


ETN009 EN July 2013	Design of the equipment control system	 JOINTLY INNOVATIVE
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01	500000009972	2018-03-06	D.CONZELMANN	2018-03-08	A.KUENSTLE	2018-03-08	U.KAMPHAUS
DOC-VER.	CHANGE NO.	EDITED		CHECKED		RELEASED	
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				100011087_Z25_001_01			
				REPLACEMENT FOR DOCUMENT NO			

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1 Purpose and Scope

This company standard is currently valid for ETO MAGNETIC GmbH.

This equipment specification (ES) is a guideline for the design of facility and machine control systems. This equipment specification shall be applicable to all orders placed by ETO. The technical design is examined during machine acceptance testing using a checklist.

In case of contradiction between this equipment specification and the specifications sheet, the design in the specifications sheet shall be applicable.

If special agreements are made, these shall only apply to the relevant order and shall be documented in writing. Oral agreements shall not apply.

If during acceptance testing, deviations from the equipment specification are detected, the observance of which would have been possible, a modification at supplier's expense may be requested.

The aim of this equipment specification is the following:

- High availability (operational availability) of the machine.
- Minimum spares inventory and short downtimes in case of repairs due to the use of suitable preferred components.
- Avoid additional work and costs during start-up.
- Ensure safety for the operating and service personnel.
- Ensure use of modern technology in respect of cost effectiveness, maintenance and set-up times.
- Due to the standardization forming the basis of the equipment specification, ETO personnel can familiarize themselves quickly with new machines and facilities.

2 Change history

Issue	Change Description
November 2014	Translation of the German version July 2013

3 Project Organization and Project Management

At ETO, the relevant technical department is responsible for the technical assessment and the design of the machine control system during procurement.

All drawings and planning documents shall be presented to ETO for viewing and approval purposes on the occasion of the design discussion. The approval only relates to the design principle. However, this shall not release the supplier from their obligation to produce a fully functional machine which meets the technical specification as well as the applicable standards and laws.

Project planning documents include:

- Machine / system concept
 - Software structure
 - Concept of operations
- Operation chart
- NOK strategy
- Handling of reference parts

Technical modifications arising during production and project planning shall be agreed upon with ETO. The supplier acts as general contractor. The supplier is also responsible for all interfaces and processes.

Acceptance testing of the design of the control system is performed according to the specifications sheet. The supplier shall complete the Equipment Acceptance - Control Engineering checklist and document the results. ETO will perform random sampling.

4 Specifications and Standards

The Directive 2006/42/EC on Machinery shall be applicable. The current version of the EC Low Voltage Directive shall be complied with accordingly.

The supplier shall be responsible for the safe operation of electrical facilities and compliance with the occupational health and safety standards and guidelines applicable at the time of operation acceptance.

5 Software scope of supply

The scope of supply of the software includes the supply and the test of any system, application and test program required for solving the tasks up to machine acceptance, as well as any changes, corrections and additions resulting from functional tests of the test operation or proof of performance.

Programming tools, software for parameterization of components as well as licenses, if not available at ETO, are part of the machine scope of supply. Details shall be clarified with the responsible technical department at ETO. A list of software tools shall be provided in advance.

The source code of project specific software is part of the scope of supply, as well as the source code for product components. The data shall be provided on CDs or DVDs. After start-up of the machine at ETO, any software change shall be presented to ETO by providing a data storage medium. The date of day shall be consistent with the index.

Any machine parameters and process parameters shall be discussed with ETO and provided in a current version.

6 Operating modes

6.1.1 Set-up / manual mode

During set-up mode, actuators of a previously addressed station can be moved via the user terminal or be switched on and off.

Movements which could directly cause damages to/destruction of the machine shall be prevented by suitable locking devices. An appropriate message shall be displayed.

During set-up mode all manual functions are displayed. If movements cannot be performed due to an active interlock, this shall be displayed in the touch panel.

The status of the addressed actuator shall be displayed.

The hazard potential caused by individual movements shall be determined on the occasion of a risk assessment.

Set-up works shall be possible without manipulating the guards ("Operating mode 3: Extended manual intervention" / "Operating mode 4: Process surveillance").

The positions of servo axes shall be displayed on the user interface and made teachable via the user interface.

6.1.2 Automatic mode

During automatic mode, a program cycle of a machine or module is performed fully automatically and continuously in consideration of all relevant safety functions.

Prerequisite for starting the automatic mode is a specified home position or a specified position of the machine. Automatic mode must be started by the operator. Automatic start of the automatic mode is not permissible.

When the machine is in automatic mode and the STOP request is actuated, the machine stops at the current step. If the machine is re-started, processing of the step sequence is continued.

6.1.3 Cycle end

When "Cycle end" is activated, the current process is finished and the machine stops in home position. Automatic mode is stopped. Successful completion of "Cycle end" is displayed. Automatic mode can be re-started immediately.

6.1.4 Run to empty

When "Run to empty" is requested, the machine continues processing until no parts to be processed are left in the machine. In this modus, e.g. on a rotary table machine, no part is inserted at the loading and discharging area, and the machine continues processing until all nests have been discharged as finished parts. After that, the machine changes into "Automatic Stop" mode and the "Run to empty" mode is completed. Successful completion of the "Run to empty" process is displayed. Automatic mode can be re-started immediately.

6.1.5 Step mode

The step mode is a semi-automatic operating mode. For the step mode, the same conditions apply as for the automatic mode. Switching from automatic mode to step mode must be possible without any restrictions.

During step mode, the next process step is released via keystroke on the user terminal. The conditions of the automatic mode still apply.

In case of pick-and-place tasks, the step mode shall be possible in forward direction as well as reverse direction. In case of joining processes, forward / reverse operation shall be possible until the process starts.

In case of comprehensive assembly machines, the step mode shall be realized at station and module level, as agreed upon with ETO.

6.1.6 Reference run

During a reference run, reference parts are automatically transferred to the processes to be referenced. Referencing starts automatically. The results are displayed on the user terminal (OK or NOK). In case of a negative result, the process is interrupted, the worker acknowledges notice of the result and the reference part is discharged. Whether after a NOK reference run further processing shall be possible, is to be determined by the ETO project team on a case-by-case basis.

Every process to be referenced must be separately selectable. The reference runs are specified in the specifications sheet.

The reference run is requested either on a production rate related basis or following an event according to the specifications sheet or after consultation of the project manager. Selecting the reference run via the user terminal shall be possible also independently of a cycle.

Interruption of the reference run shall be possible.

6.1.7 First part / last part / SPC parts

After each manufacturing step it shall be possible to discharge the parts for first part / last part acceptance testing or as SPC parts. Discharge shall be agreed upon with ETO.

6.1.8 Rework

In case of linked machines, inserting parts for rework (e.g. replicate test, test parts, etc.) shall be made possible via a manual workplace.

6.1.9 Functions for a process capability study

In order to perform process capability studies, functions for a straightforward procedure, e.g. by manual functions, shall be provided.

After each manufacturing step it shall be possible to discharge the parts for a process capability study. Discharge shall be agreed upon with ETO.

6.2 Home position run

During the home position run, all actuators and interfaces to other systems are brought into the specified home position. Sensor and interfaces are examined for plausibility. This is performed fully-automatically in the specified order so that no movement causes destruction of the machine.

All parts which are currently located in holders or grippers are transferred back to their original location or remain in the gripper. If re-processing or testing of the part is not possible for procedural reasons, this part shall be labeled with the NOK status "Interruption". Finished parts labeled with the respective processing results are transferred to following processes.

The home position run must be started by the operator. Automatic start of the home position run is not permitted. A successfully performed home position run is the prerequisite for starting the automatic mode.

7 Special functions

7.1 Moby

For testing purposes the Moby can be deactivated for one processing cycle via the user interface. The station processes the part without including the Moby data. The work piece carrier shall be classified as NOK. When the automatic mode is restarted, Moby mode shall be automatically activated.

7.2 Type change

Type changes shall be agreed upon with the project team.

7.3 Deselection of test processes

For test purposes and for assembling sample parts, it must be possible to deactivate test and measurement processes in password "Level 3" via the control panel. In doing so, only the OK / NOK rating is deactivated. However, these deactivated processes shall be reactivated automatically after 5 min.

7.4 Discharging trays in palletizers and on conveyor belts

It must be possible to discharge trays in palletizers or on conveyor belts via the control panel.

8 Diagnosis

8.1 Machine diagnosis

During automatic mode and home position run all sensors and actuators shall be monitored for plausibility. In case of sensors not assigned to actuators, all switching statuses shall be examined for plausibility. Every sequential control shall be monitored by timeouts. If after completion of the timeout, a step enabling condition is not available, the relevant actuator / sensor shall be diagnosed as having provided an error message. Subsequent errors shall be suppressed.

All non-defined machine conditions shall be diagnosed by means of error messages.

For a detailed diagnosis, the current step number of the sequential control shall be retrievable.

8.2 Process diagnosis

Every process feature of a process step shall be assessed and the result for the following process steps be transferred for assessment. Uncontrolled stopping of the manufacturing process shall be recorded as "Interruption".

Adding process features later shall be possible at any time.

In case of semi-automatic machines a detailed NOK reason shall be displayed on the user interface when parts are removed.

In case of fully automatic machines the different NOK parts shall be separated according to the different NOK features.

9 Operation, display, HMI

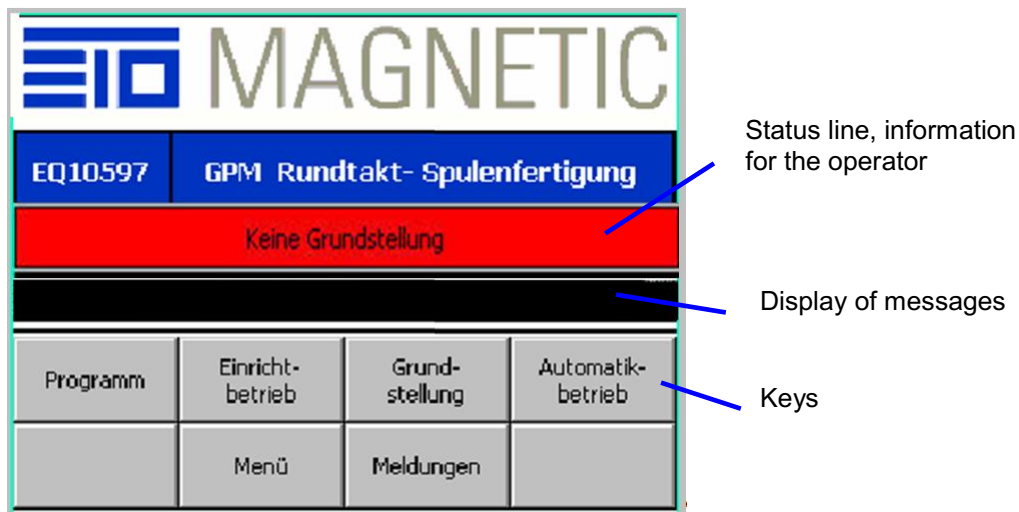
The user interface shall be in German for the location Germany, in German and Polish for Poland and in German and English for the U.S. Languages for other locations shall be agreed upon.

The individual control windows shall be self-explanatory. The user interface shall be presented to ETO during the design discussion.

9.1 Display

On the touch panel at least the following images shall be provided:

Basic display:



Status of the machine

Set-up mode

Home position

Automatic mode

Messages

Menu

Program

9.1.1 Machine components

The status of machine components shall be displayed on the control panel.

9.1.2 Display of data storage media (Moby, also virtual Moby)

In case of machines having several processing stations, the content of the data storage medium shall be displayed on the user interface and be editable (only in user "Level 3"). When parts are removed, it must be possible to delete the data on the data storage medium.

9.1.3 Data acquisition

In case of machines having a superordinate control system or when data is transferred for a production data acquisition system / lot acquisition, the data shall be displayed.

9.2 Messages

Operation-relevant events occurring within the machine are displayed as messages and/or recorded. Messages are generally classified into error messages, warning messages as well as information messages. It must be possible to assign any message to display areas in order to - as regards the location of origin - only display the locally relevant messages. Recording (message buffer) of the messages shall be performed in an "archive". The archive can be selected via the control panel.

- Warning and error messages may only be sent to a superordinate system once when the malfunction occurs. Repeated sending of the message, without any action having taken place in the meantime, is not permitted.
- Message texts shall make sense and be informative such that they provide effective and specific information for troubleshooting even for a technically unversed person. The actual message cause shall be clear and self-explanatory.
- Messages shall only be generated or sent to superordinate systems during those operating modes for which they are relevant.
- Message texts which are intended for the machine operator shall generally be agreed upon with ETO.

Message texts shall at least contain the following information:

- Type of message
- Number of message
- Reference designator of the affected actuator/sensor according to the specifications, station number if applicable, also including home position/work position in case of runtime errors.
- Message text
- (If messages are recorded: date and time)

9.2.1 Information messages

Information messages serve to support personnel in operating the machine, e.g. "H010 Door 1 Dosing Station open".

In case of semi-automatic machines, the operator shall be informed by information messages about actions expected by the control system (operator guidance).

Key: Hxxx beginning with 001

Examples of information messages at ETO:

H001:	E0.2 Key switch "Doors bypassed" activated!
H002:	E0.3 Light curtain interrupted!
H003:	! Processing OK, Remove part!
H004:	! Processing NOK, Remove part!
H005:	Movement not permissible! (in case of bypassed doors, press enabling button)

9.2.2 Operator guidance in case of manual workstations or special procedures of linked lines

In case of linked lines, an operator guidance or selectable help texts on the user interface shall be provided to the operator for support.

9.2.3 Warning message

Warning messages serve to notify operating personnel of upcoming events and operating conditions.

Key: Wxxx beginning with 001

Example warning message texts at ETO:

W001:	Perform reference part run after x cycles
W002:	Xxx change after yyy welds
W003:	Lack of parts in feeder bowl xxx
W004:	Replace electrode! (Service life reached or type was changed)! Acknowledge!
W005:	<XX> more welds until next electrode replacement!
W006:	Electrode was removed from welding head! Acknowledge after re-installing of electrode!

9.2.4 Error messages

Error messages are messages which influence quality, quantity as well as directly or indirectly influence the machine. Error messages generally result in immediate machine stop.

Error messages will remain until the cause for malfunction has been eliminated and acknowledged (by acknowledging the malfunction, this message must not be sent to the superordinate system as "Error fixed" as long as the cause for malfunction has not been fixed).

Follow-up messages should already be suppressed in the control system in order to keep the number of messages manageable and thus maintain clarity of the error messages.

Key: Fxxx beginning with 001

Examples of error messages at ETO:

F001: Unlock EMERGENCY STOP push-button switch! Acknowledge EMERGENCY STOP!
F008: Light curtain intervention during procedure!
F012: Guard door(s) open
F013: Welding apparatus not ready!
F016: -203B6 Compressed air not available!
F017: Sequential control - Plate separation in step: <XX>
F033: Z2.3 -201B2 Plate feed - Holding cylinder rear closed does not report!
F034: Z2.3 -201B2 Plate feed - Holding cylinder rear closed always reports!
F035: Z2.3 -201B1 Plate feed - Holding cylinder rear open does not report!
F036: Z2.3 -201B1 Plate feed - Holding cylinder rear open always reports!

9.3 Parameter entry

All machine parameters and process parameters shall be adjustable and changeable via the user terminal.

Parameter entry of machine and process parameters shall be performed in a unit agreed upon with ETO and is described in the specifications sheet. (Normally the unit is selected according to customer requirements.)

Entries and changes of machine and process parameters shall be examined for plausibility by the software. A wrong or unintended entry must not cause destruction of parts or components.

Parameter changes may only be performed by qualified personnel by means of a password protected access authorization (see chapter Access Authorization).

Machine and process parameters shall remain stored after voltage breakdown. Machine and process parameters shall be stored in such a fashion that they can be secured by a data backup, if the control system allows this feature.

Axis positions shall be accessible and teachable via the control panel.

9.4 Displaying measured values / parameters

All measured values shall be displayed using the corresponding unit. The measured values shall be applied and displayed until a new processing cycle begins. The display includes the current value and the corresponding limits. NOK values shall be highlighted in red in the display. The location of display is agreed upon for the individual project.

9.5 Counters

Different types of counters shall be provided for the machine. The type and number of counters to be provided shall be as defined in the specifications sheet or as agreed upon with the project manager.

9.5.1 Total piece counter

The total piece counter counts the total number of production cycles. The total piece counter cannot be deleted. The storage size of the total piece counter shall be selected according to the number of pieces expected during the service life of the machine.

9.5.2 NOK counter

The NOK counter counts the number of NOK parts. One NOK counter shall be provided for every station or process. Depending on the type of machine, a feature-related NOK counter, a shift-related and/or order-related NOK counter may be required.

A parametrizable maximum limit (e.g. x of y parts, z parts in a row, etc.) of the NOK parts shall also be provided. As soon as this limit is reached, a suitable error or warning message shall be generated and/or the station having an error message stops when the maximum limit is reached.

The NOK counters can be deleted individually or altogether by pressing a key.

9.5.3 Order counters

The order counter counts the number of OK parts. In order to record the output of a process step, at least the last process step shall be provided with an order counter. If for further stations order counters are to be provided, this is described in the specifications sheet.

When the required number of pieces is reached, a message shall be generated saying that the order quantity is reached.

The order counters can be deleted individually or altogether by pressing a key.

9.5.4 Maintenance counters

For machine components subject to wear (e.g. die plates, laser protection glass, caulking devices, flanging tools, etc.) maintenance counters shall be provided. The maintenance counters shall be provided with editable warning and stop limits.

9.5.5 Other counters

If required in the specifications sheet, other counters shall be provided for display purposes.

9.6 Access authorization

All passwords shall be handed over to ETO. A password change may only be performed in the next higher level or by entering the active password. As a minimum, time and date of password change shall be archived.

Active password levels shall be automatically locked after 5 minutes without any use.

9.6.1 Password "Level 1"

Operator level

Access to unblocked functions is possible without entering a password.

Authorization for:

- Type entry and selection function (provide at least 12 digits of SAP material number)
- On a limited scale - reset function, e.g. home position run and error acknowledgment (i.e. it must be possible to run the machine to its home position in case of malfunctions)
- Reset function of good parts / bad parts counters.
- Operating modes "automatic mode", "Cycle end", "Run to empty", "Reference run"

9.6.2 Password "Level 2"

Adjuster level

Password protected

Authorization for:

- See level 1
- Parameter adjustments
- Operating mode "Set-up / manual mode", "Step mode"

9.6.3 Password "Level 3"

Software engineer level

Password protected

Authorization for:

- Everything is unlocked

9.7 Type selection, Type management

A type change may only be performed when the machine has been run empty. The maximum permissible duration for a type change is defined in the specifications sheet.

Type selection can be performed in 2 different ways:

- Manual selection via the display by entering or selecting the SAP material number. The set up tool set shall be examined.
- Automatic selection by means of identification of the set-up kit / interchangeable part. The set up SAP material number shall be displayed.

When performing a type change, the worker shall be notified of all expected actions (e.g. replace electrode, empty vibrating spiral conveyor).

All interchangeable parts shall be labeled and coded. Erroneously set up interchangeable parts shall lead to a machine stop and generate an error message in the display.

In case of linked machines, manual confirmation of the type change shall be possible, i.e. enforce a type change.

9.8 Order management (for linked machines)

Order management shall be provided. The order management shall at least comprise order number, type and quantity. When the specified OK quantity is reached, a signal is generated.

Additional information is given in the specifications sheet.

9.9 Lamp test

The user terminal shall be equipped with a lamp test function. This test serves to examine the function of the control lamps.

With a keystroke all control lamps are switched on. The lamps must be lit long enough for the operator to verify without any doubt that the lamps function properly.

10 Program structure

When writing the software program, the following issues shall be observed:

- Modular structure of the program.
- Independent machine components shall have individual modules and sequential controls.
- Comments shall be provided in all program segments in such a fashion that significance and function of the respective program segment is unambiguous and clear.
- The documentation of the program, symbols and comments shall be prepared in the following languages:

Production location	Language
Germany	German
Poland	German or Polish
U.S.	German or English
China	German, English or Chinese

10.1 Programming language

The program shall be written in STL, LAD or FBD.

10.2 CPU usage, cycle time

The size of the CPU shall be selected such that a maximum of 70% of the work memory and load memory is used. Also, the cycle time must not exceed 40ms.

10.3 Symbols

All variables used in the program (modules, flags, timers, inputs and outputs, counters, etc.) shall have a symbol and a suitable comment. Not commented program segments are not accepted.

The symbol shall represent the function of the variable.

10.3.1 Inputs / Outputs

The symbols for input and output shall be selected according to the reference designation in the circuit diagram. If this symbol is not unambiguous, it shall be supplemented by the terminal or connector designation and the pin number. The symbol comment clearly describes the function of the symbol. The symbol comment should be consistent with the circuit diagram comment.

Compound words always start with a capital letter.

Example:

Symbol	Operand	Unit	Symbol comment
S00.01	E0.4	BOOL	Compressed Air OK
A30_X1:13	E0.5	BOOL	Station 2 X-Axis Enable
A35_X3:5	EW100	WORD	Station 2 Precision Probe Height of Stroke

A30_X1:13 means: Pin 13 on Terminal Block X1 on Controller Module A30

10.3.2 Modules

The modules shall each have a symbol as well as a comment clearly describing the function, e.g. Dose_silicone_AUTO functional module "Dosing - Automatic Sequential Control".

10.3.3 Internal variable

Each variable shall be given a sensible, symbolic name and have a meaningful comment (reference to the function).

Areas for flags, timers, etc. shall be assigned on a module basis, i.e. no overlapping of different stations or machine parts must occur.

10.4 Program structure

10.4.1 Modules

Every module shall have a module header indicating the following information:

- Module function
- Module writer
- Date of issue
- Last authorized user
- Last processing date including reason for change(s)

Every network shall be given a network comment clearly indicating the function of the network. In addition, readability of the program shall be improved by line comments.

The size of the network shall be selected such that a clear arrangement of the elements is ensured in case of a diagnosis. Individual functional program segments shall be distributed to individual networks.

Unneeded program codes shall be deleted. Infinite loops in the program are not permissible. Commenting out or jump instructions must not be used to omit unneeded program codes.

Locked functions or function modules are not permissible.

10.4.2 Sequential controls

The sequence control shall be programmed as a clear step sequence. Every step shall be commented as regards its function. The individual steps shall be monitored by means of timeouts. A non-available step enabling condition shall cause an error message after the end of the monitoring time (sequential control timeout).

10.4.3 Analog value processing

Analog values shall generally be normalized to the measured physical value. In the program and on the user interface only the normalized value shall be used. Normalization shall be evaluated using suitable measuring equipment. The measured values shall be displayed in the control panel including units and set limits.

10.4.4 Variable for start up

For testing and start-up purposes a "LOG0" and "LOG1" flag shall be implemented in the program. "LOG0" means continuously low level, "LOG1" means continuously high level.

10.5 Change documentation

In the first completed module (OB1, Main ...) the change record of the project shall be documented in the first network or first lines. During software programming and start-up the respective software change records at the time of acceptance testing shall be documented. During series production all changes shall be documented.

The following information shall be documented:

- Authorized user
- Date
- Name of backup file
- Changed modules
- Changed image in HMI
- Reason for change

11 Gripper / actuator query

The position of grippers and cylinders shall be queried using sensors.

In case of grippers, at least home position and gripped part shall be monitored.

Gripper open = home position

Gripper closed with part = work position

Gripper closed without part = no signal / possibly 3rd signal

In case of cylinders querying of home position and work position is generally sufficient.

12 Field bus systems

The use of ProfiNet systems as field bus systems is preferred at ETO. The use of different field bus systems is possible according to the specifications sheet or after consultation of the technical department. All machine components and additional equipment available by ProfiNet shall be addressed by means of a ProfiNet interface.

12.1 Addressing the bus stations

Addressing the bus stations shall be performed in a logic manner. Templates are available at the responsible technical department.

12.2 Reaction in case of ProfiNet network malfunction or bus station failure

It must be ensured that an uncomplicated and fast diagnosis of the cause for malfunction can be performed by means of diagnosis modules. A visual error description including the type of malfunction and station address is mandatory. If technically feasible, initialization and parametrization of exchanged or replaced assemblies shall be performed automatically by the program.

13 Process control system

The requirements for the process control system are described in the specifications sheet.