MAGNETI MARELLI	**MAGNETI MARELLI** *ELS Back-End Equipment* *Industry 4.0 requirements*	***Issue Date***	05.01.2018
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Contents

1 Introduction

1.1 Scope

The purpose of this document is to define the basic requirements for the new Back-End Lines in order to allow them to be compliant to Industry 4.0 specs, to communicate with MM Industry 4.0 infrastructure and to collect from the machines the information for the following purposes:

- Product Traceability
- Process Traceability
- Component Traceability
- Line Efficiency monitoring
- Logistics
- Quality Control

1.2 Conventions

1.2.1 Product

It is a part under processing in the manufacturing line, identified by a unique ID or Serial Number.
The term product is referred to the final output of a manufacturing line.
A product can be either the final good sold to customer or a sub-assembly used in further assembly steps to build a more complex product.
The requirement for being considered a product is that the sub-assembly could be identified by a Serial Number.

1.2.2 Component

It is a **Part** or a **Material** used to build a product and included in the product itself.
It is a child of the product on a hierarchically point of view.
A component can either compare in the BOM or not.
The choice to include a component in the BOM is depending on logistics strategies.
All the parts or materials used during the manufacturing process but not being part of the final product are not considered to be component.
Nevertheless also this parts/materials can be tracked for traceability purposes.

1.2.3 Part Number

A **Part Number** (often abbreviated as PN or P/N) is the a non-ambiguous identifier of a particular part type used in or resulting from a manufacturing process. Its purpose is to simplify the reference to the part.
The non-ambiguity refers to the non-existence, within the same company or corporations, of two different types of items referred by a single part number
Products, components and all parts and materials used in the manufacturing process have a P/N.

1.2.4 Serial Number

The **Serial Number** is a unique sequential identifier for a single product or component item.
Normally it contains, directly or indirectly through a database, the information about when and where the

item has been produced.

1.2.5 Batch Number

The Batch Number is the counter part of the serial number for items / components that can't be identified individually but only in batches or lots.

1.2.6 Process result

The result of a process step during manufacturing can be

- **GOOD** or **OK** if the part / product / component have been processed with successful result
- **FAIL** or **NOT OK** if the part / product / component have been process with unsuccessful result
- **PASS** if the part / product / component have been re-processed / reworked with successful result after re-process / re-work

If the process step is a test, a failed part and re-tested with successful result at the following test is referred as **NTF** (**N**o **T**rouble **F**ound)

1.2.7 Defect / Scraps

The term **Defect** refers to parts / components / products processed with an unsuccessful result that requires a re-work step to be recovered.
The defects that can't be recovered are referred as **Scraps**.

1.2.8 Component congruence

It represents a check of correspondence between a product and a component, if it is congruent, a product can mount that component, and otherwise component is incongruent.

1.2.9 Automatic program congruence

It's the check of congruence between a product and the program currently active in the machine.
If the program can process the product, there is congruence otherwise the is not congruence.
The requested solution is to have an intelligent program selection that load the correct program into the machine by recognizing the product to be processed.

1.2.10 Consistency

It refers validation of position and process results of a product. If a product is consistent, it can continue along production line, otherwise out-of-consistency condition raises a warning.

1.2.11 Product Traceability

Product traceability refers to the manufacturing history of the product with a focus on the product itself:

- Process steps performed on the product
- Date, time and process result for each process steps

1.2.12 Process Traceability

Process traceability refers to the manufacturing history of the product with a focus on all process data for each process step:

- Process steps performed on the product
- Date, time and process result for each process steps
- Measurements and settings for each operation performed, including tests

1.2.13 Components Traceability

Components traceability refers the tracking of all components used to produce a selected group of products (single unit or batch) or, conversely, tracking all products built with a certain component batch.
The information required are

- Components PNs and Batch numbers mounted
- Date and time of use
- Rejected (scraps) components during the mounting

For components sensible to humidity and/or with an expiration date, the congruence check must include the control of the date of use vs package opening date and the expiration date.
Some components can be "restored" after their expiration date or if a too long time has elapsed since package opening date.
The restoring is performed by specific procedures depending on the component and it won't be subject of this document.
In this case the remaining batch, after restoring, must be managed as a new batch with a new opening date and/or a new expiration date.
The storage of unused batch remains in dry chamber won't have effect on the opening date that will be extended.

1.3 Abbreviations

Acronym	Description
MM	Magneti-Marelli
PLC	Programmable Logic Controller Level 0 of automation
P/N	Part Number
S/N	Serial Number
NIP	Numero Identificativo Prodotto (MM 9-chars Serial Number)
MIC	Marelli Identification Code (MM 12-chars Serial Number)
Fiche	Batch/Lot Number

2 Standard minimum requirements

All Middle-Line stations must to be compliant with the following requirements:

2.1 PLC-Based Stations

It can be controlled by a PLC; PLC must be programmed and chosen according to "MM Equipment Specs – IoT Requirements Guideline".

2.2 PC-Based Stations

PC-Based Stations are controlled by a PC. All the communications between the test station and DSM (MM Scada) must be compliant with "MM Equipment Specs – IoT Requirements Guideline".

2.3 "Mixed" Stations

The "mixed" stations have a PLC and a PC at the same time. The communication between the test station and DSM must be compliant with "MM Equipment Specs – IoT Requirements Guideline" both for PLC and PC.

2.4 "Physical" connection

The Test Station must have a Network Interface Controller (Ethernet or Wi-Fi) that allows to connect the Station to the MM network.

3 Back-End configuration

There is no standard configuration for back-end because the configuration is depending on the product that must be processed. Here in the following a list of machines typically found in a back-end is present.
The IoT requirements in the following cover all the machines of a back-end, regardless its real configuration.
Some stations of the back-end can be multiplied because of capacity purposes (es. EOL testers).
Each module must be considered separately.
Not all the stations are included in all the lines; the model can be considered as the "most complete" middle-end. Conveyors won't be considered in this context.

Product transformations

- De-paneling Stations
- Laser Soldering stations
- Hot-iron soldering stations
- Ovens (Polymerization, Curing, etc.)
- Pre-heating ovens (for EOL testing)
- Resin dispensers
- Thermal grease dispensers
- Screw-drivers (both automated and full-automated)
- Flame treatment / Plasma cleaning stations

Assembly mounting stations

- Assembly stations (both automated and full-automated)
- Needles mounting stations
- Product labeling (*PSP – "Postazione Specializzazione Prodotto"*)
- Packaging stations

Optical and non-electrical Testing

- Resin dispensing AOI & AOI Analysis stations
- Thermal grease AOI
- Sub-assembly mounting AOI (for checking the correct mounting performed manually)
- Sealing testers
- Optical / Electrical Pin-Checkers
- Firewall (aesthetical controls)

Electrical and functional testing

- In-Circuit Testers

- On-Board Programmers
- Functional Testers (including LED testers)
- Power Run-in stations
- EOL (**E**nd-**O**f-**L**ine) testers
- Application SW downloading stations

For Electrical and functional test equipment also refer to Industry 4.0 specifications for testing equipment (**ELS TST Industry 4.0 requirements**).

4 Data requirements

The data to be sent by the PLC are as follows:

4.1 Product Traceability

Here in the following there is a minimum set of parameters regarding the traceability of **each** product processed.

Parameter	Unit of Meas.	Type
Operator Code		String
Serial Number		String
Process Result		String
Process Start Time	Date / Time	Timestamp
Process End Time	Date / Time	Timestamp
Process Time	sec	Double Prec
Program Name		String
Fixture/Tool/Stencil Code		String

If a sub-assembly can be considered as a product, it must follow the same rules as a product.

4.1.1 Operator code

There should be a login step in which only allowed operators can access the system.
The Operator code info must available for product / process traceability

4.2 Process Traceability

All process parameters must be saved in log text files.
Datalog structures are defined in a separate document and are depending on the type of station / process considered.

Process traceability log files can be

- Daily for all units processed in a day
- For single process operation, one for each time a unit is processed (including unit re-processing)

Alternatively data can be stored in a database that must be accessible (read-only mode) for retrieving data.

4.2.1 Daily datalog

The daily log file is allowed in case the process operation is a simple operation that return a single operation result (GOOD / FAIL / PASS) and, optionally, a single measured value.
Each unit generates a row within the daily log every time the unit is processed (including re-processing).
Each row contains the timestamp, the unique unit ID, the operation result and optionally a measured value.

4.2.2 Single unit datalog

Some process steps are composed of many operations and each operation returns a result and a measured value (e.g. Automatic Electrical or Optical Test).
The final result of the operation is GOOD (or PASS) if and only if all the single operations returned a GOOD result. If one or more operations returned a FAIL result, the process step result is FAIL.
For these process steps a single-unit datalog is required.
The datalog contains information about the unit processed, process timestamp, process operation conditions and settings (including tools ID – e.g. fixtures), process operation result (GOOD / FAIL) and one row for each single operation performed.
The rows describing the operations contain a label identifying the operation, the allowed range for measured values (min / max), the measurement unit, resulting value and the result of the operation (GOOD / FAIL).

The single unit datalog is also used in case of a single process operation that returns multiple values, like in case of curves or profiles (e.g. Thermal profiles or screw driving curves)
In this case the single log will contain a stream of data representing the curve or profile.

Another case in which the single unit datalog is required is when the machine has a set of process parameters with their related real-time measurement.
In this case the log must contain all the information about the settings and the real-time measurements during the unit processing.
In this case the log is managed as in case of automatic / electrical tests (single measure for each setting, with detail of the limits) or as in case of curves or profiles (e.g. measured profile/curve and upper/lower curve/profile).

4.3 Component Traceability

Components traceability data are listed below:

Data	U.M.	Type
Final product Serial number		Text (with rules)
Raw material batches (every PN used)		Text (with rules)
Component part number		Text (with rules)
Scraps (for each PN)	Number	Long Integer

4.3.1 Raw material PN and Batch Number

The raw material entering the SMT line must be tracked by reading the MM part and batch number.
The MM batch number (fiche) must be linked to Supplier Part Number and Batch Number.

4.3.2 Scraps

All the stations machine must be able to identify as many types of scraps as they can.
Each time a machine error is raised, the part in process has to be considered as a scrap if the error code belongs to process errors.
A counter of the scraps with scrap codes must be available for every part number.

4.4 Data for Maintenance

A set of data related to scheduled and predictive maintenance is listed below

Data	U.M.	Type
Maintenance Up-Time	min	Double Prec
Maintenance Working Time	min	Double Prec
N° of units produced	Number	Long Integer
Energy consumption	kWh	Double Prec
Air flow consumption		Double Prec
Machine stoppages and cause	---	Text

4.4.1 Maintenance Up-Time

Time elapsed from last machine switch-on.

4.4.2 Maintenance Working Time

Period of time, within Up-Time, in which the IMM has been working (injection).

4.4.3 Number of units produced / GOOD / FAIL

Number of units processed by the machine.
The number of units must be monitored for :

- Stations / Modules
- Stencil

The counters can be reset when maintenance is performed.

4.4.4 Machine stoppages and cause

A database of the stoppages must be kept with the following information:

- Error / Stoppage code
- Time stamp (occurrence Date & Time)
- Duration

The database, together with Up-Time and Working-Time, will be used to provide the OEE in real-time.

4.5 Data for Quality

In addition to data for product traceability, a set of data for quality must be available on the machine for displaying and retrieving.

Data	U.M.	Type
Date		Date
Period (shift)		Label
N° of units produced (GOOD / FAIL)	Number	Long Integer
N° of units GOOD	Number	Long Integer
N° of units FAIL	Number	Long Integer

4.5.1 Date & period

Day and shift

4.5.2 Number of units produced / GOOD / FAIL

Number of units processed by the machine (Total / GOOD / FAIL).
The number of units must be monitored for :

- Stations / Modules
- Tools / Fixtures / Jigs

The counters are reset at the beginning of each shift. Data remains available on-demand for future uses.
The counters, together with Up-Time and Working-Time, are used to provide the OEE and the FTQ in real-time.

4.6 Data for Logistics

Back-end lines must be able to provide data for the following logistics purposes:

- Logistics working time
- SAP Declarations for good products
- SAP Declarations for scrapped / defective products
- SAP Declarations for scrapped components
- Raw materials scrap rate and consumption
- Automatic raw material call-off

4.6.1 Logistics working time

Logistics working time is measured as time elapsed while the machine is processing units, as in case for maintenance working time.
It's considered as a separate counter because the logic for resetting the two working time counters are different.

4.6.2 SAP Declarations for good products

The point for SAP Declaration for good products in a back-end line is the packing station, where the finished good is put in the packaging and a packaging label is applied.
For each product good a file for SAP declaration must be created.
Further there must be a file for all products contained in a package, if packaging contains more than one product.
This file must have information about

- Packaging timestamp
- Package number (SAP Fiche)
- Finished Good Part Number
- Serial number of all products contained in the package.

The specification for these files are described in a separate document.

4.6.3 SAP Declarations for scrapped / defective products

For SAP Declaration for scrapped products a point of declaration must be defined for each operation after which a part is submitted to a GOOD/FAIL check.
Normally the declaration points are corresponding the test stations (both electrical and non-electrical).
An automatic segregation of the scraps is required to discriminate between GOOD and FAIL parts.
For each scrapped part a file for SAP declaration must be created.
The specification for this file are described in a separate document.

4.6.4 SAP Declarations for scrapped components / materials

For each component discarded during a process operations, an information for SAP scrap declaration of raw material must be created. The specification for this information are described in a separate document.

4.6.4.1 Resin, Coatings and Thermal Grease purging / SPC

For materials like resin, coatings and so on the quantity of material periodically purged or used to perform SPC controls must be tracked and discarded as scrap with a specific scrap cause (e.g. periodical purging / SPC).

4.6.4.2 Labels

For labels, two quantities must be counted

- The quantity of labels in the reel (when material enter the station during a reel replacing)
- The quantity of labels printed and applied to products

The difference between the two quantities above is considered as scrapped and declared to SAP.

4.6.5 Raw materials scrap rate and consumption

The average scrap-rate is calculated using the working time (see maintenance data) and keeping a counter for each component used.
The counter can be reset by logistics depending on logistics strategies to find the most accurate measurement interval for the having the most efficient raw material feeding.

4.6.6 Automatic material call-off

For each component used in each process operation an automatic call-off to SAP there should be the possibility to create an automatic call-off.
For each component the following parameters must be defined for the call-off:

- MachineID
- Part number
- Call-off threshold
- Machine average scrap-rate
- Machine average consumption

The specification for the information required for the call-off are described in a separate document.