to be avoided. Contamination through chips is to be avoided.
- Appropriate devices are to be installed to ease the disassembly or maintenance of the equipment (MAE). Examples: transport rings, guides for forklifts, fixtures for tool changes. (N51MM20 Pkt.8)
- Andon systems are installed per BPS standards with customer input.
- Lack of parts, tool changes and automatic stops for maintenances must be defined and be indicated early. Justifications are given for the design of the equipment based on calculations for cycle time, change over time, capacity.
- Energy usage (compressed air, electricity, coolant) are to be documented during start up.
- Necessary checks are possible while the machine is running.
- Other requirements are specified and justified.

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## 5.0 Technology

### 5.1 Mechanical

- To allow easy inspection of covers of belts, chains, Cover of V-belts are transparent.
- All functional elements, e.g., slide guides are pinned for positioning. Components that are in danger of collisions the pins are to be removed.
- Transport systems less than 1.5 m have functional elements such as sensor banks/blocks, actuators, guides etc mounted on bars.
- Feeder bowls and rails have the distance of magnet and anchor documented.
- The contamination removal abilities for vacuum units are guaranteed. Associated cleaning and maintenance intervals, e.g., filter changes are defined. (CP/MAE Requirement Specifications (Las-tenheft), etc. for processing machines Pkt.4.5 is to be consulted)
- The machine is leak tight, no oil, coolant water, chips, etc. can escape. Fluid drips from parts, transporting, transport systems are captured.  
Fluid drips are defined with a measurable quantity (per part). (N51MM25 Pkt.4.2.8.3)
- Commercially available tools to carry out the maintenance work set up activities and inspections are to be used.  
Justification for special tools needed is to be provided and the tools are to be supplied with the equipment. Storage for it must be provided at point of use.
- Accessibility of all grease and lubrication points must be provided. (DIN8659 Teil 1)
- Work trays are marked per Bosch standard, drawing number and sequential WT numbers are marked permanently.
- Standard parts are used for rollers, chains, ropes. Application of ropes under load are to be avoided, tow chains are sufficiently dimensioned (1.5 - 2 times)
- Openings to the test belt tension exist. Necessary belt tension is provided. Type marking with technical data is permanently and unmistakable mounted on the equipment (MAE).
- Other requirements are specified and justified.

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## 5.2 Electrical

The current Bosch standards apply: N51MM23

For special-purpose machines additionally the current Bosch standards (N54 Teil B1, B2, B3 apply)

- An electrical circuit plan, including a parts list, exists and is approved by the responsible department.
- Cable races-ducts are sufficiently dimensioned (1.5 - 2 times).
- Connectors in cable trays/ducts are not permitted.
- Plug-and-socket connections or connectors are to be used as per existing standard. (N51MM23 Pkt.8.1)
- Connectors are clearly marked.  
Note: Avoid usage of Y plugs in connector blocks - reasons: transparency, accessibility. Mark the cables in connector blocks clearly (N51MM23 Pkt.10 and DIN EN 61346-2)
- Round sensors are mounted in clamps (no counter nut attachment). (N51MM23 Pkt.7.2)
- All ready signals of the overload protection switches and motor protection switches are integrated in the error diagnosis.
- Install LED plugs on all actuators, sensors and fluid level sensors. (N51MM23 Pkt.7.2)
- Motors are equipped with connectors. Length of the cables at the motor is between 0.5m to 0.8m. (N51MM23 Pkt.6.1)
- Motors are mounted horizontally near or above the transmission. (Avoid damage of the motor when the transmission leaks).
- Enough space is provided for the exchange of motors.
- All initiators and light switches have connectors. If the light switches come only with cables, the cables are to be shortened and equipped with connectors. (N51MM23 Pkt.7.2)
- Incoming and used air filters of the control cabinets are easily accessible and easy to change.
- Motors are equipped with a standard particle filter (fan caps filter). Filters are easy to change as per existing standard. The required air flow must be considered.
- In wet surroundings cable connectors with medium contacts are leak tight at the interfaces. Depending on the case the correct classifications are used.

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- During automatic mode all switches point into the same direction. (N51MM23 Pkt.7.1 and DIN EN 60 447)
- Other requirements are specified and justified.

### **Electrical Installation considering service and short maintenance times**

- Installation modules (valve blocks, bus modules) are mounted only vertical in the machine. Mounting the modules vertical minimizes damage. Horizontal modules complicate the cleaning of the working space. (N51MM23 Pkt.8.1)
- Color coded cables are used in the installation (N51MM23 Pkt.8.1)
- Mobile cables have connectors on each end. The connections are easily accessible. Connections are located close to the cable trays/ducts. The cable tray/duct is hinged. (N51MM23 Pkt.8) DIN EN 60204-1 Pkt 14.5)
- Touch less systems is used for the electronic sensors to decrease the wear.
- Necessary checks are possible while the machine is running. The bus connection plug in the first bus card have an extra socket (PG Buchse) installed.
- Plan an additional socket for cleaning devices with appropriate safety (16 A) per machine / cell.
- Other requirements are specified and justified.

### **5.3 Hydraulic**

The current Bosch standards apply: N51 M25

- A hydraulic circuit plan, including parts list, exists and is approved by the responsible department. (N51MM25 Pkt.7.2.8)
- Metric screw connections (hoses) are used.
- Hydraulic lines in cable trays/ducts are laid separately, in parallel and both ends are isolated. Dividing bars are applied. The bend radius is set by the design.
- Fluid level displays with min/max markings are easily visible and oil resistant. Display preferably includes fill amount. An oil resistant description of the hydraulic fluid and the tank and system capacity is mounted close to the fill opening, well visible. (N51MM25 Pkt4.4.6)
- Filling of the hydraulic tank must be simple.
- Hoses and pipes are routed properly to avoid wear, chafing and tear. Wear protection exists with critical cases.

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- Filters are easily accessible and can be changed without special tools. For critical activities such as safety, quality risks, etc instructions (One Point Lessons) are created. Safety related documents are created with the responsible qualified personnel.

- Pressurized filters have a monitoring device. Shut downs are executed with shut off valves and pressure relief.

- Filter change is possible without disassembly of other components.

- Other requirements are specified and justified.

#### 5.4 Lubrication

The current Bosch standards apply: N51MM20

- A lubrication chart with layout plan exists, all lubrication points are marked. (N51MM20 Pkt.10)

- Accessibility of all lubrication points is provided. Badly accessible lubrication points are moved to the outside of the machine.

- All lubrication tanks are centrally located (preferred machine side -Maschinenvorzugsseite), well accessibly and refillable while machine is running.

- Lubrication tasks can be executed with commercially available tools.

- Equipment (MAE) lubrication points are marked/visualized.

- Multiple static single lubrication points are to be connected possibly to a central oiling unit.

- Specified oils and grease' are based on existing oil and grease standard.

- Single lubrication points are uniform, based on the existing standard. Flat head lubrication nipples are preferred (Handling). Consider central lubrication instead of individual points.

- Slides and slide tables are to be equipped with countersunk head lubricating nipples (accessibility and crash prevention).

- Other requirements are specified and justified.

#### 5.5 Pneumatic

The current Bosch standards apply: N51MM26 and DIN EN 983

- All pneumatics components are easily accessible and easily changed. (N51 MM26PKT5/2/2)

- Valve blocks must be installed accessible outside of the leak protection (avoidance of machines shutdown). (N51MM26 Pkt.5.1.7)

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- Pneumatics is designed for oil free operation. If the compressed air at the customer includes oil, an appropriate solution is to be planned accordingly.
- Maintenance unit are installed based on the standard (preferred machine side), well accessible and visible.
- Open reserve spots for valves are provided.
- Separate signs are used if incoming air throttle valves are utilized. These valves are marked in the pneumatic circuit diagram.
- Markings for Valves / valve blocks are durable, in the vicinity, visible and oil resistant. (N51MM26 Pkt.7.3.1)
- A second filtration system need to be considered if the filter change interval is short, or filter change out times are long.
- Standard, adequately dimensioned, incoming air filters are to be used with the application of vacuum pumps. Defined filter change cycles for the special application are given. Utilize the HSE department to verify the noise level. The continuous stress level (Leq - energy-equivalent permanent noise levels) needs to be measured as a time weighted average, not a timed peak value. Avoid venture nozzles (compressed air consumption and noise development)
- Recommended spare parts are specifically marked in the parts lists. The data required for the procurement exist.
- The marking of all units and necessary components are easily readably (manufacturer, type, nominal pressure etc). (N51MM26 7.3.1)
- Sufficient additional free connections for equipment exist
- Other requirements are specified and justified.

## 6.0 Change Over

### 6.1 Tools, Gripper Fingers, Fixtures, Wear Parts

- The required internal change over time is defined.
- Changeover possible without changeover parts. An exchange without tools (quick change system) should be used if changeover parts are inevitably. If tools are required, common tools should be utilized. Justification for exceptions is present.
- Changeover parts are positioned clearly. If there is the danger of a collision, the pins/fixations are to be removed.
- Storage for changeover parts exists, if possibly in the stations and is organized meaningful.
- Unavoidable special tools are provided / mounted in the machine.

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- A changeover matrix about the different changeovers exists. The different changeovers are defined, and visualized in the standardized work form (standard changeover plan).
- Tasks instructions (One Point Lesson - OPL) are constructed for critical activities.
- Changeover parts are clearly marked, identified in the changeover plan and the position marking in the equipment matches.
- Exchange of tools in tool magazines should be possible while the machine is running.

### 7.0 Tool Monitoring

- Tool monitoring and tool removal strategy after tool breakage, wear and collision is defined in the concept phase.

### 8.0 Bearing Monitoring

- Measuring interfaces for diagnosis systems are to be defined in the concept phase.
- To facilitate a condition based monitoring, the necessity of a permanent bearing monitoring system is defined in the concept phase. The surveillance or vibration analysis system with clarification of the necessary sensors is defined. Indication: Vendors are a companies VE IFM-Octavis 1001, Test Technology - Vibscanner; e.g., VIB 6.140

### 9.0 Equipment (MAE) Visualization

- All units or devices are easily readable and marked in an oil resistant manner (manufacturer, type, nominal pressure etc). (N51M M23,-M25,-M26)
- Layout of the machine with check and maintenance points exists.
- Check and maintenance points are visualized in the machine.
- Principle „glass machine " is kept.
- Simple means of visualization are used for fan functions.
- One Point Lessons exist for critical activities or tasks on subjects of safety, quality risks, etc.
- Pressure gages have markings for the correct operating pressure. In addition, visual markings of pressure tolerances are provided to allow correct and fast reading of the gage.
- Visualize the correct operating pressure with tolerances on flow meters.
- Fluid tanks (oil, grease, coolant, etc) have a sign which specifies upper fill level and description as per DIN ISO VG.
- Fluid levels are readable from the outside. Min/Max markings exist.

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- Lubricating nipples are marked red.
- All lubrication tanks are set up at centrally, well accessibly and can be filled while machine is running.
- Digital or LED display electronic flow meters or pressure gages have a sign specifying the operating pressure, including the tolerance, next to the display.
- Manual valve handles have the correct position color coded. Open is green, closed is red.
- The handles must be mounted that in the open position the handle is parallel or in line/flow direction with the pipes/lines. The closed position handle direction is 90 ° to the flow direction.
- Throttle valves have the correct positioning clearly marked.
- Camera systems and manual workstations have no reflective surfaces.
- Sharp edges have protection or edge guard.

## 10.0 Qualification

A detailed training program is established. It is based on the W I I matrix (Maintenance-Inspect-Service matrix). Table of contents, duration, place, number of participants as well as qualification of the participants (if needed) is provided. The training is developed by the equipment (MAE) vendor together with the end user/customer, TEF, etc.

The following training is offered, including table of contents and the tasks of the training participants. The W I I matrix (Maintenance-Inspect-Service matrix) is to be utilized for the definition of the qualification concept with appropriate measures.

- Operator training
- Set Up/Technician training
- Maintenance / service training TEF
- System training (process, technology, control)
- Production support training
- Change Over
- Other: \_\_\_\_\_

## 11.0 Additional Material and Resources:

TPM Element Description, TPM Analysis, Best Practice examples etc. are available on the Bosch TPM Intranet site.

Checkpoints from relevant Bosch TPM Analysis questions.

CP/MAE – Guideline for MAE planning and procurement German/English

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CP/MAE Requirement Specification (Lastenheft), etc. for processing machines Pkt.4.5

VT ATMO - MAE Installation brochure covering electric with examples  
Version 01.09.2001

AE/MFP – Requirement Specification (Lastenheft), etc. / Specifications of Purchase Order  
(Pflichtenheft) for Special Machines (Sondermaschinen (PCB-, Hybrid-, Sensor- and Assembly  
technology))

AE – General description of the Machine Assembly Line Equipment (MAE) Version 1.01.2006 (RTP1  
– Waferfertigung)

PA-ATMO1/EES34 - OEE Analysis-Auswertungen

**Original Wording for documents some may be only available in German**

TPM Bausteinbeschreibung, TPM Analyse, Best Practice Beispiele etc. sind  
auf der Bosch TPM Intranetseite verfügbar.

Checkpunkte aus relevanten Bosch TPM Analysefragen

CP/MAE - Leitfaden zur MAE Planung und Beschaffung deu/englisch

CP/MAE Specification List for Machining Tools

VT ATMO - MAE Installationsbroschüre bereich Elektrik mit Beispielen Stand 01.09.2001

AE/MFP – Lastenheft/Pflichtenheft Sondermaschinen (PCB-, Hybrid-, Sensor- und Montagetechnik)

AE - Allgemeine Beschreibung der Maschine Anlage Einrichtung (MAE) Stand 1.01.2006 (RTP1 –  
Waferfertigung)

PA-ATMO1/EES34 - OEE Analysis-Auswertungen

