

Technical Specifications for Production Lines Machines & Equipment

embraco POWER **IN.**
CHANGE **ON.**

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1. Objective

This Industrial Corporate Technical Standard, henceforth in this document just Corporate Standard, establishes the required conditions to be complied by the Suppliers of machine and equipment, from the offer elaboration up to the end of the warranty for the machine/equipment.

For the application of the known and recognized International Standards, it has become necessary for EMBRACO:

- to explain or complete certain recommendations;
- to make choices when several options are proposed.

Thus, this Corporate Standard must ALWAYS be followed whenever a new project starts and it is necessary to buy or to modify a machine or equipment. This specification applies to all machine/equipment delivered to EMBRACO. Any deviations to this should be clearly specified and agreed upon. If not, this specification is valid for the delivery.

This Corporate Standard is the property of EMBRACO. It's proprietary and confidential and is being disclosed in confidence to Supplier. Any Supplier receiving this Corporate Standard is required to hold and use them for the **SOLE BENEFIT** of EMBRACO. Supplier shall not disclose, use, alter or reproduce this Corporate Standard, or perform any act adverse to EMBRACO's interest, without the express written consent of EMBRACO.

Accepting the order means to respect all the specifications included in this document.

EMBRACO reserves the right to reject any machine or equipment which does not conform to this document.

2. Definitions / Abbreviations / Complementary Documents

2.1. Definitions

a) Supplier - Manufacturer

It means any physical or moral person handling an order, which it acts designs, manufactures, assembles, service providers, subcontractors or supplies machine and equipment.

b) Implementation

Introduction of a machine and equipment in the manufacturing process after its development and the general agreement among the areas involved with the machine and equipment utilization.

c) Element

The element field represents a decomposition of the component structure, which means the minor parts of the machine structure.

In this case, all parts of the component are exploded and separately disposed as single elements.

Examples: screws, nuts, cables, balls from bearings/ball screws, sealing, washers, belts, etc.

d) Component

Components do technical function like move, detect or control etc. It is in the Bill of Materials level where preventive maintenance is normally done, or can be replaced at a breakdown intervention.

Examples: Pump, sensor, filters, electric motor, cylinder, gearbox, etc.

e) Equipment

It is an individual, physical object that is to be maintained as an independent unit to track maintenance cost and technical history. Equipment is basically a single system, sub-system, a set of components or sometimes even a single component that fulfill a function, depending on the required application.

Examples: conveyor, hydraulic unit, positioning unit, pneumatic system, safety system, inspection system, a driving system, etc.

f) Section

Section is a direct subdivision of a machine, being in fact a submachine from the main machine. It fulfills a Process Step or handles a function for the superior Whole Main Machine. Sections are created only if it is really necessary to decompose the Main Machine to a lower level.

Examples: unwinder, straightener, frame, common hydraulics, main cabinet, common safety, discharge conveyor, etc.

g) Machine

It is a complete main production machine or a main stand alone auxiliary unit. It is an assembly of machines arranged and controlled so that they function as an integral unit. In fact it's a complex unit in a superior level of a hierarchy, integrated by a set of single equipment pneumatically, electrically and/or hydraulically powered or controlled, used in or necessary for, manufacturing processes and assembly operations.

Examples: Press, Transfer, Winding, Crane, Dryer, Crimping, Furnace, Assembly lines, Milling machines, etc

h) Instruction Handbook

It is an integral part of the machinery and is comprised of all the necessary documentation for assembly, use, adjustment and maintenance, according to the Machinery Directive 2006/42/EC item 1.7.4.

i) Cpk

Capability Process Index, Cpk is an index (a simple number) which measures how close a process is running to its specification limits, relative to the natural variability of the process. The larger the index, the less likely it is that any item will be outside the specifications, meaning the measure of Robust Design. It is based on long-term studies in normal production activities, expressing the process real capability.

j) Cmk

Machine Capability Index, that means a metric for the capability of production machinery to produce units within specified tolerances of quality, based on short-term surveys of continuous production runs, thus no time is left for special cases to act. The Machine Capability Index, once calculated, can be used to plan longer-term production runs, and can also be used to measure the effectiveness of process improvement efforts.

2.2. Abbreviations

- a) ABNT - Brazilian Association for Technical Standardization
- b) ACGIH - American Conference of Governmental Industrial Hygienists
- c) ANSI - American National Standards Institute
- d) ASTM - American Society for Testing and Materials
- e) ATEX - Equipment and protective systems intended for use in potential Explosive Atmospheres (it comes from French)
- f) CE – Conformance Europeene (French)
- g) CNC – Computer Numerical Control
- h) CTQ – Critical to Quality
- i) DC – Direct Current
- j) DHCP – Dynamic Host Configuration Protocol
- k) DIN - German Institute for Standardization
- l) EC – European Commission
- m) EEA - European Economic Area
- n) EHS – Environment, Health and Safety
- o) ELD - Electrical Drawing

- p) EMC – Electromagnetic Compatibility
- q) EN - European Standardization Committee
- r) ESHR's - Essential Health and Safety Requirements
- s) EU - European Union
- t) HMI – Human Machine Interface
- u) IEC - International Electro-technical Commission
- v) INM - Installation Manual
- w) ISA – International Society of Automation
- x) ISO - International Organization for Standardization
- y) IT – Information Technology
- z) LVD – Low Voltage Directive
- aa) MCM – Machine Manual
- bb) MD – Machine Directive
- cc) MES - Manufacturing Execution System
- dd) MRC – Master Control Relay
- ee) MTB/NR - Labor Ministry/Brazilian Regulating Standards
- ff) MTM - Maintenance Manual
- gg) NAS – National Aerospace Standard
- hh) NBR - Brazilian Registered Standard
- ii) NFPA – National Fire Protection Association
- jj) NPT - American (National) Standard Taper Pipe Thread
- kk) ODBC – Open Database Connectivity
- ll) OPM - Operation Manual
- mm) PC – Personal Computer
- nn) PLC – Programmable Logic Controller
- oo) RCD – Residual Current Device
- pp) SPL - Recommended Spare Part List
- qq) TCO – Total Cost of Ownership
- rr) TCP/IP – Transmission Control Protocol/Internet Protocol
- ss) TF – Technical File
- tt) TNS System – 5-core System with separate N-(Neural) and PE-(Earth) conductors
- uu) UPS – Uninterruptible Power Supply

2.3. Complementary Documents

2.3.1. Internal Documents

PGE 009105 (old PGE 01259) - Process Certification

SOP 000979 (old ILM 02036) - Certification of Geometrical Control

SOP 009382 (old POP 00270) – Creation of projects - EMBRACO standard

SOP 011593 (old TRM 009122 and PGE 00773) - Safety Standards for Service Rendering Companies (Only in Portuguese version)

TEM 000329 (old POP 00160) – Data Sheet for Equipment Installation, Registration or Reallocation

TEM 001077 – Recommended Preventive Maintenance Plan

TEM 001078 – Recommended Spare Part List

TEM 001079 – Recommended Standard Preventive Maintenance Procedure

TEM 004823 – PMCT_Machine Decomposition and Ledger

TOL 000098 – Help Chain Operational Flow

TRM 001982 – LCCA - Life Cycle Cost Analysis

TRM 003608 - ELS 4 Help Chain Training

TRM 003613 – Criteria to trigger help chain

TSS 002470 – Characteristic Classification

TST 00000034 (old PTE 00001) - Metallic Surface Preparation and Painting

TST 000067 + TEM 000840 (old EHS Manual) – Safety, Health and Environment

TST 000139 - Color standardization of equipment and mark

TST 00507479 – PMCT_Factory's Installation Tree Structure

2.3.2. External Documents

2004/108/EC - Electromagnetic Compatibility Directive

2006/42/EC - Machinery Directive

2006/95/EC - Low Voltage Directive

94/9/EC – ATEX Directive

97/23/EC – Pressure Equipment Directive

ABNT NBR 10068 – Drawing sheet – Layout and Dimensions – Standardization

ABNT NBR 17094 – Rotating electrical machines – Induction motors

ABNT NBR IEC 60034-7 - Rotating electrical machines – Part 7: Classification of types of construction, mounting arrangements and terminal box position

ANSI B11.19 - Performance Requirements for Safeguarding

ANSI/NFPA 79 - Electrical Standard for Industrial Machinery

ANSI/RIA R15.06 - Industrial Robots and Robot Systems - Safety Requirements

DIN 116 - Driving Elements; Flange Couplings, Dimensions, Torques, Speeds

DIN 2217 - Driving Elements; V-belt Pulleys; Dimensions, Material

DIN 2353 - Non-soldering compression fittings with cutting ring - Complete fittings and survey

DIN 24340-2 – Hydraulic valves; mounting surfaces and connecting plates for directional control valves

DIN 43650 – Solenoid valve connectors

DIN 51502 - Designation of lubricants and marking of lubricant containers, equipment and lubricating points

DIN 740 - Power transmission engineering; flexible shaft couplings; technical delivery conditions

DIN 8187 - Chain wheels for roller chains as specified; dimensions

DIN 8651 - Machine tools; straight sided power presses; acceptance conditions

DIN ISO 1219 Fluid power systems and components - Graphical symbols and circuit diagrams

DIN ISO 5170 – Machine tools; lubrication systems

DIN VDE 0470 - Sealing washers

DIN-VDE- 0530 - Rotating electrical machines

GB 50231 - General Code for Construction and Acceptance of Mechanical Equipment Installation Engineering

GB 50235 - Code for construction of industrial metallic piping engineering

GB/T 14689 - Technical Drawing - Size and layout of drawing sheets

IEC 60034 - Rotating electrical machines

IEC 60034-1 – Rotating electrical machines – Part 1: Rating and performance

IEC 60034-14 - Rotating electrical machines - Part 14: Mechanical vibration of certain machines with shaft heights 56 mm and higher - Measurement, evaluation and limits of vibration severity

IEC 60034-30 - Rotating electrical machines - Part 30: Efficiency classes of single-speed, three-phase, cage-induction motors (IE-code)

IEC 60034-7 - Rotating electrical machines – Part 7: Classification of types of construction, mounting arrangements and terminal box position

IEC 60034-7 - Rotating electrical machines – Part 7: Classification of types of construction, mounting arrangements and terminal box position

IEC 60034-9 - Rotating electrical machines – Part 9: Noise limits

IEC 60072 - Dimensions and Output Series for Rotating Electrical Machines

IEC 60073 – Basic and safety principles for man-machine interface, marking and identification

IEC 60204-1 - Safety of machinery - Electrical equipment of machines - Part 1: General requirements (EMBRACO's Electrical Bible)

IEC 60364-5 - Electrical installations of buildings - Part 5: Selection and erection of electrical equipment

IEC 60529 – Degrees of Protection Provided by Enclosures (IP classes according to EN 60529)

IEC 60947 - Low-voltage switchgear and control gear

IEC 60947-4-1 - Low-voltage switchgear and control gear – Part 4-1: Contactors and Motor - Starters

IEC 61000-4-5:2006 - Electromagnetic compatibility (EMC) Part 4-5: Testing and measurement techniques - Surge immunity test

IEC 61000-6-2:2005 Electromagnetic compatibility (EMC) Part 6-2: Generic standards - Immunity for industrial environment

IEC 61000-6-4:2007 Electromagnetic compatibility (EMC) Part 6-4: Generic standards - Emission standard for industrial environment

IEC 61310 – Safety of machinery – Indication, marking and actuation

IEC 61310-1 – Safety of machinery – Indication, marking and actuation - Part 1: Requirements for visual, acoustic and tactile signals

ISA 99 - Industrial Automation and Control Systems Security

ISO 12100:2010 Safety of machinery: General principles for design. Risk assessment and risk reduction

ISO 1219-1 - Fluid power systems and components - Graphical symbols and circuit diagrams - Part 1: Graphical symbols for conventional use and data-processing applications

ISO 1219-2 - Fluid power systems and components - Graphical symbols and circuit diagrams - Part 2: Circuit diagrams

ISO 16528 – Boilers and Pressure Vessels

ISO 17398 - Safety colours and safety signs - Classification, performance and durability of safety signs

ISO 1940 - Mechanical vibration - Balance quality requirements for rotors in a constant (rigid) state

ISO 23309 - Hydraulic fluid power systems - Assembled systems - Methods of cleaning lines by flushing

ISO 4021 - Hydraulic fluid power - Particulate contamination analysis - Extraction of fluid samples from lines of an operating system

ISO 4401 - Hydraulic fluid power - Four-port directional control valves - Mounting surfaces

ISO 4406 - Hydraulic fluid power - Fluids - Method for coding the level of contamination by solid particles

ISO 4413 – Hydraulic fluid power – General rules and safety requirements for systems and their components

ISO 4414 - Pneumatic fluid power - General rules and safety requirements for systems and their components

ISO 5294 - Synchronous belt drives - Pulleys

ISO 5296 - Synchronous belt drives - Belts with pitch codes MXL, XXL, XL, L, H, XH and XXH - Metric and inch dimensions

ISO 5457 - Technical product documentation - Sizes and layout of drawing sheets

ISO 6020/2 - Hydraulic fluid power - Mounting dimensions for single rod cylinders, 16 MPa (160 bar) series- Part 2: Compact series

ISO 606 - Short-pitch transmission precision roller and bush chains, attachments and associated chain sprockets

ISO 7731 - Ergonomics - Danger signals for public and work areas - Auditory danger signals

ISO 8201 – Acoustics – Audible emergency evacuation signal

ISO 8434 - Metallic tube connections for fluid power and general use - Part 1: 24 degree cone connectors

ISO/DIS 13850 – Safety of Machinery – Emergency Stop Function – Principles for Design

NAS 1638 – Contamination Limits

NBR 10.068 - Drawing - General principles of presentation

NBR 10.272 - Non-destructive testing — Vibration analysis — Assessment and measuring of rotating electrical machines mechanical vibrations

NBR 5410 - Low voltage electrical installations

NBR 8896 - Graphic symbols - Fluid power systems and components - Basic and functional symbols – Symbolology

NR 13 – Boilers and Pressure Vessels

3. General Conditions

3.1. Project Coordinators

EMBRACO must designate a coordinator for the project and the Supplier as well. These coordinators will be responsible for all the future negotiations involving the project.

3.2. Standards and/or Regulations

Even if it is not specified at this document, it must be respected all decisions, laws and technical standards available on the date that the machine and/or equipment were purchased. Some of those standards, laws, directives or anything else can be quoted explicitly in the orders, but their quotations do not cancel the application of the others.

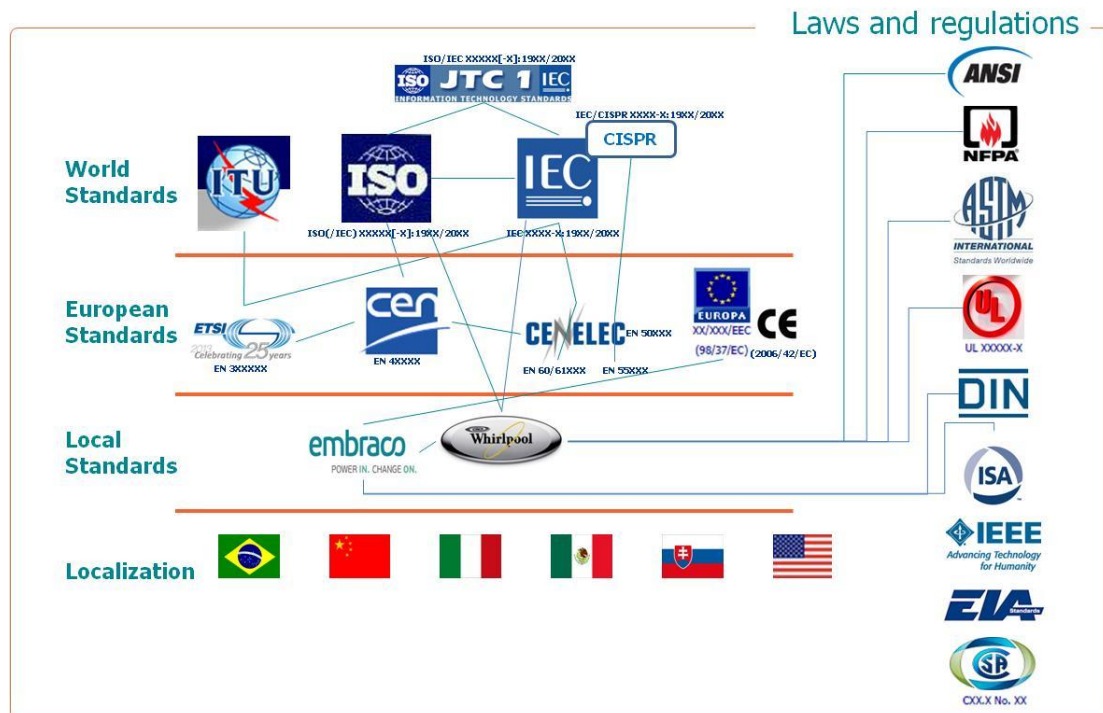
It is essential that everyone responsible for the design and construction knows how to satisfy the requirements of all the applicable directives concerned, preferably by employing Suitable Standards which detail the Limits/Methods, i.e. the EMBRACO Corporate Standards. They must also have a good knowledge of any standardization work in progress. The Supplier should participate in European, International and National standardization works. The Supplier must keep track of the progress and of useful standards.

EMBRACO demands the use of Standards to comply with the Legal Requirements.

Suitable Standards can belong to one of several groups:

- ✓ Harmonized European Standards: are standards with a formal connection to the relevant directive. Harmonized standard provides a presumption of conformity with the requirements, but it in fact does not necessarily cover all the requirements;
- ✓ International or National Standards: These standards may contain additional provisions. They have a high status because of their origin, being regarded Standard Authorities such as ISO (the International Organization for Standardization) and the IEC (the International Electrotechnical Commission). Also there are occasions where the National Standards, meaning country-related Norms, demand compulsorily to be followed, as country-legal Requirement, and thus it is necessary to overrule other defined requirements, but only allowed to do it after a thorough evaluation of pros and cons of such and each derogation. This maneuver is called Localization of Requirements;
- ✓ EMBRACO Corporate Standards: interpret and transpose the above standards. The Corporate Standards may have stricter requirements than external standards. This is due to guarantee alignment between machines and to facilitate interconnection of

them on site, with a significant effect on the final operating modes of the machines and equipment, which may avoid the undesired results in a diversity of machines and equipment, detrimental to the efficient running of our facilities. For example a Corporate Standard may select just one out of several options to achieve a specific function or requirement.



There may be some exceptional cases where a standard applies to an application but for some reason a specific requirement in the standard cannot practically be applied, as the Localization case example. The reason in this exceptional case for not applying the requirement of the standard shall be justified in the Technical File. The standard shall in this case not be listed on the Declaration of Conformity.

Technical Files or TF are documents that provide evidence of a safe and reliable machine and need sometimes to be accessed by an authority, a customer or by a market company.

EMBRACO may request the Supplier to show or submit the documents to satisfy themselves that the machine/equipment is really safe and reliable.

If special standards or Supplier's standards are needed, these must be submitted in writing in advance for review, comments and approval by the leadership of the Maintenance Area involved.

The International or National Standards and/or any Regulations mentioned in this Corporate Standard will not be supplied by EMBRACO and must be obtained from the respective association, except for specific EMBRACO's Instructions and Standards.

Standard Code	Part	Revision	Confidentiality	Date	Creator Name	Approver Name	Responsible Area
TST 000138	GL0	04	Public	29/01/2015	Edson P. Ferreira	Sergio Maganhoto	Corporate Assets

3.2.1. Maintenance Safety Strategy

EMBRACO Machines and Equipment shall not endanger the health or safety of persons when properly installed and maintained, and used for their intended purpose in accordance with the information for use provided.

All the Machines and Equipment to be installed in EMBRACO Plants shall be adequately safe and reliably designed in accordance with the **European Machinery Directive Annex 1**.

The concept of "Maintenance Safety" considers the ability of a Machine and Equipment to perform with highest reliability its intended function(s) during its lifecycle where risk has been adequately reduced. In summary any Machine and Equipment to be provided to EMBRACO must be Safe and Reliable at maximum levels agreed.

3.2.2. Regulatory Compliance

Individual Machines and Equipment shall comply with applicable regulations, laws and standards. All individual Machines and Equipment shall be **CE Marked** under the applicable European CE marking directives.

Main applicable European directives and regulations are listed as follows, but not limited to:

- ✓ Machinery directive (MD) – 2006/42/EC;
- ✓ Low voltage directive (LVD) – 2006/95/EC;
- ✓ Electromagnetic compatibility directive (EMC) – 2004/108/EC;
- ✓ Noise directive – Check EHS Manual TST 00067;
- ✓ Pressure equipment directive (PED) – 97/23/EC; and
- ✓ ATEX directive (EXplosiveATmospheres) – 94/9/EC.

The integration of individual Machines and Equipment (for example in Transfers and Assembly Lines) shall comply with applicable regulations and standards. When placed in the EMBRACO Plants, the integrated Machines and Equipment shall be CE marked where they constitute a Machine as defined in the Machinery Directive.

Machines for incorporation into other machines are not CE marked as individual products. They shall be included and CE marked in the integration when placed in the EMBRACO Plants.

National legislation, according to the respective Localization rules, applies to machines and equipment placed on markets outside the EEA - European Economic Area. Despite of that, in most of the cases complying with the EU Directives also cover all those Localized requirements, thus EMBRACO has chosen to be in compliance firstly with European CE marking directives along with the other applicable regulations and standards.

Therefore, where other requirements than the **EU Directives** and the ones indicated in this **Corporate Standard** should be complied with, this formal agreement should be indicated in the **purchasing order**, see Section 3.3 (Purchasing).

3.2.3. Declaration

The European Directives require a "Declaration of Conformity" to be signed before CE marking any machine/equipment, thus such document shall be delivered to EMBRACO upon Machines and Equipment delivery.

The Machinery Directive, Pressure Equipment directive and ATEX require the declaration to accompany the Machines and Equipment. The EMC directive and Low Voltages directive do require a declaration to be signed but not that it accompany the Machines and Equipment. The EMBRACO version of declarations to be received shall include the EMC and Low Voltage directives, besides Noise directive as well. Any other important and not mentioned directive shall also be included.

It is the "Declaration of Conformity" that shows which directives the machine/equipment complies with, not the CE mark.

The Machinery Directive also has a "Declaration of Incorporation". This declaration is aimed for machines to be incorporated into some other machine, machines by definition but not safe until it has been incorporated. It may for example use the guards from the machine where it is incorporated. The applicable Essential Health and Safety Requirements (ESHR's), from Machinery Directive 2006/42/EC, of the final machinery with the incorporated machinery have to be fulfilled.

Determination of Conformity enables the **Supplier** to list:

- conformity or non conformity of each of the International Standards headings in relation to the required specifications;
- for each non conforming heading, the corrective solution proposed and also its completion date, and even the person responsible for the action;
- derogations relating to the contract.

3.2.4. Responsibility

The Manufacturer of an individual Machine and Equipment is responsible for its compliance with the relevant regulations and standards. The Manufacturer is responsible under the New Approach directives for the design and construction of their machine/equipment. The responsibility includes keeping the Technical File available for competent authorities, signing the Declaration of Conformity and affixing the CE mark. Some of these tasks may be delegated in writing to a

representative. Procedure for delegation and Power of Attorney shall be established within each organization.

By signing a “Declaration of Conformity” or a “Declaration of Incorporation”, the Manufacturer, his Authorized Representative within the EEA or the Importer declares the machine/equipment is in conformity with applicable directives. He or she also ensures and guarantees that certain technical documentations are and will be available for any competent national authorities for inspection purpose.

In the other side, the Integrator, for example of individual products in Transfers or Assembly Line, is responsible for its compliance with the relevant regulations and standards.

EMBRACO in this sense is just responsible for the contents and updating of the Corporate Standards, respecting the scope limits.

Responsibility regarding translation shall be also considered and detailed in the “General Conditions” term, but rather from the **Purchase Agreement Process**, see Section 3.3 (Purchasing), for ordering and delivery agreements. Translations into official language(s) of the country, the machines and equipment are going to, must be provided by the manufacturer or his authorized representative, see Section 3.7.1. Normally the Manufacturer has to accept liability over that and therefore take care that original instructions are faithfully reproduced in the desired language.

EMBRACO audits Supplier during Manufacturing of Machines and Equipment, on request or according to the project progress, regarding compliance with directives, regulations and standards.

The Supplier together with EMBRACO’s specialist support is responsible for the “Interpretation” of directives, regulations and standards.

3.3. Purchasing

The Supplier shall include in the **Offer**, a chapter informing all the requirements regarding “General Utilities” related to its specific Machine and or Equipment being targeted of the proposal. It means to detail all the demanded “Utility Connections” and “Consumptions” to its Machine and or Equipment, like Electrical Energy, Compressed Air, Water and so on, so as to get an adequate working condition. For example: the Electrical Voltage and Consumption for Welding Machines, Ovens, etc. That information of the utilities points with their estimated values of consumption shall be outlined by the supplier, but not limited to, by filling out the TEM 000329 – Data Sheet for Equipment Installation, Registration or Reallocation, in the respective part of the mentioned template. The EMBRACO’s Technical Specifications for Utilities and Supplies are in the Section 3.5.

The "Purchasing Agreement Specification" or any document being considered as technical considerations in the Purchase Order is an important document also in relation to machine and equipment safety and reliability.

Everyone in the trade chain has a responsibility for the supply of safe and reliable machines and equipment. The purchaser, which means EMBRACO, has, by means of suitable inspection procedures etc, to ensure himself that the Supplier complies with the "Purchasing Agreement". The Purchasing Agreement should state what directives and all other regulations, as applicable, the purchased machine and equipment is supposed to comply with, see Section 3.2, and that the Technical File shall be shown on request. It is especially important to distinguish between machines for incorporation and machines ready for use. Machines for incorporation shall not be CE marked under the machinery directive while machines ready for use shall be CE marked. The integrated machine together with its interface with the existing machine shall be CE marked under the machinery directive by the integrator. The integrator is responsible for the integration while the machine manufacturer remains responsible for the machine under the product liability directive. For machines and equipment purchased from a non EEA country, the purchaser has to ensure the Supplier is able to provide TF documents if requested by an authority. A suitable means of inspection procedure is for example performing an audit on the Technical File. To ensure the Supplier agrees to disclose his TF, this has to be included in the "Purchasing Agreement". Together with the Supplier, EMBRACO shall walk through the Technical File documents to ensure the documents:

- ✓ Are of suitable quality;
- ✓ Are traceable;
- ✓ Risk assessment is performed;
- ✓ Safety measures are implemented;
- ✓ Remaining risks are indicated in the instructions; and
- ✓ a Conformity Declaration of Incorporation is signed.

It is also recommended to briefly review the machines and equipment to assess how safety has been implemented, by then. To determine the Safety Performance Level for every Safety Function see EHS Manual TST 000067.

When purchasing equipment, which may be considered as a component or an apparatus, for instance printed circuit boards, state in the agreement if it should be regarded as an apparatus and thus CE marked under the Low Voltage directive (LVD) and/or the EMC directive.

This Corporate Standard has to be given to the machines and equipment's Supplier, when EMBRACO requires an offer, to let the Supplier writes down the supply description keeping in mind

the whole EMBRACO specification. A copy of this Corporate Standard, which means the version agreed upon, has to be countersigned by the Supplier for Acceptance and may return to the purchaser on delivery of the offer and in any case before purchase order issuing by EMBRACO. Possible derogations have to be previously required in formal way by the Supplier and approved in the same formal way by EMBRACO.

The present General and Technical Conditions are integrative parts of the purchase order, thus the best scenario is: the Supplier, after having signed it for Acceptance, returns it to EMBRACO, before making the offer.

3.3.1. Contractual Accomplishments

3.3.1.1. Delayed Delivery

It is agreed that, in case of "supply" delivery delay (also only partial), a penalty will be applied. The exemption expiration at the end of delivery and the penalty amount applied after that expiration will be agreed and indicated on the Purchase Order. Whether indications are missing, the following information will be taken into account:

For "supply", we mean the complete machine and equipment including all the technical documentation, with particular reference to the **Instruction Handbook**, see Section 3.7.3, as well as foreseen certifications and marks, if required.

- ✓ Exemption: The penalty will be applied after 15 days from expiration of delivery terms;
- ✓ Penalty: The penalty amount will be calculated on the basis of a weekly increase each equal to 0,5% of the amount agreed of the supply, until a maximum of 5% of the agreed amount of the same one;

3.3.1.2. Purchase Order Acceptance

When the purchase order is accepted, it means that the Supplier accepts the purchase order in all its parts, including purchase General and Technical Conditions of this Corporate Standard, except the formal agreed derogations related to the contract.

3.3.1.3. Confidentiality Agreement

The Supplier shall undertake in formal way not to divulge to third party the technical characteristics included in this Corporate Standard, all the components applied, the machining systems and any other of our processing methods or any relevant information that the Supplier receives, whether by documentation or relationships among the Supplier and EMBRACO.

3.3.1.4. Use of Inventions Placed under Patent

EMBRACO places to the Supplier a great stress on the illegal use, during the machine and/or equipment manufacturing, of inventions that are under patent. If it does occur, EMBRACO reserves itself to take legal steps towards the Supplier in order to safeguard the due proper rights.

3.3.1.5. Copyright

If the project of the Machine and/or equipment was executed by EMBRACO, the drawings, any documents and invention contents will be uniquely and exclusively property of EMBRACO. The total or even partial reproduction as well as the disclosure of any of such materials to third parties is expressly prohibited.

3.3.1.6. Schedule

Upon the Purchase Order confirmation for Acceptance, the Supplier shall also send to EMBRACO the Planning agreed and properly updated. Unless otherwise agreed and indicated on the purchase order, this Planning has to be monthly updated. EMBRACO reserves the right to verify, at the Supplier facilities, the progress of the work.

3.3.1.7. Training, Commissioning and Start-up

The modalities concerning the training approach, as well as duration and place, must be previously agreed, see Section 3.10.

The instructions and trainings of EMBRACO's personnel by the Supplier, for the maintenance, adjustment and for operation under the desired conditions, including safety, have to satisfy the laws, regulations, standards and technical specifications in force.

In particular, the Supplier has to support by documentary evidence that the training has been held successfully, indicating the participant names and also the knowledge acquired by those ones.

The machines and equipment Commissioning, Start-ups, Inspection Tests and Training, are to be understood, however it should be included in the total price of the supplies, but to be negotiated previously.

3.3.1.8. Warranty

The warranty beginning will be subject to the approval of the final Acceptance by EMBRACO's engineers, according to Section 3.11. The warranty will be agreed and indicated on the Purchase Order. The warranty minimal time required is described below:

- ✓ 12 months for mechanical parts; and
- ✓ 12 months for electric and electronic parts, unless otherwise previously agreed.

3.4. Use of Components

- a) All the homologated manufacturers and brands of machine and equipment's components are defined from the Section 6.2 on, so as to limit the unnecessary and uneconomical diversity of components in the respective site from EMBRACO. The preferable components to be used in the project are the ones listed in the First Choice Brand Column of the respective tables. The use of components placed in the Second Choice Brand Column shall be previously justified and agreed with the leadership of the respective Maintenance area involved, which the machine and/or equipment are to be delivered to, just to avoid any unexpected and unpleasant outcome afterwards. The use of components that are not homologated by EMBRACO shall be previously authorized in writing by the leadership of the respective Maintenance area involved. The component lists in the Annexes are divided by each different country, site, thus it must be paid special attention to the component list to the respective country, site it belongs to.
- b) Components obsolete or in the process of obsolescence, recognized by its manufacturers, shall not be used in services for EMBRACO under penalty of replacement without charge for EMBRACO.

3.5. Utilities / Supplies

The EMBRACO's responsible for the Process, Machine and/or Equipment involved in the Project applying this Corporate Standard, shall remind the Supplier about including all the demanded "Utility Connections" to its Machine and/or equipment, in the **Offer**. See Section 3.3.

EMBRACO will specify any additional details required to meet specific facility constraints and requirements. The machine and/or equipment supplied must comply with the following conditions:

a) For Brazil:

UTILITIES AVAILABLE AT EACH RESPECTIVE EMBRACO SITE:		RELATED TO		BRAZIL
a) Compressed air:		f) Industrial Water:		
Low pressure compressed air	5.0 bar \pm 0.5	Industrial Pressure / Temperature	2.0 bar at 30 °C	
High pressure compressed air	15.0 bar	g) Drinking Water:		
b) Steam:		Drink Pressure / Temperature	3.5 bar at 25°C	
Pressure	6.0 bar	h) Oil:		
c) Natural Gas:		Cooling oil	5.0 bar at 30 °C	
Pipeline	2.0 bar at 30 °C	Cutting oil	5.0 bar	
Heat power	9065 kcal/Nm ³	Burnishing oil	4.0 bar	
d) Cooling water:		Grinding oil in the generation point	5 \pm 0,5 bar	
Maximum pressure in the pipeline	3.0 bar	i) Filters:		
Return pressure	1.5 bar	Grinding machine	40µm	
Speed	2 to 3 m/s	Buffering (polishing)	5µm	
Feeding temperature	29.5 to 30 °C	j) Power supply:		
Return temperature	35 °C (maximum)	Grounding System	TN-S	
e) High Temperature Water:		Voltage Levels	220-Single Phase and 380-Three Phase	
Input pressure	TBD	Frequency	60 Hz	
Feeding water temperature	TBD			
Return water temperature	TBD			

b) For Mexico:

UTILITIES AVAILABLE AT EACH RESPECTIVE EMBRACO SITE:		RELATED TO		MEXICO
a) Compressed air:		f) Industrial Water:		
Low pressure compressed air	7.0 bar \pm 0.2	Industrial Pressure / Temperature	2.0 bar at 30 °C	
High pressure compressed air	18.0 bar \pm 0,5	g) Drinking Water:		
b) Steam:		Drink Pressure / Temperature	3.0 bar at 25°C	
Pressure	7.0 bar	h) Oil:		
c) Natural Gas:		Cooling oil	5.0 bar \pm 0.5 at 30 °C	
Pipeline	2.0 bar at 30 °C	Cutting oil	5.8 bar	
Heat power	36.5 MJ/m ³	Burnishing oil	4.4 bar	
d) Cooling water:		Grinding oil in the generation point	5.6 bar	
Maximum pressure in the pipeline	4.5 bar	i) Filters:		
Return pressure	1.5 bar	Grinding machine	34 g/m2	
Speed	2 to 3 m/s	Buffering (polishing)	51 g/m2	
Feeding temperature	30 °C	j) Power supply:		
Return temperature	35 °C (maximum)	Grounding System	TN-S	
e) High Temperature Water:		Voltage Levels	127-Single Phase 220-Two Phase 277-For lighting 480-Three Phase	
Input pressure	6 Kg/cm ²	Frequency	60 Hz	
Feeding water temperature	115-120 °C			
Return water temperature	80-90 °C			

c) For China:

UTILITIES AVAILABLE AT EACH RESPECTIVE EMBRACO SITE:		RELATED TO	CHINA
a) Compressed air:		f) Industrial Water:	
Low pressure compressed air	6.5 bar \pm 0.5	Industrial Pressure / Temperature	3.0 bar at 20 °C
High pressure compressed air	18.0 bar \pm 0.5	g) Drinking Water:	
b) Steam:		Drink Pressure / Temperature	3.0 bar at 20 °C
Pressure	5.5 bar \pm 0.5	h) Oil:	
c) Natural Gas:		Cooling oil	TBD
Pipeline	10 KPa at 20 °C	Cutting oil	4.8 bar
Heat power	Min: 8400 kcal/Nm ³ Max: 9300 Kcal/Nm ³	Burnishing oil	8.0 bar
d) Cooling water:		Grinding oil in the generation point	4.8 bar
Maximum pressure in the pipeline	4.5 bar	i) Filters:	
Return pressure	2 bar	Grinding machine	40um
Speed	2 to 3 m/s	Buffering (polishing)	5um
Feeding temperature	32 °C	j) Power supply:	
Return temperature	42 °C	Grounding System	TN-S
e) High Temperature Water:		Voltage Levels	220-Single Phase and 380-Three Phase
Input pressure	0,5-0,6 Mpa	Frequency	50 Hz
Feeding water temperature	125-135 °C		
Return water temperature	60-70 °C		

d) For Italy:

UTILITIES AVAILABLE AT EACH RESPECTIVE EMBRACO SITE:		RELATED TO	ITALY
a) Compressed air:		f) Industrial Water:	
Low pressure compressed air	6,4 bar \pm 0.7	Industrial Pressure / Temperature	2.5 bar at 18 °C
High pressure compressed air	12 bar \pm 1	g) Drinking Water:	
b) Steam:		Drink Pressure / Temperature	3.0 bar at 25°C
Pressure	3.5 bar \pm 0.5	h) Oil:	
c) Natural Gas:		Cooling oil	none
Pipeline	1,5 bar at 30 °C	Cutting oil	none
Heat power	36-38 MJ/m ³	Burnishing oil	none
d) Cooling water:		Grinding oil in the generation point	5 bar
Maximum pressure in the pipeline	2,8 bar	i) Filters:	
Return pressure	1,5 bar	Grinding machine	40um
Speed	1,2 to 2,4 m/s	Buffering (polishing)	TBD
Feeding temperature	18 °C	j) Power supply:	
Return temperature	30 °C (maximum)	Grounding System	TN-S
e) High Temperature Water:		Voltage Levels	220-Single Phase and 400-Three Phase
Input pressure	4,5 bar	Frequency	50 Hz
Feeding water temperature	98-102 °C		
Return water temperature	90-94 °C		

e) For Slovakia:

UTILITIES AVAILABLE AT EACH RESPECTIVE EMBRACO SITE:		RELATED TO		SLOVAKIA
a) Compressed air:		f) Industrial Water:		
Low pressure compressed air	6,5 bar \pm 0.3	Industrial Pressure / Temperature		N/A
High pressure compressed air	16,5 bar \pm 0.3	g) Drinking Water:		
b) Steam:		Drink Pressure / Temperature		4.5 bar at 10°C
Pressure	none	h) Oil:		
c) Natural Gas:		Cooling oil		5.0 bar at 30 ° C
Pipeline	4 kPa, 10 KPa	Cutting oil		4,5-5.0 bar
Heat power	34-36 MJ/m ³	Burnishing oil		4,5-5.0 bar
d) Cooling water:		Grinding oil in the generation point		3,5-4,5 bar
Maximum pressure in the pipeline	4,5 - 5,5 bar	i) Filters:		
Return pressure	1.5 bar	Grinding machine		40µm
Speed	1,5 m/s	Buffering (polishing)		5µm
Feeding temperature	20-25°C	j) Power supply:		
Return temperature	16 °C	Grounding System		TN-S
e) High Temperature Water:		Voltage Levels		220-Single Phase and 400-Three Phase
Input pressure	0,7 MPa	Frequency		50 Hz
Feeding water temperature	140-100 °C			
Return water temperature	60-90 °C			

3.5.1. Power Supply System

To minimize electrical interference it is recommended to install a TNS-system. A TNS-system is a 5-core system with separate N- (Neutral) and PE- (Earth) conductors.

If the plant contains a bigger Computer Controlled System, it is recommended that all power supplies to the system shall be supplied from a separate Distribution Panel. This Distribution Panel shall be supplied directly from the main low voltage switchgear. No other machine/equipment than PLC panels, control panels and operator/programming stations shall be connected to this distribution panel.

Note(1): The tolerance for the power supply is -7.5% to +10%. Machine and equipment requiring closer voltage control shall be equipped with voltage regulators. Proper waveform must be maintained.

Note(2): All the information about the utilities available are also in the TEM 000329 – Data Sheet for Equipment Installation, Registration or Reallocation.

3.6. Painting

Painting is a subject that has to be previously and formally agreed in writing with each respective EMBRACO's Plant that the Machines and Equipment are to be delivered to. The important consideration is once a certain pattern of color is chosen; it shall be really standardized in the respective site, meaning that the same combination shall be rigorously applied all over and for good, or almost that in the site.

The important point considered in this Corporate Standard is that Color for EMBRACO is very serious and deemed a "Coding of Visual Signals", see item 3.6.1, for the concept of "Visual Management" within EMBRACO's Continuous Improvement Program.

This Corporate Standard strongly "recommends" the following Color Coding as best practice and when applied it shall obey the rules all over in the site:

- For Machine and Equipment Body Parts, where applicable, it should be preferably **White RAL 9003** or any similar **Light Color, as Cream RAL 9001** as the second option whether White Color doesn't suit it fine. The painting shall be internally and externally in the Machine and Equipment Body Parts. Of course, stainless steel parts or aluminum shall not be painted, as example. Keep in mind to standardize just one color once chosen for the respective site;
- The color for Electrical Parts: cabinets, control boxes (for pushbuttons and HMI), connection boxes and motors, it should be **Blue RAL 5015**. The painting shall be only externally and again; stainless steel parts or aluminum shall not be painted.

See pictures from Figure 1, as reference for the final expected results.

Related to safety related parts and piping, the color coding shall be taken from the EHS Manual TST 000067.

Apart from those corporate recommendations, any additional local information, for Brazil and China, may be found as follows:

- Brazil: for the preparation, metal surfaces painting and color of the machine and equipment, must be taken into consideration the technical standard TST 00000034;
- China: for the preparation and painting of metal surfaces of equipment, see standard TST 000139.



Figure 1: Painting Standard

3.6.1. Coding of Visual Signals

3.6.1.1. Use of Colors

The color shall be chosen with regard to the information to be imparted, conveyed:

1. Machines and Equipment painting, Section 3.6;
2. Safety related parts and Piping, EHS - TST 00067;
3. Electrical Wiring inside Panels, Section 4.4.4.3;
4. *Andons* and Indicator Lights, Section 4.4.5;
5. Pushbuttons and Actuators, Section 4.4.6;
6. General use of colors on electrical machines and equipment shall be in accordance with IEC 60204-1, when not indicated in this Corporate Standard or any EMBRACO's Internal Document related to this subject.

3.6.1.2. Warning Signals

Warning signals shall follow the concerned recommendation included in the EHS Manual TST 000067.

Additional information, uncovered on that Safety-related document and specifically related to Electrical Warnings and Safety Signals in Machines and Equipment, shall be followed the content in Section 4.4.7.

3.7. Technical Documentation

3.7.1. Language

All the documents shall be written in English, which is the Global and Corporate Language and, in addition, it shall be written in the official language(s) of the country in which the machinery

and equipment is to be used, according to the requirements of Machinery directive (MD) – 2006/42/EC, clause 1.7.4, see also Section 3.2.4

In some cases also the Supplier's native language may be additionally used, Section 3.7.8. This must be agreed during the proposal phase with the MAINTENANCE ENGINEERING department and included in the purchasing, see 3.3.

3.7.2. Information required in the proposal - Proposal

The proposal must contain values and prices concerning:

- ✓ Project cost of the supplied item;
- ✓ Manufacturing cost of the supplied item;
- ✓ Assembly/installation;
- ✓ Training;
- ✓ Start-up;
- ✓ Taxes and duties;
- ✓ Packing;
- ✓ Transportation;
- ✓ Tools/accessories;
- ✓ Painting/others;
- ✓ Warranty;
- ✓ Technical documentation (data sheet);
- ✓ Warranty of the materials;
- ✓ Warranty deadline.

Any proposal must be fully elaborated as specified. All information must be clearly stated throughout the documents included.

3.7.3. Documentation That Must Be Provided To EMBRACO

The necessary documentation that must be sent to EMBRACO is written in the Section 6.1, annexes A's.

The document lists in the Annexes are divided by each different country, site, thus it must be paid special attention to the document list to the respective country, site it belongs to.

Instruction for safe and reliable use including Transport, Assembly, Installation, Commissioning, Start-up, Operation, Cleaning, Setting, Adjustment, Maintenance, Dismantling and Disposal of the machine shall also accompany the machines and equipment.

The following instructions, in summary, for safe and reliable use shall accompany machines and equipment:

- ✓ Installation Manual, INM;
- ✓ Electrical Drawing, ELD;
- ✓ Mechanical Drawings, MEC;
- ✓ Hydraulic Drawings, HYD;
- ✓ Pneumatic Drawings, PND;
- ✓ Maintenance Manual, MTM;
- ✓ Operation Manual, OPM;
- ✓ Technical Standards, TSD;
- ✓ Recommended Spare Part List, SPL;
- ✓ Machine Manual, MCM.

All those manuals, including the list in the Section 6.1, annexes A's, shall be produced in English before signing the Declaration of conformity. A translated version of those manuals shall, in addition to the English version, be available at the Machine and Equipment when it is being put into service. Any other needs may be agreed upon purchasing agreement, according to Section 3.3.

3.7.4. Standards for Submission of Drawings

- a) In the preparation of drawings and diagrams should be observed norms and standards with which this document has link;
- b) The formats of the drawings used must be in accordance to the standard A4, A3, A2, and A1 as in the ISO 5457, ABNT NBR 10068 standard (for Brazil) and GB/T 14689 (for China);
- c) Electronic Standard of Drawings:

EMBRACO will receive the drawings that have the file extension informed below:

1. Extension to mechanical projects: (DWG or DXF) and PDF
2. Extension to electric projects: DXF and preferably Eplan format (to be agreed upon purchasing)
3. Extensions compatible with the Software Pro/Engineer must be used with extensions PRT, ASM, DRW in case the project contains 3D drawing files, if it is not possible to use this extension, use the IGES format.

Important considerations:

- ✓ Each drawing must be a single file.

- ✓ The number of the drawing must be the file name.
- ✓ The number of the drawing must follow EMBRACO Standard for Mechanical Projects. This number is provided by EMBRACO's Tool Shop.
- ✓ When the drawing is done in A4 format, the sheet must be in the portrait position and if the paper size is larger than A4 format, the sheet must be in the landscape position.
- ✓ PDF files must be monochromatic.
- ✓ Drawings containing more than one sheet, with same number/name, must be in a single file. The drawing caption must show the position of each sheet.
Ex: 1/3, 2/3, 3/3.
- ✓ Software platforms receivables: Pro/Engineer, Eplan (to be agreed upon purchasing) and AutoCAD. If the file is not in one of these two platforms, it must be converted to DXF.
- ✓ For each drawing/file, a copy in PDF format must be sent;

Note: For more information about the numbering / naming of electronic files to be delivered, consult the procedure SOP 009382 – Creation of projects – EMBRACO standard and the Section 6.1, annexes A's.

- d) The electronic files (drawings) must go through a process of review, before be sent to EMBRACO, and the integrity of the drawings must be maintained when the conversion from one platform to another is done. Ex: SolidWorks to DXF.

3.7.5. Any Changes during the Project

After the project has been approved, any kind of change in project, asked by the Supplier, must be submitted to a new approval by EMBRACO. The expenses involved in these changes will be paid by the Supplier.

3.7.6. Property of Drawings and Technical Documents

EMBRACO must formalize with the Supplier the limits for the use of the drawings, technical documents and any other information related to the machine and equipment or part of it by EMBRACO or any third parties.

EMBRACO must formalize with the Supplier the rules related to the confidentiality of drawings, technical documents or any other information related to the machine and equipment or part of it. For more information see Sections 03.3.1.3 and 3.3.1.5.

3.7.7. Machine Decomposition and Ledger

Two of the documents required by EMBRACO, when buying a new machine or retrofitting any existing one, are: the “Machine Decomposition” and the “Machine Ledger”.

3.7.7.1. Machine Decomposition

The machine decomposition, Figure 2, is the explosion, deployment in certain levels, of the machine and equipment until the single component or element level. The classification that EMBRACO chose to decompose its assets is based in: Country & Plant, Line, Process, Machine, Section, System, Sub System, Component and Element. From all these levels, following exactly that order, the Supplier shall start from the machine level, already known, going deep through the levels into the single component and element level. The main goal during the machine decomposition development is to dispose clearly each class of the machine, in a neat, tidy and organized mode, naming and coding each of these levels, providing a single code for each combination of levels, until the component or element level, according to the case.

[illegible]

Figure 2: Machine Decomposition

This Figure 2 is the template, according to TEM 004823 – PMCT_Machine Decomposition and Ledger, for the machine decomposition activity. For each one of the levels there shall be an ordering number, the description and a specific code. The machine decomposition construction is a difficult activity, and it shall follow the Global rules defined in the EMBRACO Standard Machine Decomposition Structure, according to the TST 00507479 – PMCT_Factory's Installation Tree Structure.

3.7.7.2. Machine Ledger

The machine ledger, Figure 3, is a visual and interactive tool to follow machine, its components and elements condition and status. It is completely based on the machine decomposition seen before, and also includes drawings or pictures of each level (machine, section, system, sub system, component and element). For the ledger, there are some requirements to enter, which are:

- ✓ All the levels which are provided by the Suppliers shall be indicated at the document, including photos, drawings, or images;
- ✓ Maintenance procedures descriptions;
- ✓ The probable frequency of components useful lifetime;
- ✓ Preventive maintenance activities at the single component or element level;
- ✓ The A, B, C component classification must be done. The rule to do this classification is:
 - Component A: when the component breaks, machine stops;
 - Component B: when it breaks, machine loses performance;
 - Component C: when it breaks, machine keeps working, few damage.

This filled out reference template in the Figure 3 is applied to build up the machine ledger.

[illegible]

Figure 3: Machine Ledger

According to the Figure 3, TEM 004823 – PMCT_Machine Decomposition and Ledger, starting from the sections of the machine, the Supplier shall include name, code and images/drawings of the components and elements accordingly. There are also in the ledger, fields about component classification, frequency of maintenance and maintenance procedure description,

where the Supplier shall describe with details the maintenance activity that has to be done periodically.

3.7.8. Spare Part List and Bill of Material

EMBRACO must negotiate with the Supplier the delivery, in the maximum 30 (thirty) days before the Try-out of the machine and/or equipment, of a list of Recommended Spare Parts, according to TEM 001078 – Recommended Spare Part List, which SHALL contain all the critical and also the perishable fabricated parts used in the machine and/or equipment, based on the Machine Ledger, Section 3.7.7, with the following minimum information:

- Model;
- Material description;
- Manufacturer's part number code;
- Manufacturer;
- Quantity;
- Cost per unit;
- Delivery time.

The Recommended Spare Part List is MANDATORY to follow the standardized EMBRACO form's example, TEM 001078 – Recommended Spare Part List, see Figure 4. EMBRACO will send this form by email so as to the Supplier's compliance in terms of spare part valuable information. This present standard fixes the contents of the Recommended Spare Part List having to be delivered by the Supplier.

In the case of parts manufactured by the Supplier itself, should also include:

- The drawing number;
- The number of the component list.

EMBRACO must negotiate with the Supplier the possibility to manufacture spare parts of the machine and/or equipment by the EMBRACO tool shop or third parties authorized by EMBRACO.

Last but not least, the Bill of Material related to all parts, like mechanic, hydraulic, pneumatic, automation, electrical and so on must be on Bill of Material specific sheets showing the main assembly, also based on the Machine Ledger, Section 3.7.7. The material list shall show quantity, original manufacturer's name, type or model, catalog number and serial number for each device used, and pertinent material description information relative to cross-referencing parameters in the event of an emergency replacement, exactly following the same rules as for the Material Description of the Recommended Spare Part List explained in the EMBRACO's form

previously presented. The Supplier is responsible for adding all these information. Bill of Material shall contain an additional blank 12 digit wide column for later addition of EMBRACO assigned stock numbers.

In fact, the list of spare parts is derived from the Supplier's engineering bill of material and is handed over to EMBRACO along with the article's technical data sheets.

It's MANDATORY that both, the Recommended Spare Part List and Bill of Materials, documents be written in English as well as in the Supplier's Native Language in order to make easier the process to new parts acquisition. In addition it shall be written in the official language(s) of the country in which the machinery and equipment is to be used, see Section 3.7.1.

SPARE PARTS DELIVERABLE INFORMATION FORM (Description)

Objective: To standardize the deliverable information of the spare parts info.

Advantages:

- A.) Wider broad of information (Manufacturer, description, part #, model)
- B.) Avoid long, useless descriptions by creating a concise description
- C.) Avoid search/purchase with different manufactures/suppliers for a material with same characteristics
- D.) Easier to create warehouse material number
- E.) Avoid warehouse material number duplicity
- F.) Simplify material search in SAP, focusing on 4 different options, not only on "Material description"
- G.) Reduce MTTR by having an easier spare part search in SAP.
- H.) Easier to identify which machines have the same spare part, even though manufacturer is different
- I.) Reduce warehouse's physical & financial inventory, avoiding future rework

MODEL:
Material Number Corresponding to Manufacturer Part Number

MATERIAL DESCRIPTION:
Concise description of the material. Include name and main characteristics, separated by a comma.
There should be no more than 32 characters.

MANUFACTURER'S PART NUMBER:
Specifies the number used by the manufacturer, or also by the vendor, to manage a material

MANUFACTURER:
Identifies the Manufacturer's name

QUANTITY:
Recommended amount of pieces

COST PER UNIT:
Cost for each piece in US Dollar

DELIVERY TIME:
Total time to deliver the material in days

Description in English and Manufacture's Language	Model	Material description	Mfr. Part Number	Manufacturer	Quantity	Cost Per Unit	Delivery Time	Description Length. No more than 32 char
Example	IME08-1B5PSZT0S	Inductivesensor,2mm M8 PNP NO	1040838	SICK	2	\$22,99	1	29
Example	IEB3002BBPKG	Inductivesensor,2mm M8 PNP NO	IE5328	IFM	3	\$115,00	7	29
Example	9102KD	Ballbearing,15-32-9	9102KD	FAF	1	\$2,32	1	19
Example	6002 Z	Ballbearing,15-32-9	6002 Z	FAG	2	\$2,32	1	19
Example		ACMotor,420Y-0.5Hp-50Hz-1380RPM	S37DT71D4	SEW	5	\$889,21	30	31
Example		V-belt,ext035"	AX33	Goodyear	4	\$5,96	1	14
Example		v-belt,ext01250mm-11mm	11M1250	Gates	1	\$29,28	1	22

SPARE PART SEARCH SCREEN (SAP)

SPARE PART SEARCH RESULT (SAP)

MPN Mater...	Material description	Int. material n...	MPN	Manufact.	Language
602781	SENSOR GIMATIC CB3N 0.25A				EN
602781 M	SENSOR SOLAR M0PRH	602781	334416617871	MITUTOYO	EN
602781 T	SENSOR GIMATIC CB3N 0.25A	602781	5133-M00850.T	TOSHIBA	EN

Figure 4: Spare Part List

3.7.9. Preventive Maintenance Plan

The machine and/or equipment manufacturer shall provide Recommended Preventive Maintenance Plan, Standard Preventive Maintenance Procedure (SMP) and Lubrication Schedule, based on the Machine Ledger, Section 3.7.7, no later than the date of machine and/or equipment shipment.

The Preventive Maintenance Plan supplied must be, in fact, composed by these two main divisions:

- How to do:

This includes all Standard Preventive Maintenance Procedures or new maintenance instructions that shall follow TEM 001079 – Recommended Standard Preventive Maintenance Procedure.

- When to do:

This shall contain all Preventive Maintenance Plans and the suggested frequency that must be done following TEM 001077 – Recommended Preventive Maintenance Plan.

These present standards fix the contents of the plan and procedure of preventive maintenance having to be delivered by the Supplier.

The design of the machine/equipment should favor minimal preventive maintenance. It must be targeted and must contribute to reducing the risks of critical malfunctions.

The preventive maintenance has a major impact on the maintenance costs:

- ✓ Its recurrent aspect translates into major expense and resources and results in regular costs;
- ✓ If it is not done, it may result in production stoppages.

Due to this, its cost must be minimal and flexible as much as possible. Thereby the intervention frequencies must be adjusted according to the quantities of parts or components produced.

The machine and/or equipment Suppliers are, in this way, called upon to increase their skills in the construction and the optimization preventive maintenance. This mandates particular care in the design of the machine and/or equipment, to reduce the costs to EMBRACO, by applying the following rules:

- ✓ The creation of the preventive maintenance should not in any way alter the operation of the machine/equipment;
- ✓ Long operations must be reduced to the absolute minimum;
- ✓ Most of the operations must be carried out with the machine/equipment in operation or in production (in required time);

- ✓ The preventive maintenance must be built to mitigate the risks of appearance of the dysfunctions considered to be critical (comparative analysis risks/costs), and which could not be avoided by the design, thus focusing, prioritizing and adapting to the non-reliability sections of the machine/equipment;
- ✓ The maximum number of operations can be carried out by non-high-skilled maintenance technician;
- ✓ Visual monitoring under operation carried out by the operators of production and least expensive actions must be favored;
- ✓ The periodicities of these operations, as already mentioned, must be expressed when that is possible in a number of cycles so as to be able to adjust the preventive maintenance with the quantity of products manufactured;
- ✓ The formalization of the Preventive Maintenance Plans comply with the standards:
 - ✓ TEM 001077 – Recommended Preventive Maintenance Plan
 - ✓ TEM 001079 – Recommended Standard Preventive Maintenance Procedure

The Recommended Preventive Maintenance Plan, Standard Preventive Maintenance Procedure and Lubrication Schedule are MANDATORY to follow the standardized EMBRACO forms' example. EMBRACO will send all these forms by email so as to the Supplier's compliance.

3.8. Inspection and tests

3.8.1. Previous Inspections

EMBRACO claims the right to, whenever considered necessary, inspect the parts and the assembly at the Supplier's factory, having the Supplier previously notified.

3.8.2. Machine Start Up

It will be done by the manufacturer, with material supplied by EMBRACO, to adjust the machine and/or equipment according to the proposal done. The amount of material used in the test will be previously agreed and confirmed in the contract.

3.8.3. Machine Try-out

Machines and Equipment on field test shall comply with all applicable directives, standards and regulations. It shall be CE marked as applicable.

- a) The tests will take place at the Supplier's plant, according to the PGE 009105 - Process Certification, with material supplied by EMBRACO, aiming to approve the machine and/or equipment as arranged at the time of the offer.
- b) EMBRACO's responsible personnel for the try-out will make use of suitable check lists to evaluate compliances with this Corporate Standard.
- c) The Supplier shall submit a written request for its implementation, with at least 15 days before the intended date, stating that the machine and/or equipment are in accordance with the specifications of the request.
- d) Should be provided by the manufacturer a period between the Try-out and the deadline for delivery the machine and/or equipment, so there is time to meet any items in disagreement with the standards.
- e) For imported machines and/or equipment, the Supplier must request the Try-out at least 30 days before the scheduled date.
- f) At the scheduled date, an amount of parts will be manufactured with the presence of an EMBRACO's technician.
- g) It will be observed all the items in disagreement with the standards: electrical, mechanical, vibration, hydraulic, functional, exercise stress test, security, etc. These items will be conferred by an EMBRACO's technician inside the Supplier's factory prior to releasing for delivery.
- h) EMBRACO reserves the right to interrupt the inspection / Try-out at any time without charges in the following cases: lack of necessary conditions for their implementation, the machine and/or equipment is not in working conditions or in the event of lots of successive breaks while it's working. In this case a new date will be scheduled.
- i) For machines and/or equipment that are not purchased for specific operations, in addition to the geometric tests, will be carried out functional tests, and a test piece may be asked to be checked.
- j) The release to the machine and/or equipment delivery only occurs if it is deemed approved. The Supplier will receive an official communication from EMBRACO authorizing the delivery. In case of disapproval new test / Try-out must be done.
- k) EMBRACO will provide to the Supplier all the materials (e.g. tools, process materials, raw material) required in the try-out.
- l) In the case of machine and/or equipment for surface finishing, the Supplier must provide Chemical Analysis Laboratory for residual measurements.

- m) The calibration standards and devices used during geometric tests will be supplied with the machine and equipment and must be accord with the standard DIN 8651.
- n) The parts measurements made in the Supplier factory, during the try-out, will be supplied with the machine and equipment.
- o) For the parts characteristics considered CTQ (Critical to Quality) and produced by the machine and/or equipment under approval in try-out, the manufacturer must confirm with a Machine Capability – Cmk, as indicated in the TSS 002470 – Characteristic Classification.
- p) The manufacturer must confirm and document that observed cycle time is < than cycle time described on purchasing proposal.

3.8.4. Certification Test in EMBRACO / Final Approval

The final approval will be granted after:

- a) The machine is installed in EMBRACO, reaching production times and tolerances specified;
- b) All the same specific items evaluated in the try-out, Section 3.8.3, have been reevaluated and assessed again and are all in compliance with, meeting all the defined requirements;
- c) The machine does not submit technical disputes;
- d) The technical documentation (Annexes A's), be delivered, checked and approved by the leadership of the maintenance area involved;
- e) The training had been conducted.

Note: Tests to be held at all stages of approval mentioned in this chapter shall be established in the technical proposal that is part of the application.

3.9. Transportation / Assembly

- a) The Supplier must pass on to EMBRACO previously according to the requests from Machine Technical Proposal, the following information;
 - a.1) Total weight of the machine and/or equipment;
 - a.2) Weight of the largest part;
 - a.3) Number of volumes;
 - a.4) Dimensions: height, width and length.

b) The Supplier must send to EMBRACO, at least five (5) days before the machine and/or equipment assembly beginning, the name of the technicians, respective identification number and other documents related and listed on TST 000067;

c) List of tools and equipment to be used, which must be presented at EMBRACO entrance gate.

3.10. Training

The Supplier is responsible for the operational and maintenance training and this training must be part of the supply. The training to be provided will be defined by EMBRACO and by the Supplier, upon the purchasing contractual agreement, see Section 3.3.1.7.

3.11. Warranty

- a) EMBRACO must negotiate with the Supplier the terms of the guarantee to be provided to all components / materials, including those supplied by third parties, aligned with Section 3.3.1.8.
- b) The negotiation to be undertaken by EMBRACO must consider:
 - (i) the obligation to provide a list of components purchased from third parties with their respective periods of warranty informed by the sub-Suppliers;
 - (ii) hypothesis for replacement or repair of any parts of the machine and/or equipment that become defective, either resulting due the manufacturing process or resulting from inappropriate material;
 - (iii) details of the technical assistance, that must be provided in a period of time no longer than forty-eight (48) hours starting from the notification of failure / defect;
 - (iv) details for the extension of the warranty deadline in case of any delays due to the commissioning phase and downtime of the machine and/or equipment for maintenance during the acceptance period; and
 - (v) impacts in warranty deadline and in the terms of the warranty in case of repair of the machine and/or equipment made by EMBRACO.

4. Technical Conditions

4.1. Mechanical Installation / Lubrication

4.1.1. Materials and Brands Homologated By EMBRACO

The list of homologated material's manufacturers and brands are in the Section 6.2, Annexes B's, so as to limit the unnecessary and uneconomical diversity of components in the respective site from EMBRACO. The preferable components to be used in the project are the ones listed in the First Choice Brand Column of the respective tables. The use of components placed in the Second Choice Brand Column shall be previously justified and agreed with the leadership of the respective Maintenance area involved, which the machine and/or equipment are to be delivered to, just to avoid any unexpected and unpleasant outcome afterwards. The use of components that are not homologated by EMBRACO shall be previously authorized in writing by the leadership of the respective Maintenance area involved.

The component lists in the Annexes B's are divided by each different country, site, thus it must be paid special attention to the component list to the respective country, site it belongs to.

4.1.2. Construction Directives

- a) Access shall be provided for servicing ALL components, and for changing tools and dies.
- b) Finish surfaces shall be accessible to check level of the machine and/or equipment or section without removing components or fixtures after installation.
- c) Adequate clearance shall be provided to afford easy chip and scrap removal.
- d) Work height for assembly or similar manual operations shall be done ergonomically.
- e) Provide plan and smooth points (surface) to put (by lodestone) the accelerometer on the bearings of the machine and/or equipment with a criticality "A". It SHALL be checked with MAINTENANCE ENGINEERING about the criticality of the machine and/or equipment that is being provided.
- f) The protections must have windows for inspection, on the rotating bearings, to collect vibration data.
- g) The bearing and coupling protections must have windows for inspection for monitoring by stroboscope.
- h) The limits of vibration must be according to the standards IEC 60034-14, ISO 1940 and NBR10.272 (for Brazil).

Note: The four previous items refer to the constructive demands that are according to the practice of predictive maintenance performed in EMBRACO.

- i) All the constructed machine parts and its respective threads used on the equipment must be millimeters. Screws, nuts and washers must preferentially comply with the internal or DIN standards. Those Threads with measurements in inches will not be allowed.

Note: Exception is done for hydraulic units and pneumatic piping and fittings. Please see it in the respective chapters.

- j) All hydraulic and pneumatic pipe threads can be either millimeters or American (National) Standard Taper Pipe Thread (NPT), meaning that it can be either chosen to use millimeters or inches.
- k) All piping, fittings, tubing and hose shall meet the appropriate ASTM standard and also comply with any applicable state or local pressure piping code.
- l) Foresee special devices for assembly and transportation of large components, machines and equipment. Provisions shall be made for slings, hooks or skids to adequately handle the machines, sections or equipment during erection. Critical lifting points shall be called out and marked.
- m) Special tools used to assist the machine and/or equipment maintenance must be supplied by the Supplier.
- n) All flanged connections, covers, washers, etc., must have threaded holes to assure an easy disassembly of the parts.
- o) The machine and/or equipment provided with slide bars must be supplied with replaceable guides (e.g.: linear guides, prismatic guides, roller guides etc.), and the guides and slide bars must be provided with automatic (centralized) lubrication points and they must also be provided with protection (e.g.: retractable covers, discharge trays, telescopic, bellows, etc.).
- p) All machine and/or equipment must be provided with protection, and guiding elements for electrical cables and hydraulic hoses, such as chain rollers or cable reel.
- q) It is the responsibility of the machine and/or equipment builder, with the help of the MAINTENANCE ENGINEERING, to select the technique of lubricant application, whether splash, manual points, manual or automatic centralized systems, oil mist, or re-circulating system, in order to provide adequate lubrication as dictated by his own machine and/or equipment design and in compliance with these standards.

- r) The lubrication system of the machine and/or equipment components must be provided with collecting trays to avoid oil dropping on the floor.
- s) All lubrication systems (automatic or manual) shall be designed to be filled and adjusted while machine is in operation.
- t) The Visual level indicator, filling holes and outlets must be located in such a way as to allow easy access for inspection, and fast lubrication oil change, in the least time possible.
- u) Hydraulic reservoirs must contain filters installed in such a way that is easy to be replaced without the need for withdrawal the volume of oil.
- v) The lubrication system must be provided with signaling devices to indicate filter saturation, minimum oil level and lack of oil.
- w) The components of the lubrication system must be identified according to the schematic diagram, as close as possible to them, with aluminum tag, riveted or screwed on the machine and/or equipment.
- x) The technical and commercial specification of the component must be completely described in the scheme of lubrication and in the parts list.
- y) All the lubrication points on the machine and/or equipment must be marked according to standard DIN 51502 which indicates the type of lubricant to be applied.
- z) Lubrication points shall be centralized, when manually carried out it. But, Automatic lubrication is the preferred one.
- aa) To allow easy cleaning service, the tanks must be built in such a way as to allow the liquid discharge from the bottom part of the tank. The tank bottom must be unlevelled for that purpose.
- bb) All hydraulic oil reservoirs and refrigeration oil reservoirs must contain hatches to assist cleaning procedures.
- cc) All machine and/or equipment must have automatic centralized lubrication.
- dd) On PLC controlled machine or equipment, the PLC shall be used to control and diagnose the lubrication components.
- ee) There shall be anchorage points for work that has to be done at height.
- ff) There shall be deflectors installed in key points of the machine or equipment in order to guide and block the sources of debris, chips and coolant, preventing scattering and splattering. It has to be installed exactly in the processing points. The best solution is to automatically convey all its debris and chips towards external part of the machine and or equipment.

- gg) Coolant shall be applied focusing exactly on the product machining area as well as protect the other areas from coolant splattering.
- hh) The Machine and equipment structure shall be designed to prevent the accumulation of debris, chips and coolant inside.
- ii) Transparent inspections windows and hinged shall be installed in all important processing points, so as to help quality, inspection and other problems' checking.
- jj) Manual valves shall be identified according to its respective status: open or closed and respecting the color coding Green for open and Red for closed. If applicable the handle can be painted with the color that it has to be kept, meaning green if it's normally open or red if it's normally closed.
- kk) The fluid direction in piping and hoses shall be depicted by applying arrows accordingly.
- ll) Screws shall be reduced to a minimal amount in protections.
- mm) It shall be applied clamp holders as much as possible, where applicable.
- nn) Protections shall be hinged as much as possible, where applicable.
- oo) Wipers shall be compatible and considered its robustness according to the cutting fluid oil.
- pp) Rotation Direction shall be marked on gearboxes, shafts, belts and rollers, where applicable.
- qq) There shall be position indicators for important movable parts of the machine and or equipment.
- rr) There shall be easiness for checking belts physical condition and alignment by applying transparent windows and opening hatches for its tension checking.
- ss) There shall be placed a metallic identification on the safety cover, showing the belts technical specification.
- tt) Critical bolts shall be marked for tightness checking during inspection routine.
- uu) Machines and equipment shall be protected against sources of dust and grime.

Note: Whenever applying systems to improve the access to the internal component parts of the machine and or equipment, safety means shall be provided to avoid any injury. Check EHS Manual TST 00067 and TEM 00804 for details.

4.2. Hydraulic Installation

This chapter deals mainly with the ISO 4413 Standard, which sets out a large number of general recommendations in the design and execution of machine hydraulic transmission systems, thus this Corporate Standard supplies partially the General Rules Relating to Hydraulic Transmission Systems along with EMBRACO's best practices.

This International Standard shall be applied whenever the design, construction and modification of hydraulic systems and their components is demanded. By applying properly this ISO Standard, it is provided a means of conforming to Essential Requirements of the New Approach Directive 2006/42/EC on machinery.

Use of this International Standard assists in:

- a) identifying and specifying the requirements for hydraulic systems and components;
- b) identifying respective areas of responsibility;
- c) designing systems and their components to comply with specific requirements;
- d) understanding the safety requirements of a hydraulic system.

Deviations from that International Standard, along with this Corporate Standard, shall be previously agreed to in writing between the Supplier and EMBRACO.

4.2.1. Materials and Brands Homologated By EMBRACO

The list of homologated material's manufacturers and brands are in the Section 6.3, Annexes C's, so as to limit the unnecessary and uneconomical diversity of components in the respective site from EMBRACO. The preferable components to be used in the project are the ones listed in the First Choice Brand Column of the respective tables. The use of components placed in the Second Choice Brand Column shall be previously justified and agreed with the leadership of the respective Maintenance area involved, which the machine and/or equipment are to be delivered to, just to avoid any unexpected and unpleasant outcome afterwards. The use of components that are not homologated by EMBRACO shall be previously authorized in writing by the leadership of the respective Maintenance area involved.

The component lists in the Annexes C's are divided by each different country, site, thus it must be paid special attention to the component list to the respective country, site it belongs to.

4.2.2. General Construction Directives

- a) All components and piping shall be selected or specified so that they have adequate characteristics to allow them to operate reliably under all intended uses of the system.

- Particular attention shall be paid to the reliability of components and piping that could create a hazard in the event of their failure or malfunction. [ISO 4413 – clause 5.2.1.1]
- b) All hydraulic powered equipment and components shall be used and installed in accordance with the component manufacturer's recommendations. [ISO 4413 – clause 5.2.1.2] - Hydraulic Fluid Power - General rules and safety requirements for systems and their components
 - c) In case the hydraulic oil is used for lubrication, it must not return to the tank.
 - d) All parts of the hydraulic system shall be designed to operate or otherwise protected against pressures exceeding the maximum working pressure of a system or any part of the system or the rated pressure of any specific component. All hydraulic components must be rated to handle continuous flow and pressure required by the individual system. [ISO 4413 – clause 5.2.2.1]
 - e) Hydraulic power systems shall be designed to operate with Sound levels in accordance with EHS Manual (TST 000067). [ISO 4413 – clause 5.2.4]
 - f) Hydraulic power systems shall be designed to operate with working fluid temperature within 45 – 55 degrees C, under all conditions, including idle. All hydraulic Power systems, operating with temperature above 55 degrees C shall be provided with a water type cooling system (liquid-to-liquid heat exchangers). [ISO 4413 – clauses 5.4.5.2.1 item e) and 5.4.5.4]
 - g) Hydraulic systems shall be provided with pressure, level and temperature gages. These gages shall be mounted so they are accessible for inspection and no higher than 1.5 meters off the mounting surface of the hydraulic system, which in average should be the eye's height in average. They shall also be protected against system transients with a snubber or isolator. [ISO 4413 – clauses 5.4.5.2.3.1, 5.4.5.4.2.5, 5.4.8.2 and 5.4.8.4]
 - h) Hydraulic systems shall be designed to use non-synthetic oil as a working fluid, preferably petroleum based hydraulic oil viscosity class ISO VG 68.
 - i) Over-pressure protection shall be provided on the discharge of all hydraulic pumps. These devices shall be sized to accommodate the full flow capacity of the pump. The preferred means of protection against excessive pressure is one or more pressure-relief valves located to limit the pressure in all related parts of the system. Other means, such as pressure-compensator pump controls, may be used to limit main system operating pressure, provided these means ensure safety under all operating conditions. [ISO 4413 – clause 5.2.2.2]

- j) Hydraulic systems shall be designed to prevent damage to the equipment or injury to personnel in the event of an electrical power failure or the loss of hydraulic pressure. [ISO 4413 – clauses 5.2.2.4, 5.4.7.2.2 and 5.4.7.3.7]
- k) In multi-pump hydraulic systems control logic circuits shall be designed to prevent equipment damage in the event of a pump loss. Also, ball valves shall be installed in order to isolate the pumps for maintenance purposes thereby allowing one pump to continue to supply the needs of the system while the other pump is in maintenance.
- l) Hydraulic systems shall be designed so that the working fluid maintains laminar flow under all operating conditions.
- m) Hydraulic systems and their associated components shall be protected from contamination by coolant, cutting or lubricating oils, chips or dirt by either placing the systems or components out of the immediate area where they could be contaminated or by providing a barrier, cover or protective shield for the system in order to keep contaminants out.
- n) Hydraulic systems shall be designed so that the components shall be accessible for adjustment and maintenance; that is, controls on stationary industrial machines and equipment should be a minimum of 0.6 meters or a maximum of 1.8 meters above the plant floor or machine base. Hydraulic systems shall use only SAE straight threads or 4-bolt flanges for connections. Pumps and motors shall be accessible for maintenance with minimal disassembly of piping or other surrounding components. [ISO 4413 – clauses 5.3.2.2, 5.3.2.4, 5.3.2.5.2, 5.4.1.1, 5.4.5.3.2.3 and 5.4.7.6.2]
- o) All hydraulic systems shall be designed and manufactured to meet a target system cleanliness level of hydraulic fluids, expressed in accordance with ISO 4406. It shall be suitable for the most contaminant-sensitive component in the system, as determined by the components' manufacturer, considering the strictest contamination one. It is also the responsibility of the manufacturer to flush all hydraulic systems until an optimum cleanliness level, considering the one indicated to the most critical component. System cleanliness shall be evaluated from dynamic samples taken from the system return line and upstream from the return filter. According to Standards NAS 1638, ISO 4406. ISO 23309 and ISO 4021. [ISO 4413 – clauses 5.4.5.1.3, 5.4.5.3.1, 5.4.7.4.4, 5.4.8.3 and 7.3.1.1 item j)]
- p) All filters shall have a visual indicator, mechanical or electrical of impurity degree found in the oil. For non-stopping installations, interchangeable single or double filters shall be

- installed. The filters shall have easy access for cleaning and change jobs. [ISO 4413 – clauses 5.4.5.3.2.2, 5.4.5.3.2.3, 5.4.8.5 and 7.3.1.1 item i)]
- q) All hydraulic systems shall be thoroughly tested. After completion of testing and prior to shipment the reservoirs shall be drained and cleaned and all system filter elements shall be replaced. Documentation will be provided to EMBRACO showing that the hydraulic systems passed preliminary tests and function to design specifications. [ISO 4413 – clause 6]
 - r) A stamped metal or engraved tag shall be permanently attached in close proximity to each hydraulic component to identify the component schematic ID and function. The tag should be easily read without any aids or removal of any machine component. [ISO 4413 – clauses 5.4.4.3.5, 5.4.6.1.4, 7.4.1.2, 7.4.2.1, 7.4.3.2 and 7.4.4.1]
 - s) Light signaling shall be added to indicate the working conditions status, high, low and normal, for example, of most important variables linked to anomalies; like level, pressure, temperature and so on, close to the hydraulic unit, so as to get easiness of inspection. The standard coloration of the criteria shall be Green for normal, Yellow for abnormal and Red for risky. It shall stand in one position and organized in a logical and intuitive way, divided by section of the machine, system, similar function and so on.
 - t) The normal working range, setting pressure values from the components (pressure switches, pressure gauges, regulators and so on) shall be identified in a precise, permanent, readily visible and conspicuously fashion. [ISO 4413 – clause 7.4.1.1]
 - u) Components (pressure switches, pressure gauges, regulators, light signaling and so on) subjects to regular inspections and adjustments shall be all centralized and stand in one position, at the eye's height according to item g). It shall be organized in a logical and intuitive way; divided by section of the machine, system, similar function and so on.
 - v) Specifically for Pressure Gauges with glass, the collared dial with indication of normal working range shall be done internally and never on the protection glass cover, since it can turn around and defeat the purpose. Normal working range shall be colored green and superior and inferior limit values as red.
 - w) Specifically for Pressure Gauges with glass, they shall be sized, selected the range accordingly and organized as item u), with the central value of the normal working range positioned at 12:00, as Figure 5.

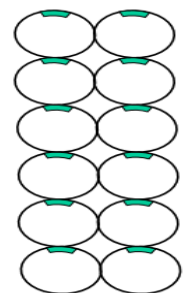


Figure 5: Gauges Alignment

- x) It shall be integrated and centralized, all the hydraulic components: valves, switches and gauges along with light signaling, standing in one position and organized in a logical and intuitive way, divided by section of the machine, system, similar function and so on.
- y) All filling points for fluids shall be clearly and permanently marked, readily visible and conspicuously fashion. [ISO 4413 – clause 5.4.5.2.3.2]
- z) All hydraulic systems and associated components shall be of standard design and shall not require any unusual or special tools for maintenance. [ISO 4413 – clause 5.3.2.5]
- aa) Hydraulic systems shall be provided with oil test ports immediately before the return filter and directly after each pump pressure outlet in an accessible location to obtain dynamic oil samples. [ISO 4413 – clauses 5.4.7.5.2 and 5.4.8.3]
- bb) Always provide pressure gauge connector in the hydraulic pipeline after the valves and after the pump as well as pressure indicators. [ISO 4413 – clause 5.4.7.5.2]
- cc) Hydraulic systems shall be designed so that valves controlling parallel devices are based solely on function and not timing. Consideration shall be given to different requirements in pressure, lubrication, speed, and wear of components in all parallel systems. In systems where there are parallel devices, each one shall have provisions for independent speed/flow control. Electrical control of parallel components shall be as per Section 4.4.
- dd) Hydraulic system components performing safety-related functions shall be designed and constructed to fail to a safe, know state and be capable of being monitored for failure by the safety control system. It shall be in accordance with EHS Manual (TST 000067). [ISO 4413 – clauses 5.2.3 and 5.4.7.1]
- ee) Dismantling of an accessory or component must not contaminate the machine or the floor. [ISO 4413 – clause 5.4.1.7]
- ff) Additional means shall be provided to prevent that the oil from spills, that occurred during maintenance, and/or leaking, drains off on the floor or return to the reservoir.
- gg) Painting: see the Section 3.6. Follows pictures of hydraulic units painted as reference example, as Figure 6.



Figure 6: Hydraulic Units Painting

4.2.3. Pumps and Motors

- a) Hydraulic pumps shall not be mounted inside the system reservoirs. [ISO 4413 – clause 5.4.1.1 item a)]
- b) In the case of submerged pump application, which its utilization shall be compulsorily approved by EMBRACO engineering in writing, its replacement must be possible without requiring the emptying of the reservoir.
- c) Hydraulic pumps shall be mounted so they are protected from damage that may be the result of a passing piece of equipment, a negligent employee or the like. The pumps shall also be easily accessible for maintenance with minimal disassembly of surrounding piping or components. [ISO 4413 – clauses 5.4.1.1 item a) and 5.4.1.7]
- d) The direction of rotation of each pump and motor shall be clearly and permanently marked adjacent to the pump and motor set. All hydraulic pumps shall be right-hand rotation. [ISO 4413 – clause 7.4.7]
- e) C-face flanged electric motors shall be used. The pump and the motor shall be mounted on a common rigid base to assure coupling alignment under varying workloads and temperature variations. The entire assembly shall be mounted resiliently with shock mounts. The use of double ended motors or vertically mounted pumps requires written approval by EMBRACO engineers. [ISO 4413 – clauses 5.4.1.1 item b) and 5.4.1.2.1]
- f) The connection of the motor-pump system with the hydraulic circuit must be made preferably through flexible element.
- g) Driving couplings and mountings shall be capable of continuously withstanding the maximum torque that may be generated at the pump or motor under all conditions of intended use. [ISO 4413 – clause 5.4.1.2.1)]

- h) Drive couplings shall be suitably guarded. [ISO 4413 – clause 5.4.1.2.2]]
- i) The bell housing between the pump and the motor shall have a detachable access cover or provide through window an easy access to allow coupling inspection and adjustment. [ISO 4413 – clause 5.4.1.2.2)]
- j) Variable displacement pumps shall be piston type. Positive displacement pumps shall be vane type. Prior to selecting and installing such kind of pump, written approval by EMBRACO engineers is requested.

4.2.4. Valves

- a) All electrically operated hydraulic valves shall have indicator lights. Mount all valves horizontally. [ISO 4413 – clauses 5.4.7.2 and 5.4.4.4.1]
- b) Solenoids shall be sized and selected (e.g., cyclic rate, temperature rating) so that they are capable of operating the valves reliably at minimum and maximum voltage, including the appropriate degree of protection in accordance with IEC 60529. Nominal voltage preferably 24 VDC +10% -20% [ISO 4413 – clause 5.4.4.4.1.2]
- c) Valve type and method of mounting shall be selected to ensure correct function, adequate leak tightness, maintenance or adjustment requirements, and resistance against foreseeable mechanical and/or environmental influence. [ISO 4413 – clause 5.4.4.1]
- d) Valves shall be mounted with sub-plate base or manifold. [ISO 4413 – clauses 5.4.4.2 and 5.4.4.3]
- e) The valves must be, preferably, installed next to each other, by stage, at the same frame, in modules and next to the actuators.
- f) There shall be means to avoid incorrect mounting of valves. [ISO 4413 – clause 5.4.4.2 item e)]
- g) The solenoids shall have isolation protection type IP68.
- h) Valves shall be located above the high fluid level of the reservoir except where proper functioning requires otherwise. [ISO 4413 – clause 5.4.4.2 item c)]
- i) The operation of valves shall not produce detrimental hydraulic surges. [ISO 4413 – clause 5.2.2.3]
- j) Where the application of a valve requires an external drain, the drain shall be piped to the reservoir, only if such drainage can not cause any contamination or hazard. [ISO 4413 – clauses 5.4.1.4 and 5.4.7.2.3]

- k) Solenoid valves shall have manual overrides which can be operated without removing solenoid covers or enclosures, but which cannot be operated accidentally. [ISO 4413 – clause 5.4.4.4.1.3]
- l) VALVES FOR CLAMPING OPERATIONS - Hydraulically actuated clamps shall be controlled by two-position, double solenoid operated and four way valves. The clamp solenoid is to be maintained energized throughout the clamping cycle.
- m) VALVES FOR INDEXING MECHANISMS - Hydraulic indexing mechanism shall be controlled by three-position, spring centered, double solenoid operated four-way valves.

4.2.5. Filters, Regulators and Accumulators (FRA)

- a) An external suction strainer of 100 meshes shall be provided to protect the pumps from large debris or chips that may enter the reservoir. Strainers shall have external indication to show strainer cleanliness. [ISO 4413 – clauses 5.4.5.2.2.5 item b), 5.4.5.3.2.2, 5.4.5.3.3 and 7.3.1.1 item i)]
- b) Full-flow filters should be positioned in the circuit to achieve the targeted cleanliness level described in Section 4.2.2 item o). For systems without servo or proportional valves: [ISO 4413 – clause 5.4.7.4.3]
 - 1. Pressure line filters (with bypass capabilities) should be located between the pump and the relief valve back to the tank. This is to provide continuous filtration anytime the machine is running; [ISO 4413 – clause 5.4.5.3.2.1]
 - 2. Off line filters should be used on all systems without return line filters. The offline flow rate should be a minimum of 15% of system volume per minute; [ISO 4413 – clause 5.4.5.3.1]
 - 3. All filter assemblies shall include:
 - A visual / electrical differential pressure device with surge control, to prevent actuation due to transient pressure spikes, and thermal lockout, to prevent a false signal to replace the element due to high oil viscosity during cold start-ups; [ISO 4413 – clauses 5.4.5.3.2.2, 5.4.8.2, 5.4.8.5 and 7.3.1.1 item i)]
 - Maximum clean element differential pressure shall not exceed 0,7 Kgf/cm² with ISO 68 oil at average operating temperature;
 - An element capable of maintaining the target cleanliness code set for the system. [ISO 4413 – clauses 5.4.5.1.3, 5.4.5.3.1 and 5.4.5.3.2.1]

Note: Reinforcing that these gages shall be mounted so they are accessible for inspection and not far off the mounting surface of the hydraulic system. These gauges shall be located on the hydraulic system so that they can most accurately measure what they are intended to measure. They shall also be protected against system transients with some kind of isolator.

4. Pressure gage isolators for each circuit. [ISO 4413 – clause 5.4.8.2]
- c) Systems with a servo or proportional valve shall have (in addition to the item b) of this section and its sub points) a non-bypass isolation filter Beta greater than or equal to 100, fitted downstream of the pump and upstream of the valves(s). [ISO 4413 – clause 5.4.7.4.3]
- d) All reservoirs shall be fitted with air breather filters having a minimum filtration rating in air of Beta greater than or equal to 100. Pressure drop through clean breathers should not exceed 0.3 PSIG at maximum flow. **NOTE:** Maximum flow may be equal to return line flow. [ISO 4413 – clause 5.4.5.2.3.3]
- e) Hydraulic systems shall be provided with oil test ports immediately before the return filter and directly after each pump pressure outlet in an accessible location to obtain dynamic oil samples. [ISO 4413 – clauses 5.4.7.5.2 and 5.4.8.3]
- f) All accumulators classified as pressure vessel shall comply with standard ISO 16528 (NR-13 for Brazil). All accumulators shall be provided with a means to release pressure upon loss of power in no more than 30 seconds. Attention must be paid to the size of the accumulator and the speed of volume discharge. Safety of the system operator shall be of paramount concern in designing such a relief system.
- g) Duplex filters shall be used where the system cannot be shut down for element change.
- h) In the hydraulic tank, the filters should be installed in such a way that it is easy to be replaced without the need of withdrawal the volume of oil. [ISO 4413 – clause 5.3.2.1]

4.2.6. Cylinders

- a) The cylinder rods shall not be subject to buckling, distortion, scoring or any other damage. [ISO 4413 – clauses 5.4.2.1, 5.4.2.7, 5.4.2.8 and 5.4.2.13.1]
- b) Cylinders shall be mounted such that the motion axis is in alignment with the work slides, and the mounting shall be designed so no side or radial loads occur on the piston rod. The complete slides of the rod shall be used. [ISO 4413 – clause 5.4.2.7]
- c) Bellows or sleeves shall be used to protect cylinder rods and rod bearing when used in a harsh environment. [ISO 4413 – clause 5.4.2.13.1]

- d) Cylinders shall be equipped with adjustable flow control valves on both ends. The flow control valve shall control the cylinder exhaust. [ISO 4413 – clauses 5.4.7.3.2 and 5.4.7.3.3.1]
- e) Any components mounted on or connected to a cylinder shall be attached in a way that resists loosening caused by shocks, vibrations, etc. [ISO 4413 – clause 5.4.2.5]
- f) All cylinder ports shall be straight threaded and o-ring sealed.
- a) NFPA type cylinders shall be used.
- b) Modifications are permitted to cylinders (special mounting, rod ends, double rod ends) where modifications are required. The modification of internal cylinder parts is not permitted. All cylinder modifications shall be clearly marked on the hydraulic diagram.

4.2.7. Plumbing, Fittings and Hydraulic Passages

- a) Tubes (i.e., rigid conductors) should be always used. Hoses may be used if required for mechanical reasons, e.g. accommodation of movements of parts, damping of vibration or reduction of noise. [ISO 4413 – clauses 5.4.6.1.3.1]
- b) All plumbing, fittings, tubing and hoses shall comply with ISO 8434-1 or DIN 2353 standards.
- c) All hydraulic pipe threads can be either millimeters or American (National) Standard Taper Pipe Thread (NPT), meaning that it can be either chosen to use millimeters or inches.
- d) Tubing should be made of steel, unless other materials are agreed upon in writing, with EMBRACO engineers. [ISO 4413 – clauses 5.4.6.2]
- e) All hydraulic passages shall be free of burrs, sharp edges, and foreign materials. [ISO 4413 – clauses 5.4.4.3.4 and 5.4.6.4]
- f) Teflon tape shall not be used as a thread sealant. Liquid type thread sealants shall be used on tapered threads.
- g) Plumbing and tubing shall be mounted using commercially available mounting systems, such as Parker- Hannifin "Multi-Clamp", which shall guarantee secure support and at the same time not damage the tubes. The use of isolators in the plumbing mounting system is required. [ISO 4413 – clause 5.4.6.3]
- h) When plumbing is removed for shipping, all connections shall be clearly identified and protected from outside contamination. All plumbing shall be removable without removing equipment components. [ISO 4413 – clause 5.3.4.1]

- i) All parts of the hydraulic system shall be packaged for transportation in a manner that preserves their identification and protects them from damage, distortion, contamination and corrosion, including sealing and protection of openings. [ISO 4413 – clauses 5.3.4.2 and 5.3.4.3]
- j) Plumbing shall not be used to support components such as control valves. [ISO 4413 – clauses 5.4.4.2 and 5.4.6.1.3.3]
- k) Provision shall be made for quick -disconnect tap points in the hydraulic plumbing system so that pressure may be tested. [ISO 4413 – clause 5.4.7.5.2]
- l) Tubing shall not be internal to the machine or equipment.
- m) Pressure surges shall be minimized at their source. Protective devices shall be provided in the circuit(s) to protect piping and fittings from hydraulic impact. [ISO 4413 – clauses 5.2.2.2, 5.2.2.3 and 5.2.2.5]
- n) Piping shall have sufficient cross-sectional area to prevent cavitation, excessive power losses, and the generation of excessive heat. [ISO 4413 – clause 5.4.4.3.4]
- o) All connectors shall be permanent crimp type for hose assemblies.
- p) Piping should be identified or located in such a manner that it is not possible to make an incorrect connection that can cause a hazard or malfunction. The fluid direction shall also be depicted by applying arrows accordingly. [ISO 4413 – clause 5.4.6.1.4]
- q) All flexible lines, hoses, shall be vertically mounted, where possible, and have minimum length and sufficient slack, necessary to avoid sharp flexing and straining of the hose during the component operation. These lines shall not exceed five (5) meters in length. [ISO 4413 – clause 5.4.6.5.2 item a)]
- r) These flexible lines shall be constrained to avoid wear due to rubbing. [ISO 4413 – clause 5.4.6.5.2 item c)]
- s) Flexible lines, hoses, shall be supported, if the weight of the hose assembly could cause undue strain. [ISO 4413 – clause 5.4.6.5.2 item d)]
- t) When failure of a hose assembly can constitute a whiplash hazard, the hose assembly shall be restrained, by installing clamp holders attached to the machine structure, or shielded by suitable means. If this is not possible because of intended machine movements, information on the residual risks shall be clearly given. [ISO 4413 – clause 5.4.6.5.3.1]
- u) If the failure of a hose assembly can constitute a fluid-ejection hazard or fire hazard, it shall be shielded by suitable means. If this is not possible because of intended machine

movements, information on the residual risks shall be given. [ISO 4413 – clause 5.4.6.5.3.2]

4.2.8. Hydraulic Reservoirs

- a) Reservoir filling, draining and topping up operations shall be carried out using without disassembly of components. [ISO 4413 – clauses 5.4.5.2.2.5, 5.4.5.2.3.2 and 7.3.1.1]
- b) Hydraulic reservoirs shall have minimum one (1) drain port in the bottom part. It will have a 1/2 inch full flow ball valve for sample oil. It shall be evaluated the need of additional drain in order to empty the tank faster during cleaning procedure. The existing openings shall be fitted with steel plugs. A drip pan shall be provided mounted under the reservoir, with a specific and efficient method of draining. [ISO 4413 – clauses 5.2.5, 5.3.1 item n, 5.4.5.2.1 item d) and 5.4.5.2.2.5 items c) and d)]
- c) When hydraulic reservoirs are mounted on balconies or platforms above actuators, valves etc., they should be equipped with shut off valves to allow maintenance to be performed without draining the reservoirs. Limit switches should be used to sense that the valves are open to permit pump operation. [ISO 4413 – clause 5.4.4.3.4]
- d) Reservoirs shall be sufficiently sealed to prevent airborne contaminants and water from falling or dripping into the reservoir. [ISO 4413 – clauses 5.4.5.2.2.4 item e), 5.4.5.2.3.2, 5.4.5.3.2.5, 5.4.7.5.2 item b) and 5.4.8.2 item b)]
- e) All current sound abatement technology shall be applied to the design of the reservoir and the power unit in general, such as rubber foot mounts for reservoir, quiet pumps, etc. [ISO 4413 – clauses 5.2.4, 5.4.5.2.2.2, 5.4.6.1.3.1, 5.4.6.3.3]
- f) The oil reservoirs shall comply with the following requirements:
 1. They must not be mounted within bodies and bases of the machines;
 2. They must be sealed and provided with:
 - Visual level indicator;
 - Minimum level electric/mechanic controller;
 - Filling hole with diameter not smaller than 50 mm; [ISO 4413 – clause 5.4.5.2.2.5 item a)
 - Temperature indicator;
 - Air filter.
 3. Shall have at least one opening for cleaning. If the tank has internal divisions, it must have one opening for each of them;
 4. Stay away from the floor at least 150 mm. [ISO 4413 – clause 5.4.5.2.1 item h)]

4.2.9. Documentation

- a) The technical and commercial specification of the component must be completely described in the hydraulic scheme and in the parts list.
- b) A hydraulic circuit schematic shall be supplied showing each hydraulic component, including all inter-connecting lines. The standards ISO 1219-1 and ISO 1219-2, DIN ISO 1219 and ABNT NBR 8896 (for Brazil) shall be used to be conformed with. This schematic diagram shall be submitted to the responsible EMBRACO Engineer for approval prior to the building of the equipment. [ISO 4413 – clause 7.2]
- c) The schematic shall include a description text to explain the function of the components and the sequence of operation. [ISO 4413 – clause 7.2]
- d) The schematic shall indicate the pressure in kgf/cm² and the flow rate in liters/minute for each branch circuit. [ISO 4413 – clause 7.4.1]
- e) An instruction handbook describing system operation and maintenance, including the required maintenance and operating data, for all hydraulic equipment, including piping shall be provided. [ISO 4413 – clause 7.3.1]
- f) The documentation shall include a bill of material for all hydraulic components, following the Standard Description and template according to the Section 3.7.8. [ISO 4413 – clauses 7.2, 7.3 and 7.4.1]

This Bill of Material shall include minimally the following:

1. Manufacturers Name;
2. Model Number / Catalog Number;
3. Serial Number / Part Number;
4. Diameter of Cylinder with Rod Size and Stroke Length;
5. Pump Speed (RPM) and Delivery in liters per minute;
6. Horsepower (kW), Torque and rpm for Hydraulic Motors;
7. Capacity of Reservoir;
8. Quantity of Component;
9. Cost per Unit;
10. Delivery Time;
11. 12 Digits Column for EMBRACO Crib Number (Column only for Internal Control).

4.3. Pneumatic Installation

This chapter deals mainly with the ISO 4414 Standard, which sets out a large number of general recommendations in the design and execution of machine pneumatic transmission systems, thus this Corporate Standard supplies partially the General Rules Relating to Pneumatic Transmission Systems along with EMBRACO's best practices.

This International Standard shall be applied whenever the design, construction and modification of pneumatic systems and their components is demanded. By applying properly this ISO Standard, it is provided a means of conforming to Essential Requirements of the New Approach Directive 2006/42/EC on machinery.

Use of this International Standard assists in:

- a) identifying and specifying the requirements for pneumatic systems and components;
- b) identifying respective areas of responsibility;
- c) designing systems and their components to comply with specific requirements;
- d) understanding the safety requirements of a pneumatic system.

Deviations from that International Standard, along with this Corporate Standard, shall be previously agreed to in writing between the Supplier and EMBRACO.

4.3.1. Materials and Brands Homologated By EMBRACO

The list of homologated material's manufacturers and brands are in the Section 6.4, Annexes D's, so as to limit the unnecessary and uneconomical diversity of components in the respective site from EMBRACO. The preferable components to be used in the project are the ones listed in the First Choice Brand Column of the respective tables. The use of components placed in the Second Choice Brand Column shall be previously justified and agreed with the leadership of the respective Maintenance area involved, which the machine and/or equipment are to be delivered to, just to avoid any unexpected and unpleasant outcome afterwards. The use of components that are not homologated by EMBRACO shall be previously authorized in writing by the leadership of the respective Maintenance area involved.

The component lists in the Annexes D's are divided by each different country, site, thus it must be paid special attention to the component list to the respective country, site it belongs to.

4.3.2. General Construction Directives

- a) All components and piping shall be selected or specified so that they have adequate characteristics to allow them to operate reliably under all intended uses of the system.

- Particular attention shall be paid to the reliability of components and piping that could create a hazard in the event of their failure or malfunction. [ISO 4414 – clause 5.2.1.1]
- b) All pneumatic powered equipment and components shall be used and installed in accordance with the Component Manufacturer's recommendations. [ISO 4414 – clause 5.2.1]
 - c) The pneumatic machine and/or equipment must guarantee a perfect performance at a pressure of 6 bars or higher according to the specific application. [TEM 000329, TST 000067 + TEM 000840] and [ISO 4414 – clause 5.2.2]
 - d) All parts of the pneumatic system shall be designed to operate or otherwise protected against pressures exceeding the maximum working pressure of a system or any part of the system or the rated pressure of any specific component. All pneumatic components must be rated to handle continuous flow and pressure required by the individual system. [ISO 4414 – clause 5.2.2.1]
 - e) Over-pressure protection shall be provided. The preferred means of protection against excessive pressure is one or more pressure-relief valves located to limit the pressure in all related parts of the system. Other means, such as pressure-regulators, provided these means satisfy the application requirements. [ISO 4414 – clause 5.2.2.2]
 - f) In the design of pneumatic systems, the expected noise shall be taken into account, according to There shall be one, and only one, source of air supply to the machine and/or equipment and shall include a manually operated safety valve. More than one source must be approved by EMBRACO Maintenance's Representative in writing. Consult EHS Manual (TST 000067 + TEM 000840) for additional Information.
 - g) Pneumatic systems shall be designed to minimize air consumption.
 - h) Continuous air blow-off shall not be used. PLC logic control shall be provided to activate the air blow-off only when required.
 - i) The pneumatic machine and/or equipment shall be provided with a power line with a maintenance unit. This unit must be installed in an easily accessible and visible place for maintenance. [ISO 4414 – clause 5.4.4.1]
 - j) Mufflers shall be used on all air exhausts. Piping of the exhaust shall be into the machine and equipment frame or manifold. A muffler and a low point drain must be provided in the machine and equipment frame or manifold. [ISO 4414 – clause 5.4.8]
 - k) Whenever a pneumatic device works as a means to hold parts, it shall be ensured that the part will not be released in case of air leakage or pressure variation at the feeding line or energy fall. [ISO 4414 – clauses 5.2.2, 5.2.3, 5.4.6.1 and 5.4.6.9]

- l) Lubricators and valves shall be located as close as possible to the power actuator. [ISO 4414 – clauses 5.4.4.3.3 and 5.4.5.1.4]
- m) No air logic shall be used. All components such as valves, cylinders, ports, regulators, etc., shall be identified according to the schematic diagram, as close as possible to the component, with aluminum identification plate, riveted or screwed on the equipment. [ISO 4414 – clause 7.4]
- n) Light signaling shall be added to indicate the working conditions status, high, low and normal, for example, of most important variables linked to anomalies; like pressure, temperature and so on, so as to get easiness of inspection. The standard coloration of the criteria shall be Green for normal, Yellow for abnormal and Red for risky. It shall stand in one position and organized in a logical and intuitive way, divided by section of the machine, system, similar function and so on.
- o) The normal working range, setting pressure values from the components (pressure switch, vacuum switches, pressure gauges, regulators and so on) shall be identified in a precise, permanent, readily visible and conspicuously fashion. [ISO 4414 – clause 7.4.1.1]
- p) Components (pressure switch, vacuum switches, pressure gauges, regulators and so on) subjects to regular inspections and adjustments shall be all centralized and stand in one position, at the eye's height according to item w). It shall be organized in a logical and intuitive way; divided by section of the machine, system, similar function and so on.
- q) Specifically for Pressure Gauges with glass, the collared dial with indication of normal working range shall be done internally and never in the protection glass cover, since it can turn around and defeat the purpose. Normal working range shall be colored green and superior and inferior limit values as red.
- r) Specifically for Pressure Gauges with glass, they shall be sized, selected the range accordingly and organized as item p), with the central value of the normal working range positioned at 12:00, as Figure 7.
- s) It shall be integrated and centralized, all the pneumatic components: valves, switches and gauges along with light signaling, standing in one position and organized in a logical and intuitive way, divided by section of the machine, system, similar function and so on.
- t) For air motors, the direction of rotation shall be indicated. For filters, lubricators and regulators, the direction of flow shall be indicated. [ISO 4414 – clause 7.4.1.3]

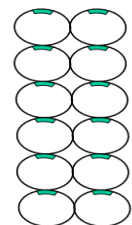


Figure 7: Gauges Alignment

- u) Pneumatic systems shall be designed to prevent uncontrolled movement of equipment power components, i.e., cylinders, and motors. Pneumatic system components performing safety-related functions shall be designed and constructed to fail to a safe, know state and be capable of being monitored for failure by the safety control system. [ISO 4414 – clauses 5.2.3 and 5.4.6.1]
- v) Pneumatic systems shall be designed such that valves controlling parallel devices are based solely on function and not timing. Consideration shall be given to different requirements in pressure, lubrication, speed, and wear of components in all parallel systems. Each parallel device shall have provisions for independent speed/flow control. Electrical control of parallel components shall be as per Section 4.4).
- w) Gages and switches with indication shall be mounted so they are accessible for inspection and no higher than 1.5 meters off the mounting surface of the pneumatic system, which in average should be the eye's height in average. They shall also be protected against system transients, rapidly fluctuating pressure with a snubber or isolator. [ISO 4414 – clauses 5.2.9 and 5.4.7.1.2]
- x) All pneumatic systems shall be thoroughly tested. After completion of testing and prior to shipment all system filter elements must be evaluated and replaced if so. Documentation will be provided to EMBRACO showing that the pneumatic systems passed preliminary tests and function to design specifications. [ISO 4414 – clause 6]

4.3.3. Valves

- a) All electrically operated pneumatic valves shall have indicator lights. [ISO 4414 – clauses 5.4.7.2 and 5.4.3.4.2]
- b) Solenoids shall be sized and selected (e.g., cyclic rate, temperature rating) so that they are capable of operating the valves reliably at minimum and maximum voltage, including the appropriate degree of protection in accordance with IEC 60529. Nominal voltage preferably 24 VDC +10% -20% [ISO 4414 – clause 5.4.3.4.2.3]
- c) Valve type and method of mounting shall be selected to ensure correct function, adequate leak tightness, maintenance or adjustment requirements, and resistance against foreseeable mechanical and/or environmental influence. [ISO 4414 – clause 5.4.3.1]
- d) Solenoid valves shall have manual overrides which can be operated without removing solenoid covers or enclosures, but which cannot be operated accidentally. [ISO 4414 – clause 5.4.3.4.2.4]

- e) Two position, double solenoid, detented valves are the preferred ones.
- f) Two position single solenoid; spring-return valve may be used if the safe operation of the equipment is dependent upon the valve returning to a "home" position in the event of a power failure. [ISO 4414 – clause 5.4.6.9]
- g) VALVES FOR CLAMPING OPERATIONS - pneumatically actuated clamps shall be controlled by two-position, double solenoid operated four way valves. The clamp solenoid is to be maintained energized throughout the clamping cycle.
- h) Systems that use three-position valves, particularly those with a closed centre position, should be analyzed to determine if leakage from the system and/or leakage through a valve can result in undesired effects, such as unexpected cylinder movement. [ISO 4414 – clause 5.4.3.8]
- i) There shall be means to avoid incorrect mounting of valves, e.g. mounting-bolt pattern, port identification or other identification. [ISO 4414 – clause 5.4.3.2 item b)]

4.3.4. Filters, Lubricators and Regulators (FLR)

- a) All pneumatic systems shall be supplied with a line filter installed at the point of connection to the supply line. This filter must be after the main lockable dump valve and must be accessible for service. [ISO 4414 – clause 5.4.4.2.1]
- b) Pressure regulators and lubricators shall be used in all branch circuits. The lubricators shall be mounted at the same level, or higher than the components that they service. Pressure gauges shall be applied to all regulators with its rated pressure readily identified on it. [ISO 4414 – clauses 5.4.4.1, 5.4.4.3.3 and 5.4.6.2]
- c) Air lubricators shall be equipped with a pressure fill button. Lubricators shall be located to allow easy access for filling. [ISO 4414 – clause 5.4.4.3.3]

4.3.5. Cylinders

- a) The cylinder rods shall not be subject to buckling, distortion, scoring or any other damage. [ISO 4414 – clauses 5.4.2.1 and 5.4.2.8]
- b) Cylinders shall be mounted such that the motion axis is in alignment with the work slides, and the mounting shall be designed so no side or radial loads occur on the piston rod. [ISO 4414 – clause 5.4.2.6]
- c) Bellows or sleeves shall be used to protect cylinder rods and rod bearing when used in a harsh environment. [ISO 4414 – clause 5.4.2.8]

- d) Any components mounted on or connected to a cylinder shall be attached in a way that resists loosening caused by shocks, vibrations, etc. [ISO 4414 – clause 5.4.2.4]
- e) Cylinders shall have adjustable cushions (dampers) on both ends to avoid mechanical shocks and vibrations. [ISO 4414 – clause 5.4.2.2]
- f) Cylinders shall be equipped with adjustable flow control valves on both ends. The flow control valve shall control the cylinder exhaust. [ISO 4414 – clause 5.4.3.7]

4.3.6. Piping, Fittings and Pneumatic Passages

- a) All piping, fittings, tubing and hose shall meet the appropriate ASTM standard, comply with the ISO 8434-1/ DIN 2353 and with any applicable state or local pressure piping code.
- b) All pneumatic pipe threads can be either millimeters or American (National) Standard Taper Pipe Thread (NPT), meaning that it can be either chosen to use millimeters or inches.
- c) All piping connections shall be designed and installed to permit quick removal and reassembly with hand tools. [ISO 4414 – clause 5.4.5.8]
- d) All pneumatic passages shall be free of burrs, sharp edges and foreign materials. [ISO 4414 – clause 5.4.3.3.4 and 5.4.5.4]
- e) Teflon tape shall not be used as a thread sealant. Liquid type thread sealant shall be used.
- f) Piping and tubing shall utilize commercially available mounting systems, such as Parker Hannifin "Multi-Clamp" (Fittings / Supports for fixing), which shall guarantee secure support and at the same time not damage the tubes or reduce the flow. Where vibration is expected, the use of isolators in the piping mounting system is required. [ISO 4414 – clause 5.4.5.5]
- g) When piping is removed for shipping, all connections will be clearly identified and protected with caps and/or plugs. [ISO 4414 – clause 5.3.4]
- h) Piping shall not be used to support components such as control valves and the latter are removed by dismantling the piping as little as possible. [ISO 4414 – clauses 5.4.3.2 and 5.4.5.2.2]
- i) Piping should be identified or located in such a manner that it is not possible to make an incorrect connection that can cause a hazard or malfunction. The air direction shall also be depicted by applying arrows accordingly. [ISO 4414 – clause 5.4.5.3.2]

- v) All flexible lines, hoses, shall be vertically mounted, where possible, and have minimum length and sufficient slack, necessary to avoid sharp flexing and straining of the hose during the component operation. These lines shall not exceed five (5) meters in length. [ISO 4414 – clause 5.4.5.9.2 item a)]
- w) These flexible lines shall be constrained to avoid wear due to rubbing. [ISO 4414 – clause 5.4.5.9.2 item c)]
- x) Flexible lines, hoses, shall be supported, if the weight of the hose assembly could cause undue strain. [ISO 4414 – clause 5.4.5.9.2 item d)]
- y) When failure of a hose assembly or plastic piping constitutes a whiplash hazard, it shall be restrained, by installing clamp holders attached to the machine structure, or shielded by suitable means. In addition, an air fuse for compressed air should be mounted. [ISO 4414 – clause 5.4.5.11.1]
- j) When the failure of a hose assembly or plastic piping constitutes a fluid ejection hazard, it shall be shielded by suitable means. [ISO 4414 – clause 5.4.5.11.2]

4.3.7. Storage Tanks

- a) Only storage tanks that comply with ISO 16528, NR13 (Brazil) for pressure vessels shall be used.
- b) Storage tanks shall be equipped with a condensate dump valve. [ISO 4414 – clause 5.4.10 item d)]
- c) Storage tanks shall be equipped with a safety relief valve.
- d) Storage tanks shall be equipped with a gauge pressure.

4.3.8. Documentation

- a) The technical and commercial specification of the components must be completely described in the pneumatic scheme and in the parts list.
- b) A pneumatic circuit schematic diagram shall be supplied showing each pneumatic component, including all inter-connecting lines. The standards ISO 1219-1 and ISO 1219-2, DIN ISO 1219 and ABNT NBR 8896 (for Brazil) shall be used to be conformed with. This diagram shall be submitted to the responsible EMBRACO Engineer for approval prior to the building of the equipment. [ISO 4414 – clause 7.2]
- c) The diagram shall include a descriptive text to explain the function of the components and the sequence of operation. [ISO 4414 – clause 7.2]

- d) The diagram shall show the operating gauge pressure in kgf/cm^2 and the consumption of free air in cubic meter per minute of each branch circuit. Over-all air consumption for the equipment shall be shown and an actual metered test must be demonstrated prior to shipment. [ISO 4414 – clauses 7.4.1]
- e) An instruction handbook describing system operation and maintenance, including the required maintenance and operating data, for all pneumatic equipment, including piping shall be provided. [ISO 4414 – clause 7.3.1]
- f) The documentation shall include a Bill of Material for all pneumatic components, following the Standard Description and template according to the Section 3.7.8. [ISO 4414 – clauses 7.2, 7.3 and 7.4.1]

This Bill of Material shall include minimally the following:

1. Manufacturer's Name;
2. Manufacturer's Model Number / Catalog Number;
3. Serial Number / Part Number;
4. Diameter of Cylinder w/rod Size and Stroke Length;
5. Horsepower, Torque, and RPM for Pneumatic Motors;
6. Storage Tank Capacity;
7. Quantity of Component;
8. Cost per Unit;
9. Delivery Time
10. 12 Digits Column for EMBRACO Crib Number (Column only for Internal Control).

4.4. Electric and Electronic Installation / Instrumentation / Industrial Information Technology

This chapter deals mainly with the IEC 60204-1 Standard, which sets out a large number of general recommendations in the design and execution of machine and equipment electrical systems. Thus this Corporate Standard supplies partially the General Rules Relating to Electrical Systems along with EMBRACO's best practices.

This International Standard shall be applied whenever the design, construction and modification of electrical systems and their components is demanded. By applying properly this IEC Standard, it is provided a means of conforming to Essential Requirements of the New Approach Directive 2006/42/EC on machinery.

Use of this International Standard assists in promoting:

- a) safety of persons and property;
- b) consistency of control response;
- c) ease of maintenance.

Deviations from that International Standard, along with this Corporate Standard, shall be previously agreed to in writing between the Supplier and EMBRACO.

4.4.1. Materials and Brands Homologated By EMBRACO

The list of homologated material's manufacturers and brands are in the Section 6.5, Annexes E's, so as to limit the unnecessary and uneconomical diversity of components in the respective site from EMBRACO. The preferable components to be used in the project are the ones listed in the First Choice Brand Column of the respective tables. The use of components placed in the Second Choice Brand Column shall be previously justified and agreed with the leadership of the respective Maintenance area involved, which the machine and/or equipment are to be delivered to, just to avoid any unexpected and unpleasant outcome afterwards. The use of components that are not homologated by EMBRACO shall be previously authorized in writing by the leadership of the respective Maintenance area involved.

The component lists in the Annexes E's are divided by each different country, site, thus it must be paid special attention to the component list to the respective country, site it belongs to.

4.4.2. Electric Motors – Technical Specifications

The brands of motors approved by EMBRACO follow in the Section 6.5, Annexes E's. See also Section 4.4.4.10 for Construction Directives.

- a) Alternating current motors, with squirrel cage rotor:

a.1) building and constructive shape according to IEC 60034-7 and ABNT NBR IEC 60034-7 (for Brazil);

a.2) performance class: high performance. Motors shall be premium efficiency motors, according to the class defined in the IEC 60034-30 and Ordinance 553 from the Energy Efficiency Law 10.295 (for Brazil);

a.3) insulation class: B (minimum), according to IEC 60034;

a.4) protection class: depending on the application IP 54 or IP 55 according to IEC 60034-5, with the following requirements:

- ✓ sealing of the condensation water drains;
- ✓ cable clamp at the junction box;
- ✓ connection screw for ground wire;
- ✓ terminal plates;
- ✓ when necessary, it must be protected against explosive gases or liquids;
- ✓ PTC temperature monitoring (in special cases).

a.5) Electromagnetic compatibility: according to IEC 60034-1

a.6) Noise limits: according to IEC 60034-9

a.7) Nameplates: according to IEC 60034 and ABNT NBR 17094 (for Brazil)

b) Direct current motors:

b.1) building according to IEC 60034, IEC 60072 and DIN-VDE-0530;

b.2) constructive shape: according to IEC 60034/ABNT NBR IEC 60034 (for Brazil);

b.3) insulation class: F, used according to class B (DIN-VDE 0530);

b.4) protection class: IP 54 or IP 55 according to IEC 60034, with all options specified item a.4) above;

Note: The use of DC motors must be done only after approval of the Maintenance Area involved.

c) General considerations for motors, please check the section 3.5 for more details on the available Power Supply according to the respective site, prior to selecting any motor electrical configuration:

c.1) Motors up to 5.5 kW (7.5 HP) with following connecting group options:

- ✓ 220/380 V;
- ✓ **480V; (Only for EMBRACO Mexico)**
- ✓ 380/660 V;
- ✓ 220/380/440/760 V.

c.2) Motors with more than 5,5 kW (7.5 HP) must be connected exclusively on 380/660V. It has to be carefully evaluated for Mexico situation, due to voltage constraints.

Note: The motors above mentioned on item c.2 must not be direct starting, must be by way of compensation, star-triangle, soft-starter or frequency converter

c.3) all the motors must be controlled by contactors and/or electronically activated and must be provided with individual overload, short circuit and phase failure protection;

c.4) the motor rotation direction for that specific application must be indicated;

c.5) the motor terminal boxes must be located in the equipment in such a way as to allow free access to them;

c.6) all the motors must be equipped with terminal boxes provided with terminal plates. Loose conductors will not be accepted;

c.7) all motors must have nameplates according to IEC 60034. Specially balanced motors or those having special insulation shall be so indicated on the motor nameplate and also on spare part list;

c.8) for the starting procedure of the star-triangle shaped motors, the conjugate analysis must be done individually;

c.9) the voltage on an electric motor brake shall be the same voltage as the motor. When the motor is controlled by a variable frequency drive, a separately controlled supply source shall control the brake;

d) A disconnecting device is recommended to be installed for all motors. The disconnecting device shall be installed close to the motor and be used mainly for maintenance purpose. If the motor is controlled via a PLC-system, it is also recommended that the disconnecting device has an auxiliary contact for a feedback function to the PLC-system. The disconnecting device shall be "lockable". Each disconnecting device shall be clearly identified with durable marking to indicate the installation or circuit which it isolates.

General Notes:

- ✓ Whenever necessary to use equipment from non-accredited Suppliers it is compulsory to have them approved by maintenance and by IT.

- ✓ In case Maintenance of the area and IT approve another manufacturer, it shall supply the entire software/hardware and the necessary training to set the machine working and to maintain the equipment.
- ✓ Even with the already accredited brands, there are always new products being launched. In those cases it is also necessary to have an updated version of the specific software as well as training.
- ✓ A critical analysis shall be carried out as to the model to be used so that models which production will soon be interrupted are not used.

4.4.3. Industrial Information Technology

Industrial Informatics information can be divided in two parts, according to highlight in Figure 8 (Level 3 and Level 2).

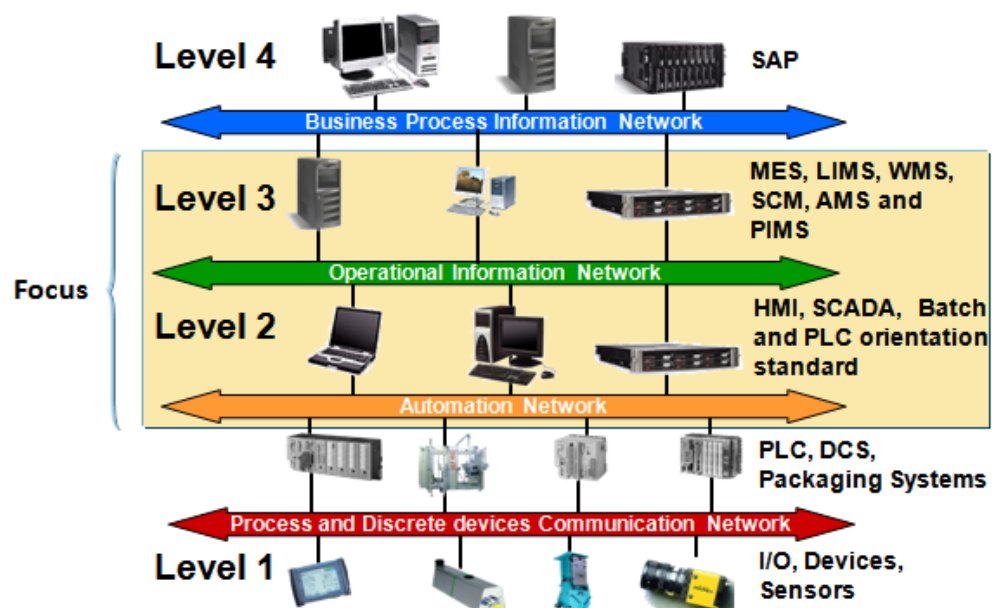


Figure 8: Automation layers according to ISA 95 orientation

This chapter has the objective to show the standard and guarantee preparation of hardware and software to get the information from machines and integrate them to the MES (Manufacturing Execution System), legacy systems and SAP. By following this document, the result is to have a low Total Costs of Ownership (TCO) that will help on having:

- a) Low hardware maintenance costs, and
- b) Lower diversity technology to IT and maintenance team.

4.4.3.1. Level 2, Workstation/PC:

In this section is presented the standard for keeping the high service level and security for Level 2 informatics equipment. All retrofitting strategies need to follow the same orientation.

a) Hardware

IT department must be consulted for information about the system requirements and hardware (minimum configuration) for Workstation/PC. That is, any PC/Workstation that will be connected to the machine and collect data must be approved by Informatics.

b) Software inside

b.1) Operating System

- ✓ The Operating System must be the one used as standard of the company – IT department must be consulted;
- ✓ If needed to purchase License for Windows and Ghost (EMBRACO), a Call must be addressed to IT;
- ✓ The user of the system (operation user) cannot be the administrator of the PC;
- ✓ The software must allow Symantec (Norton) anti-virus installation;
- ✓ The network configuration of the machine must follow following standards:
 - TCP / IP protocol;
 - Setup address by DHCP;
 - Hostname of the machine have to follow the pattern EMXXMIXX, where XX is provided by EMBRACO - consult IT;
 - The name of the Windows working group must be EMBRACO.
- ✓ IT infrastructure analyst will be together while implementation is performed;
- ✓ Machines supplied by third parties (mainly imported) must consider remote access for maintenance, but it is necessary to consult IT for each application to be assessed to network security.

b.2) Supervisory

- ✓ i-Fix (Intellution), Win CC, RSView 32 (Rockwell);
- ✓ To use the Ellipse or Wizcon, consult IT.

Note: the engineering licenses for the development of the supervisory must be purchased joined to machine and/or equipment.

b.3) Database

- ✓ Database Manager: SQL standard, consult IT with local database, allowing autonomy of the system in case of network failures;
- ✓ Create a purge routine of the local database allowing EMBRACO to set the timetable for implementing the routine and the period of data retention.

c) Storage

c.1) Information required

- ✓ Model code
- ✓ Good Parts
- ✓ Bad Parts
- ✓ Anomaly Time
- ✓ Time waiting pallet
- ✓ Time of exchange (different kinds)
- ✓ Stopped by failure
- ✓ Stopped by the operator
- ✓ Measurement results
- ✓ Kind of defect (reprocessing)
- ✓ Programmed maintenance time

c.2) Standardization of table

- ✓ The local database must have the following tables and fields.

- Production

- PO (Production Order)

- Model (Product Name)

- Begin_production (dd/mm/yyyy hh:mm:ss)

- Date_Hour (dd/mm/yyyy hh:mm:ss)

- Equipment or/and station (name)

- Production_OK

- Production_not_Ok

- Production_Total (turno)

- Reprocess (Cause)

- Scrap (Cause)

- PO_End

- Cycle_time

- Cycle_time_average (100 last parts)
 - Cycle_time_standard
 - Results (only for equipments that perform measurements)
 - Model
 - Test_name
 - Date_Hour (dd/mm/yyyy hh:mm:ss)
 - Equipment or/and station
 - Serial_Number (date + hour + line + 4 sequence numbers)
 - Result
 - Stop
 - Cause (stop button, safety door or safety, manual, anomaly, setup, calibration)
 - Stop_Begin (Start of stoppage (Stop dd/mm/yyyy hh:mm:ss))
 - Start_Begin (Start of machine functioning (Start dd/mm/yyyy hh:mm:ss))
 - Diagnosis (Diagnosis of broken, user need to confirm the diagnosis with a pre-defined list (list of EMBRACO))
 - Alarm (with comments)
 - Waiting
 - Cause (input without pieces or the output with stopped pieces, only in automatic state)
 - Waiting_Stop_Begin (Start of stoppage (Stop dd/mm/yyyy hh:mm:ss))
 - Waiting_Start_Begin (Start of machine functioning (Start dd/mm/yyyy hh:mm:ss))
 - Change_of_parameter_input (Main program sender parameters)
 - PO
 - Model
 - Quantity
 - Forecast_Begin
 - Change_of_Model_parameter_input (Main program sender parameters)
- c.3) Standardization of users
- ✓ Database user: the user must be created: sa, with a default password: Embraco@industrial1020 (this password will be modified by EMBRACO).

- ✓ System user: it must be created users for: operator, maintenance, administration, calibration, with specific access levels for each function.

d) Data Collection

d.1) Communication with supervisory

- ✓ Communication between PCs: Ethernet;
- ✓ Communication between PLC and OPC server: Ethernet;
- ✓ IP for each machine must be in specific range - consult IT;
- ✓ Communication between PCs and PLCs: Ethernet or industrial network, if cycle time is not impacted;
- ✓ Communication between the local database and server: ODBC.

d.2) Visualization

- ✓ Information that must be available to the operator:

Production Order

Model

Quantity planned

Quantity produced

Number of missing parts

Upcoming models scheduled

Production Order

Model

Quantity planned

Start planned

4.4.3.2. Level 2, PLCs connection with standard architecture

The main objective of this chapter is to understand how the PLCs will be connected to the MES for collecting production data automatically, as much as possible. The definitions established, like system architecture, OPC solution and PLC data collection guidelines can be used to drive the connection of lines on EMBRACO's plants.

The purpose is to show how the automatic data collection from line will be done, explaining how PLCs will be connected to the network and how the function block template will work to collect information from each station to the Data Acquisition Server (OPC server), which will make data available to MES.

It's important to note that all information from PLCs will be available on the Data Acquisition Server if the data really exist on the shop floor and are available on PLC program.

This functional description is valid for any station connected on Data PLC.

a) Architecture

To understand better how all PLCs and servers will be connected, a network topology was developed with all equipment separated by levels according to ISA 99 standard.

The first architecture, which can be found in Figure 9, was proposed aiming the objectives of the connection, considering implementation costs and benefits, and represents the standard architecture for connecting PLCs to the Ethernet, providing data on level 3. The PLC data must be sent to the Data Acquisition Server (OPC).

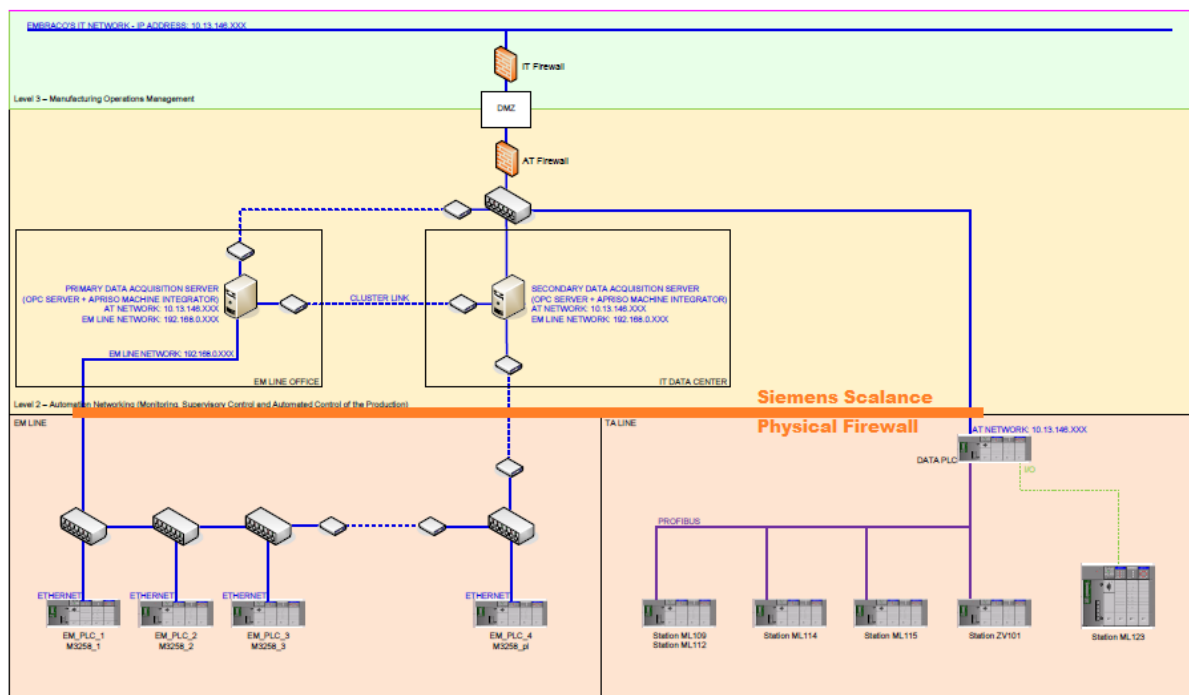


Figure 9: Example of recommended architecture including recommendation of physical firewall

Architecture for all lines must consider one OPC server per production line, according to Figure 10.

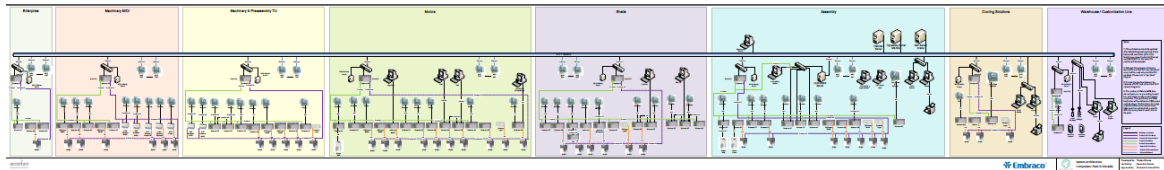


Figure 10: Architecture for whole Plant

In order to have separated subnets for each Production Line, it's required also PLC compatibility with Siemens Scalance XM416. This device will be included between PLCs (separated in subnets) and OPC server, according to Figure 11 below.

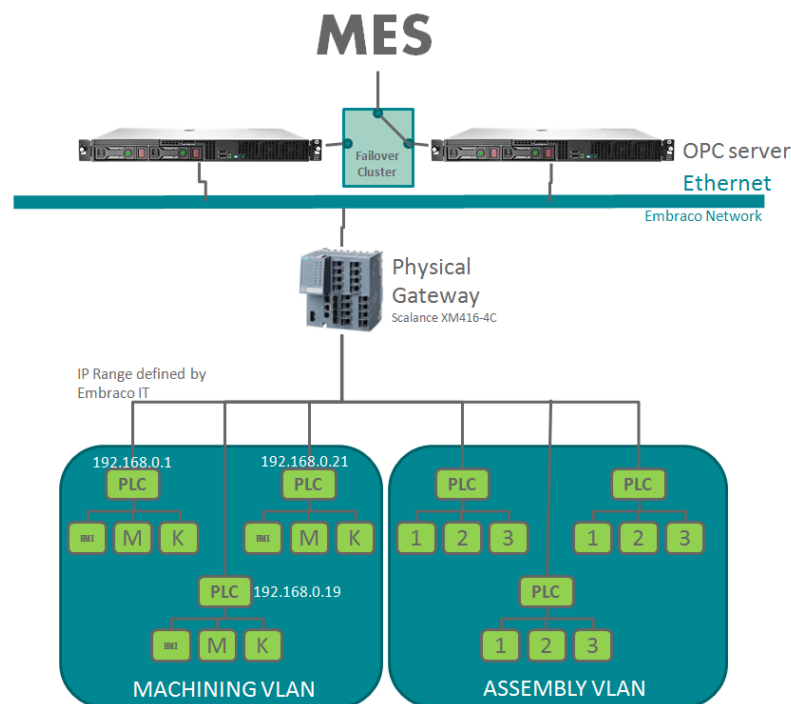


Figure 11: Architecture using physical Firewall – Siemens Scalance

b) PLC Hardware Orientation for connection with level 3

Adopt a minimal SIEMENS S7-300 family, in order to use standardized FUNCTION BLOCKS developed for EMBRACO for metric calculation (such as cycle time, downtime, counting of parts, and other necessary data).

It is desirable that PLCs used on the new applications be from the same manufacturer, in order to have more standardized assets, reducing TCO and leveraging availability. Our recommendation to use PLCs from SIEMENS S7-300 family (allowing Ethernet connection) is aligned with EMBRACO current asset map.

Using the same SIEMENS S7-300 family would help with data connection, as it would be possible to use built-in communication features between SIEMENS PLCs and to use the same FUNCTION BLOCKS developed.

In case of difficulties to use SIEMENS S7 family PLCs on all stations, it is desirable that the PLCs acquired are capable to communicate using Profinet.

In case of not using SIEMENS PLCs, the acquired PLCs must communicate using Industrial Ethernet and, in this case, it should be provided other driver for the OPC server, in order to connect it with those PLCs.

c) Function Block Structure

To provide the information of each PLC to Data Acquisition Server, the signals of stations will be available by a function block template. This function block template was designed to collect data from PLCs without compromising the control logic running (process data) on each one and can be used as a guidance to collect data from other Siemens S7 PLCs within EMBRACO plants.

Another benefit of this function block template regards to addressing standardization of signals provided to the Data Acquisition Server.

The function block – for each station - must provide the following information:

- ✓ Running Status
- ✓ Failure Status
- ✓ Failure Code
- ✓ Emergency Status
- ✓ Automatic Mode
- ✓ Ready Status
- ✓ Starving Status
- ✓ Blocked Status
- ✓ Ok Parts by Shift
- ✓ Reworked Parts by Shift
- ✓ Scrapped Parts by Shift
- ✓ Not Ok Parts by Shift
- ✓ Total Parts by Shift
- ✓ Product Name

- ✓ Station Name
- ✓ Shift Name
- ✓ Cycle Time
- ✓ Energy Consumption
- ✓ Water Consumption
- ✓ Setup Mode
- ✓ Production Order
- ✓ Quality Data (Attribute)
- ✓ Quality Data (Variable)

The function block template will work to collect the data from each station to the Data Acquisition Server.

Note: It's important to note that all information from PLCs will be available on the Data Acquisition Server and the data must to be available on PLC program. Furthermore, this template is proposed only to PLCs Siemens S7 Series.

d) Definition of Function Block Template

The function block proposed is able to get 45 variables from each station and deliver them to Data Collection Server. The variables defined are shown below:

Definition of signals for Connectivity project		
NAME	DESCRIPTION	TYPE
Actual_OK	Quantity of ok parts in current shift	INT*
Actual_RW	Quantity of reworked parts in current shift	INT*
Actual_Scrap	Quantity of scrapped parts in current shift	INT*
Actual_NOK	Quantity of not ok parts in current shift (sum of reworked and scrapped parts)	INT*
Actual_Total	Total of parts in current shift	INT*
ShiftA_OK	Quantity of ok parts in shift A	INT*
ShiftA_RW	Quantity of reworked parts in shift A	INT*
ShiftA_Scrap	Quantity of scrapped parts in shift A	INT*
ShiftA_NOK	Quantity of not ok parts in shift A (sum of reworked and scrapped parts)	INT*
ShiftA_Total	Total of parts in shift A	INT*
ShiftB_OK	Quantity of ok parts in shift B	INT*
ShiftB_RW	Quantity of reworked parts in shift B	INT*
ShiftB_Scrap	Quantity of scrapped parts in shift B	INT*
ShiftB_NOK	Quantity of not ok parts in shift B (sum of reworked and scrapped parts)	INT*

Definition of signals for Connectivity project		
NAME	DESCRIPTION	TYPE
ShiftB_Total	Total of parts in shift B	INT*
ShiftC_OK	Quantity of ok parts in shift C	INT
ShiftC_RW	Quantity of reworked parts in shift C	INT*
ShiftC_Scrap	Quantity of scrapped parts in shift C	INT*
ShiftC_NOK	Quantity of not ok parts in shift C (sum of reworked and scrapped parts)	INT*
ShiftC_Total	Total of parts in shift C	INT*
ShiftD_OK	Quantity of ok parts in shift D	INT*
ShiftD_RW	Quantity of reworked parts in shift D	INT*
ShiftD_Scrap	Quantity of scrapped parts in shift D	INT*
ShiftD_NOK	Quantity of not ok parts in shift D (sum of reworked and scrapped parts)	INT*
ShiftD_Total	Total of parts in shift D	INT*
Running_Status	Station is cycling correctly in automatic	BOOL
Failure_Status	Station is stopped due to a fault	BOOL
Failure_Code	Predisposition for coding of the cause of failure – operator must be able to insert reason code on HMI – also by barcode scanning - according to Reason Codes List (free space)	INT
Emergency_Status	Station is in emergency (possibly also safety guards open)	BOOL
Automatic_Mode	Station is in automatic mode but not running	BOOL
Ready_Status	Station is in automatic mode and there's no failure	BOOL
Starv_Status	Station empty and waiting for pallet	BOOL
Block_Status	Station cannot evacuate pallet because line is full	BOOL
Product_Name	Name of final product (<i>semifinished product [HALB]</i> – in case of component Production Line - or <i>Finished Goods [FERT]</i> – in case of Assembly Production Line, according to production order on SAP) currently in line	STRING / INT
Station_Name	Name of station which is sending information	STRING
Shift_Name	Name of current shift	STRING
Cycle_Time	Duration of cycle time, in seconds, considering start and end of cycle time according to SOP009912	INT*
Energy_Consumpt	Energy consumption measurement of machine, in kWh	INT*
Water_Consumpt	Water consumption measurement of machine, in liters	INT*
Material_Consumpt	Material consumption measurement of machine, in proper unity	INT*
Setup_Mode	Machine is on Setup (or Washing) mode (i.e. counting of parts must be ignored during the cycle)	BOOL
Production_Order	Predisposition for insertion of the Production Order – operator must be able to insert Production Order number on HMI – also by barcode scanning - according to planning (free space). Insertion of Production Order number is mandatory, functioning as a poka-yoke for allowing production start the new Production Order.	INT
Quality_Data_ <i>n</i>	Value of quality measurement on part during the process - <i>n</i> refers to quantity of characteristics measured on machine)	INT*
Quality_Data_ <i>i</i>	Attribute if condition for quality signal is OK (True) or NOK (False) - <i>i</i> refers to quantity of characteristics evaluated on machine)	BOOL

Definition of signals for Connectivity project		
NAME	DESCRIPTION	TYPE
Virtual_SN	Sequential virtual serial number created by for each part in order to have genealogy and traceability – <i>only for Assembly line</i>	INT

Note:

- All signals are sent to OPC Server, passing through Siemens Scalance XM416 (Apriso Machine Integrator gathers data from OPC);
- PLC must be able to store data of 3 shifts, at least, in internal memory;
- Data insertion (Production Order and Failure Code) must be done through HMI on Production Line, allowing input using barcode scanner;
- For virtual serial number detailing, consult IT.

It is recommended to create the function block and data blocks on the PLC program in a specific location to avoid any problem with existing control logic. So, the function blocks number recommended is 3000 and data blocks number starts from 3001 until 3XXX where each XXX number corresponds to each process station. However, if there are two identical stations on the same line, for example station ST.180A and ST.180B, the first data blocks number would be 3180 and the second, 3181. In other words, all the information for MES must not affect production data: process and production data in memories below 3000 and MES data above 3000.

The name of the function block is defined as STD OPC DATA and the data blocks as OPC DATA ST XXX, where XXX corresponds to the station number.

According to quantity and quality of data in accordance to the previous signals table, the **level of connectivity** of each machine is classified in levels from 0 to 4, according to the table below. For machines and equipment with Quality Variables measurements, it's mandatory to achieve **Level 4** in order to provide complete information in accordance to business requirements. In the other cases it's just recommended and desirable to achieve **Level 4**.

Connectivity levels:	
0	<p>No information is sent by station to MES or this information is not yet provided. Station information is totally manual.</p> <p>Ex: ST020A in Pre-Assembly - Stator loading on conveyor;</p>
1	<p>Station sends parts counting or bits concerning status of machine, like "emergency status". With this information it's still not possible to have calculation and evaluation of OEE.</p> <p>Ex: ST190 in Pre-Assembly - Suction of burrs from mechanical kit;</p>
2	<p>Station sends information for OEE calculation and analysis (counting of parts and machine status). Standard defined as implemented in Slovakia's MES pilot, according to TST 000138 version 1.</p> <p>Ex: ST055 in Pre-Assembly - Load Bearing and Washers;</p>

3	Station sends all information contained in this current TST 000138 version + quality data (only information if variable is out of specification limit - upper and lower - is provided). Ex: <i>ST140 in Pre-Assembly - Air gap between rotor & stator measurement and axial clearance;</i>
4	Same information sent by connectivity level 3 + exact value of measured variables for this station . Ex: <i>ST070A in Pre-Assembly - Rotor insertion and automatic axial clearance check (pressing).</i>

Figure 12: Classification on Connectivity Levels for Machines

e) Availability of Signals for *Andon*

The Industrial Information System must be capable of making the following superior level signals available on *Andon* Stack Light's level – see Section 4.4.5.3 and *Andon* Flash Light's Level – see Section 4.4.5.4. According to business rules, flow from Level 3 to Level 2 and 1 (ISA 95 Orientation) must be possible, i.e., allowing OPC server to send signals to PLC. Follows the Embraco Andon Rules for the superior level signals:

1. Process Control out of specification: Identified in measurements on charts and follow-up process. If the parameters are above the specified, should trigger the help chain. PLC must be able to receive bit regarding Process out of control from OPC server;
2. Equipment break down: Equipment break down signal;
3. Adjustment: Equipment adjustment signal – same as break down;
4. Setup time over target: Line technician trigger the *Andon* manually;
5. Lack of material: Lack of components to execute the operation – same as Starving;
6. Lack of Labor: Manual trigger at the beginning of the shift when the number of people is insufficient (by line technician).
7. Over cycle: Workstation (manual or automatic) working above its normal cycle time.
8. Energy and material consumption: When the machine is consuming energy or raw material more than the specification.

f) Others PLC and Measurement System

- ✓ Settings of PLCs with more than 60 points, use supervisory with diagnosis of failure to problem solving, implementation of hand controls, parameterization,

productive data visualization, test results and so on. (Relevant equipment).

All machine and/or equipment must be provided with supervisory;

- ✓ Structure PLC: if points of I/O are far from the panel containing the CPU, use I/O distributed;
- ✓ In the PLCs, CNCs and robots consider 20% of technical reserve for the points of I/O, with modules available;
- ✓ Measurement Systems: Use architecture PC + data acquisition board (National Instruments / Lab View).

4.4.3.3. PC & HMI Console

In order to avoid problems on Computers and HMIs, such as wear, accelerated deterioration, misuse and etc., there is a recommendation of adding some protective devices, which are able to provide protection, mobility and robustness to the respective cited components. It's important that its screen's support be flexible for the operator to use and the protection material be strong enough to protect the equipment against the normal mechanical shocks and impacts due to the daily routine utilization.

4.4.4. Construction Directives

4.4.4.1. Control Circuit and Control Voltage

Control Circuit is used for the control, including monitoring, of a machine and the electrical equipment. [IEC 60204-1:2009 clause 3.8]

E.g.: from secondary side of a transformer.

Control Voltage is the main and primary part of the Control Circuit, responsible for controlling and providing the necessary electrical voltage to the Control Circuit and its electrical elements. Figure 13 shows a Control Voltage controlled by a PLC, which is the preferred solution.

Each Electrical Cabinet shall have its own Control Voltage. Where control circuits are supplied from a DC source, the nominal voltage shall be 24 VDC. Where control circuits are supplied from an AC source, control transformers shall be used for supplying the control circuits and the nominal voltage shall be 220 VAC. The 24 VDC is the preferred voltage and shall be used whenever it is possible. The primary side of the control circuit transformer shall not be connected to neutral (N). The common conductor on the secondary side of the control circuit transformer shall be connected to protective bonding circuit. The secondary side shall be provided with a fused miniature circuit breaker. It may be split into different branches. Each branch shall then be fused and distributed via "disconnect" distribution terminals to facilitate troubleshooting by Maintenance. Branches shall be either internal or external (i.e. not mixed). Each branch can contain up to 10 connections, but 5 is an optimum number of objects supplied from one distribution terminal. Beige terminals shall be used for distribution of control circuits. [IEC 60204-1:2009 clauses 7.2.4, 9.1.1 and 9.1.2]

When designing the Control Voltage Circuit, Voltage and Current drop must be considered.

The branch supplying the output modules shall be connected via two separate contacts in the emergency stop circuit. When an emergency stop occurs, the power to the output modules shall be switched off. Due to this, it is important to design the circuits in such way that they are safe at an emergency stop or a power loss. Functions that need to be active during emergency stop are excluded but shall then be collected on separate I/O modules marked with a textual comment in the label "Not deactivated at Emergency stop".

In the Main Control Panel there shall be a key operated switch for all Control Voltage on the machine. The circuit shall be designed so that the Control Voltage is not switched off until the machine is standing still. It shall only be possible to switch on the Control Voltage again with the same key operated switch. [IEC 60204-1:2009 clause 9.2.3]

All cabinets shall have a feedback signal from the own Control Voltage to its own PLC.

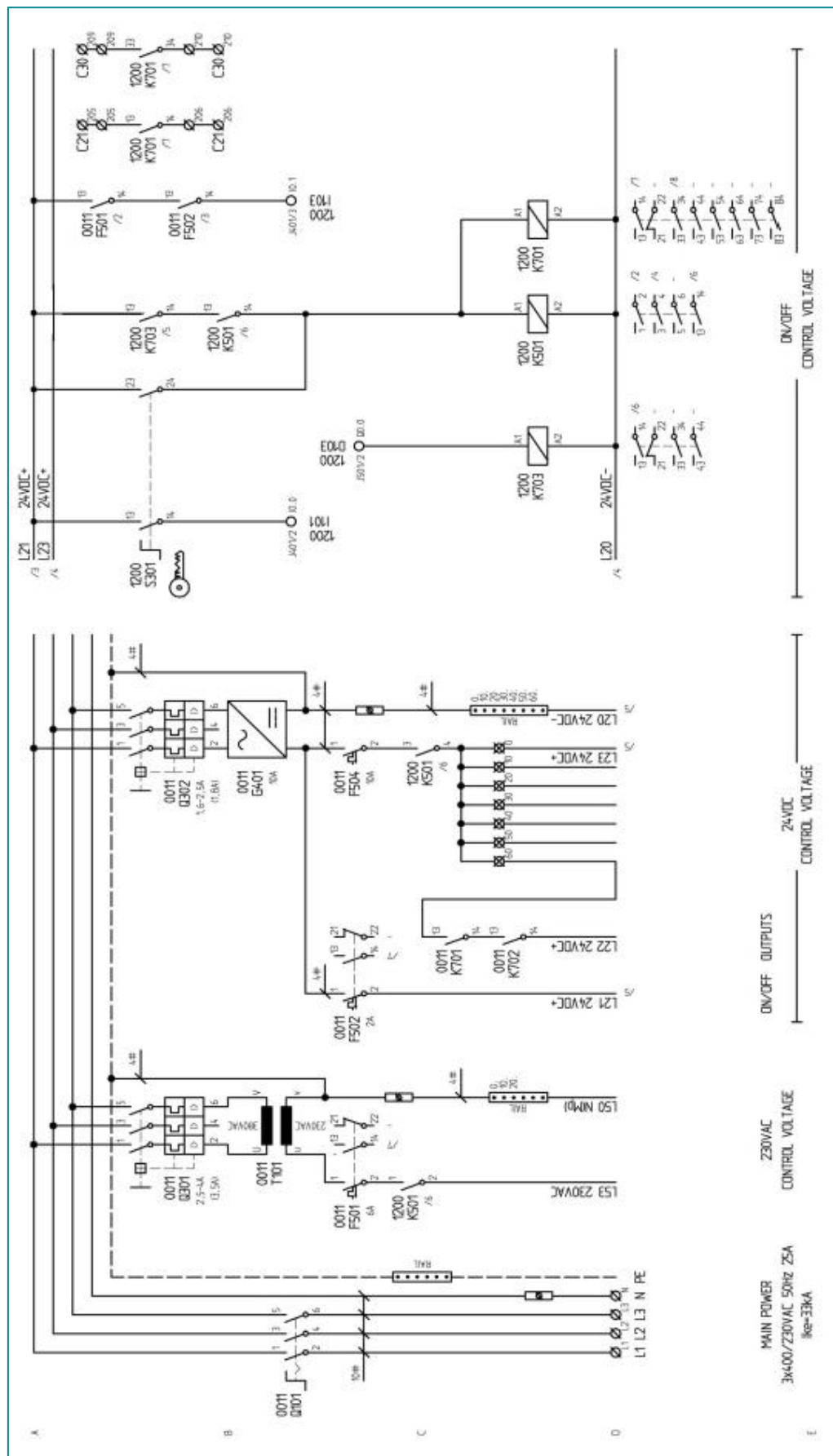


Figure 13: Control Voltage Circuit

4.4.4.2. Control Transformer

Control transformers shall have separate windings. [IEC 60204-1:2009 clause 9.1.1, partly] - Control transformers should be shielded. [IEC 60204-1:2009 clause 4.4.2, partly and modified] - Control transformers shall exclusively supply Control Circuits and provide at least 25% additional capacity for possible later supplements.

4.4.4.3. General Construction Directives

- a) **Wiring Colors Coding** - The following color requirements apply to conductors and circuits, mainly colors for wiring in Cabinets, Consoles and Control Panels: [IEC 60204-1:2009 clauses 13.2.2, 13.2.3, 13.2.4, partly and modified]

Table 1: Wiring Colors Coding

Conductors and Circuits	Colors
Power circuits AC	Black
Neutral conductor AC	Light blue (N)
Power circuits DC	Black
Protective ground conductor (earth)	Green-and-Yellow
Control voltage & Control circuit AC	Red
Control voltage & Control circuit DC	Dark Blue
Live conductor when supply disconnecting device is open (IEC 60204-1:2009 clause 5.3.5, partly and modified)	Orange
Interlock for safeguarding (According to EHS Recommendation Proposal)	Orange "OR" Yellow
Analogue signals	Grey
Analogue 0V reference	White
Analogue Shield	Transparent (hose)

Interlock for safeguarding is an arrangement that interconnects guard(s) or device(s) with the control system and/or all or part of the electrical supply to the machine. [IEC 60204-1:2009 clause 3.32]

Note: Identify the phase sequence on the power conductor points. The power supply lines must always run clockwise. Where an incorrect phase sequence of the supply voltage can cause a hazardous situation or damage to the machine, protection shall be provided. [IEC 60204-1:2009 clause 7.8]

Exceptions: to the above table are permitted where:

- individual devices are purchased complete with internal wiring;
- insulation is used that is not available in the colors required; or

- multiconductor cable is used, but not to the bicolor combination GREEN-AND-YELLOW.

Where the protective conductor can be easily identified by its shape, position, or construction (for example a braided conductor, uninsulated stranded conductor), or where the insulated conductor is not readily accessible, color coding throughout its length is not necessary but the ends or accessible locations shall be clearly identified by the graphical symbol IEC 60417-5019 (DB:2002-10) or by the bicolor combination GREEN-AND-YELLOW. [IEC 60204-1:2009 clause 13.2.2, partly]

Uninsulated conductors used as neutral conductors shall be either colored by a stripe, 15 mm to 100 mm wide in each compartment or unit and at each accessible location, or colored throughout their length. [IEC 60204-1:2009 clause 13.2.3, partly]

The following circuits need not be disconnected by the supply disconnecting device: [IEC 60204-1:2009 clause 5.3.5, partly and modified]

- Lighting circuits for lighting needed during maintenance or repair;
- Plug and socket outlets for the exclusive connection of repair or maintenance tools and equipment (for example hand drills, test equipment);
- Under voltage protection circuits that are only provided for automatic tripping in the event of supply failure;
- Circuits supplying equipment that should normally remain energized for correct operation (for example temperature controlled measuring devices, product (work in progress) heaters, program storage devices);
- Control circuits for interlocking.

It is recommended, however, that such circuits be provided with their own disconnecting device apart from the principal one.

In such electrical circuits "Orange conductors" inside the cabinet shall be applied, which indicate that the conductors may be live, even when the safety disconnecting device is turned off.

Where such a circuit is not disconnected by the power supply disconnecting device, which means there are externally powered circuits in a cabinet, see Section 4.4.7 for the identification:

- A permanent WARNING label shall be placed in proximity to the Cabinet's Main Switch. There shall also be a permanent WARNING label inside the cabinet stating that Orange wires are not disconnected by the cabinet's main disconnecting device.
- The terminals for the externally powered circuits shall be fitted with TOUCH PROTECTION and a WARNING label if the Voltage exceeds 60V. See item 4.4.7.3.5.

[IEC 60204-1:2009 clause 5.3.5, partly and modified]

There is also an additional request from EHS to identify Interlock for safeguarding (safety devices and safety circuits) for ease of viewing, by applying "Orange wires" as well, on its electrical connections, except for its electrical supply wires including neutral and ground that must follow the color coding definition according to the Table 1. Thus, since "Orange wires" might be applied for those two distinct cases explained before and in order to avoid any mixing of functionalities, Brazil's Maintenance Engineering Team has requested to apply "Yellow wires" for the electrical connections of the Interlock for safeguarding, instead of the "Orange ones". Despite of such derogation, one of those two mentioned colors has to be chosen whenever connecting electrically some Safety Devices and Safety Circuits. The wiring identification, in this case by color, shall be done inside and outside the Electrical Panels.

1. Lighting and Service Outlet:

According to Directive 2006/42/EC clause 1.1.4:

- Machinery must be supplied with integral lighting suitable for the operations concerned where the absence thereof is likely to cause a risk despite ambient lighting of normal intensity.
- Machinery must be designed and constructed so that there is no area of shadow likely to cause nuisance, that there is no irritating dazzle and that there are no dangerous stroboscopic effects on moving parts due to the lighting.
- Internal parts requiring frequent inspection and adjustment, and maintenance areas must be provided with appropriate lighting.

Internal illumination and service outlets in cabinets shall be fed from the common lighting network. The service outlet supply shall be protected by a separate over current protection and Residual Current Device, RCD mounted inside the cabinet. A RCD is a safety device that trip when there is more than 30mA earth current. Illumination shall be protected by a separate over current device inside the cabinet.

2. Externally Powered Circuits:

Supply to lighting, service outlets, UPS supply and interlocking control circuits (e.g. Emergency stop) that are powered from an external power source shall not be switched off by the cabinet's main supply disconnecting device. If the externally powered circuit is complex (i.e. involving many components in the concerned cabinet); it should have its own disconnecting device inside the cabinet. If there are externally powered circuits in a cabinet a permanent WARNING LABEL shall be placed in proximity to the cabinet's main switch. There shall also be a permanent WARNING LABEL inside the cabinet stating that "Orange wires" are

not disconnected by the cabinet's main disconnecting device. The terminals for the externally powered circuits shall be fitted with TOUCH PROTECTION and a WARNING LABEL if the Voltage exceeds 60V. [IEC 60204-1:2009 clause 5.3.5, partly and modified]

b) The **Control Cabinets** must include:

1. One duplex single-phase voltage receptacle and programming port for PLC hardware connection shall be installed in the panel AS SPECIFIED BY MAINTENANCE ENGINEERING. The duplex should be labeled - "No Power Tools".
2. An outlet installed externally to the panel of 10A and an outlet installed internally of 4 A.

Notes:

- ✓ When the plug is located outside the panel, it is possible to have problems if any equipment that is not part of the system is plugged. For example: a driller or a soldering, etc., that has a consumption over 10 A.
 - ✓ The internal plug is specific for equipment that has to be plugged to the system (e.g. programming trunk, notebook, etc.).
3. A free space of 15% on the mounting board on the panel to permit adding future control devices;
 4. Multi-plugs (male and female) for interconnection between cabinet and machine and/or equipment;

Note: the connectors must be fool-proof.

5. Data description including rated current (A), power factor (%), frequency (Hz), number of phases, rated power (kW), power supply (V) and power consumption (kWh).
6. A permanent metal data pocket shall be attached to the inside of the enclosure. The pocket should be enough wide, adequate depth and thickness to accommodate all the necessary diagrams.
7. Enclosures and its respective compartment doors shall be so designed and have sufficient rigidity to ensure continuing proper alignment between mating parts, such as disconnect mechanisms, door fasteners, etc. Door aligning guides may be used to ensure alignment and reinforcements shall be used as necessary to prevent door warp.
8. Panel components shall be grouped by voltage class (i.e. above 220 Volts, 220 Volts, low voltage control, analog signal and communications circuits). Wire

routings shall be separated by an enough air space or a metal barrier between classes or cross at right angles. Follow appropriate panel layout considerations to keep analog wiring away from sources of noise.

9. Fluorescent lamps of the single-strip type shall be used as internal illumination in enclosures of 1.5 square meters and above as well as enclosures with height > 1200 mm or whether specified in order. Fixtures shall be mounted along the top of the enclosure and not on the electrical panel sub-plate. On enclosures requiring interior lighting, a separate transformer and door switch shall be provided. The lighting factor must be based on the EHS Manual (TST 000067 + TEM 000840).

c) The **Control Cabinets** with electronic components must have:

1. Cooling (forced ventilation with filters or industrial air conditioners) for protection against dust and humidity, at a maximum temperature of 35° C;
2. Polarized connector with protection up to 4 A exclusive for programming, located in the internal part of the panel;
3. Physical separation between the mains lines and the electronic equipment/circuit;
4. Multi-plugs (male and female) for interconnection between cabinet and machine and/or equipment.

Notes:

- ✓ The connectors must be fool-proof.
- ✓ In case of aggressive environments and with previous approval by the relevant maintenance sector, use industrial air conditioners for CNCs, PLC's or converters which must be included in the package supplied.
- ✓ See also Section 4.4.4.11 for Construction Directives.

- d) AC control voltage shall be the single-phase obtained from only one transformer with an isolated secondary winding of adequate capacity and fused accordingly. The DC control voltage shall be 24 VDC.
- e) All operating coils of control devices shall be connected to one side of the control circuits, which shall be grounded at the control circuit transformer. There shall be no contacts or fuses in the ground side of the circuit, such as overloads, etc. The high side of the secondary shall be fused.

- f) One side of the control circuit shall be grounded to the machine at the source. The wiring diagram shall show the location of the grounding connection. The grounded conductor shall not be fused or switched.
- g) Where there is more than one electrically controlled or operated device on any piece of industrial machine and/or equipment, and where possible damage may be caused by the failure of any one device to function properly, the circuits shall be arranged with protective interlocks. Where practical, these interlocks shall interrupt all operations, provided such interruption does not constitute a hazard to the operator or cause damage to the machine and/or equipment or work in process. The machine and/or equipment shall be designed and constructed to fail to a safe, known state and be capable of being monitored for failure by the safety control system. Consult EHS Manual (TST 000067 + TEM 000840) for additional Information.
- h) The power supply disconnecting device system chosen shall be capable of interrupting the maximum operating overload current of all machine and/or equipment connected to it.
- i) One power supply disconnecting device system shall disconnect all ungrounded conductors of the power supply circuit simultaneously.
- j) An over-current device shall be placed in each ungrounded branch circuit.
- k) The incoming power line conductors shall terminate at the power supply disconnecting device system with no connection to terminal blocks or other devices ahead of the disconnecting device, unless properly identified and protected from accidental contact.
- l) If more than one power supply disconnecting device system is provided for multiple supply circuits, they shall be grouped in one location.
- m) A power supply disconnecting device system shall be mounted within the control enclosure. No other machine and/or equipment shall be mounted directly above it inside the enclosure.
- n) Where a machine is supplied by more than one power supply circuit, a marking shall be installed at each power supply disconnecting device system location, denoting the location of all other power supply disconnecting device system.

Note: [ANSI/NFPA 79-2002, 5.3.1.1.2]

- o) On multiple station machines, a power supply disconnecting device system shall be mounted in each control cabinet to shut off all power to the station(s) it controls.
- p) Fuse holder identification tags shall include the fuse type and size.
- q) All conductors shall be protected against steady overloads and against short circuits.

- r) Electronic control equipment (such as PLC's, CNCs, converters, etc.) must be located outside the cabinet to allow easy access for service and maintenance.
- s) When using remote I/O chassis for a separate stand-alone operation, the remote chassis and all associated control elements (starters, relays, etc.) are to be located in an enclosure with its own disconnect and control transformer. When using remote I/O chassis as strictly I/O expansion, the above requirement does not apply.
- t) Each chassis and I/O module shall be clearly identified.
- u) Control enclosure and devices shall not be mounted in a position that will interfere with machine and/or equipment adjustments or maintenance of hydraulic or mechanical equipment, or vice versa.
- v) Machine and/or Equipment subjected to excessive vibration shall have the control enclosure in a free-standing position.
- w) There shall be no exposed terminals external to control enclosures, compartments and junction boxes.
- x) Stop or emergency stop pushbuttons shall be continuously operable and readily accessible and shall be located at each operator control station and at other locations where emergency stop is required as determined by a risk assessment. It shall not be possible to restore an emergency stop circuit until the emergency stop device has been manually reset. Where several emergency stop devices are provided in a circuit, it shall not be possible to restore that circuit until all emergency stop devices that have been operated have been reset. Consult EHS Manual (TST 000067 + TEM 000840) for additional Information.
- y) Where protective measures depend on programmable devices, the reliability of these devices and the system should be appropriate for the identified level of risk (general purpose PLC or firmware based controllers shall not be used for safety related functions). Consult EHS Manual (TST 000067 + TEM 000840) for additional Information.
- z) Control systems incorporating software and firmware based controllers performing safety-related functions shall comply to all of the following, anyway you must Consult EHS Manual (TST 000067 + TEM 000840) for additional Information:
 - (1) In the event of any single failure perform as follows:
 - (a) Lead to the shutdown of the system in a safe state;
 - (b) Prevent subsequent operation until the component failure has been corrected;

- (c) Prevent unintended startup of machine and/or equipment upon correction of the failure;
 - (2) Provide protection equivalent to that of control systems incorporating hardwired/hardware components;
 - (3) Be designed in conformity with an approved standard that provides requirements for such systems;
- aa) Where starting or stopping of devices in improper sequence can result in a hazard to the operator or damage to the machine and/or equipment or work in process, circuits shall be so arranged as to ensure the proper sequence starting and stopping of such devices. For set-up purposes, manual means by use of push buttons or HMI (Human Man Machine Interface), shall be provided to perform individual functions.
- bb) The above provisions for safe operation shall be effective and shall include the following:
1. Opposing Motions Interlocked - All reversing starters or contactors, controlling solenoids mechanically connected, and contactors controlling opposing motions shall be protected from simultaneous energization.
 2. "STOP" implies safety to the infrequent user, so only hardwired buttons shall be labeled and defined as such. Stop functions shall be initiated through deenergization rather than energization operation of control devices and when executed, it shall override all other functions and modes machine operation. As a part of overall safety in operation of the machine once a stop is actuated it shall require a restart sequence before movement is reinitiated.
 3. Safety devices, when interrupted, shall drop out the master control relay (M.C.R.) for its particular station, application and so on. A set of contacts from the safety device shall be taken back to the controller for diagnostic purposes. If adjacent stations can be accessed through the same safety device, their M.C.R. shall be dropped out as well. Consult EHS Manual (TST 000067 + TEM 000840) for additional Information.
 4. Control circuits shall be designed so that the movement of any part of the industrial machine and/or equipment cannot be initiated by the actuation of any input sensing device, when auto cycle is not enabled.
 5. Hinged or sliding access doors to compartments containing belts, gears or other moving parts which may cause injury to personnel shall be interlocked through field input devices or other means to prevent machine and/or equipment operating when

doors are not closed and also avoid opening it if machine and/or equipment is already running. The interlock devices used in conjunction with guards shall be specifically designed and constructed for use in safeguarding applications. These devices should be designed to discourage the capability to easily bypass the interlock with readily available items such as tape, pieces of metal, screws, tools, etc. **Note:** [ANSI B11.19-2003, 7.1.6]

Consult EHS Manual (TST 000067 + TEM 000840) for additional Information.

6. Where doors or any kind of guards have interlocked switches used in circuits with safety related functions, the interlocking devices shall be listed certified safety switches with the universal safety symbol indicating it on the sensor (Consult EHS Manual (TST 000067 + TEM 000840) for additional Information), have either positive (direct) opening operation, or provide similar reliability and prevent the operation of the machine and/or equipment when the doors or guards are open (difficult to defeat or bypass). **Note:** [ANSI/NFPA 79-2002, 9.3.6]
7. "Jog" circuits shall be designed so that the prevention of the "Run" (or "Automatic") operation during jogging is inherent. In areas of personal safety, jogging shall require two-hand operation or a three-position enabling device.
8. TWO-HAND CONTROL - Two buttons shall be provided for each operator where pinch points or other movement hazards are exposed to operating personnel. The design, construction, or separation of the two-hand operating controls shall require the use of both hands to actuate motion. Minimum spacing between operating buttons mounted on the same plane without additional obstructions is 23.62 inches or 600 mm. The circuits shall require simultaneous maintained depression of each button throughout the cycle or until a point is reached in the cycle where the hazard ceases. Each pair of buttons shall be located and guarded so that operation by means other than the two hands of the operator is prevented. The circuit shall be designed and wired to incorporate the defined anti-tie down and anti-repeat operation at each station requiring all buttons released between successive operations.
9. MORE THAN ONE CYCLE START STATION - On mass production industrial machine and/or equipment, wherever there is more than one cycle "start" station provided, all "start" buttons, shall be concurrently depressed to initiate the cycle, and released between successive operations, unless interlocking is provided to require either (1)

the use of one station at a time, or (2) the initiation of the cycle by depressing buttons in a specified sequence. This applies to single cycle operations.

10. SPINDLE DRIVES INTERLOCKED WITH FEEDS - Suitable interlocking should be provided to ensure that spindle drive contactors are energized before spindles are driven into work, while in the "automatic cycle".
11. ENABLING DEVICE – Enabling devices shall be designed and constructed to permit limited and supervised machine motion (i.e., slow speed, jog, set-up, etc.) only while personnel are inside the hazard area and when manually actuated in one position. The enabling device shall use three positions such that when continuously held in an enabled (second) position, it permits limited motion. Release of, or compression past the midpoint-enabled position of the device, shall initiate an immediate stopping command of the hazardous motion(s). The enabling device shall be designed and constructed to require the release and re-actuation of the device before machine motion can be reinitiated. If more than one operator is to be safeguarded by the use of enabling devices, each operator shall have their own device. The selection of the enabling device(s) shall be capable of being supervised by the user (supervisor). Additionally, each selected enabling device shall be concurrently operated and shall require the release of and the reactivation of all selected enabling devices before machine motion can be reinitiated. The stop signal actuated by the enabling device shall use circuitry consistent with the circuit performance determined by a risk assessment. **Note:** [ANSI B11.19-2003, 12.3, ANSI/NFPA 79-2002, 9.2.5.7 & ANSI/RIA R15.06-1999, 4.7.3]
12. FIELD INPUT DEVICE INTERLOCKING - Where necessary, field input devices shall be interlocked by the use of both the normally open AND the normally closed contacts to prevent damage caused by the sticking of the switch in the tripped position. Consult EHS Manual (TST 000067 + TEM 000840) for additional Information.
13. Control stations shall be within easy reach of the operator and shall be placed so that operator does not have to reach past moving parts which might cause injury and be free from possibility of accidental operation by normal movement of the machine and/or equipment, parts, or operator. All manual buttons must be arranged so that they can be depressed sequentially for a complete manual cycle.

cc) All components shall comply with IEC 60947.

dd) Fusing shall provide Type II protection and coordination IEC 60947-4-1.

- ee) Reversing and multiple speed applications must use mechanical and electrical interlocks.
- ff) When a failure diagnostic system is installed in the machine and/or equipment (e.g. LED display, video monitor, etc.), is MANDATORY that the alarms and messages to the operator at the man/machine interfaces be in Local Language with Selection feature to English. Any other needs may be agreed upon purchasing agreement, according to Section 3.3.
- gg) The connection cables between machine and control cabinet must be part of the package supplied and they must be properly marked.
- hh) Wires shall run continuously from one apparatus to another without any splice in conduit, wire-ways, or junction boxes. Where multiple control connections are necessary due to machine requirements or breakdown for shipment, they shall be made on terminal blocks that shall be mounted in the defined enclosures.
- ii) All thermocouple wires shall run continuous, were possible, from the thermocouple to the controller. Thermocouple rated terminal blocks shall be used if termination is necessary.
- jj) All wiring and wiring connections external to the control panel shall be totally enclosed respectively in suitable raceways or enclosures.
- kk) All conductors of a power circuit shall be contained in the same raceway.
- ll) On industrial machine requiring a foundation, the minimum size, purpose and location of the conduit to be placed in or under the foundation by the purchaser shall be shown on the foundation drawing.
- mm) All the wire ends must be assembled with oil and grease proof insulated and marked terminals, connecting screws must also be marked. Under no circumstances the conductor ends should be tin-welded.
- nn) All the electric components must be identified on the relevant wiring termination by marking with a number according to the diagram.

Note: Under no circumstances adhesive labels should be used.

- oo) Identification plates for devices mounted internal or external to the control enclosure shall be made of a non-corrosive material and held in place by metal fasteners. I.D. plates for PLC I/O devices shall be the same but also define the I/O address, function, and device type. Identification tags shall be legible, permanent, and appropriate for the physical environment. [IEC 60204-1:2009 clause 16.1, modified]

- pp) The marking shall still be present even if the component is replaced, which means that the marking is to be located beside the component.
- qq) The power supply inputs must be located on the upper part of the component.
- rr) Cables for instrumentation: electronic analog signals, thermocouples and others alike must have electromagnetic shield. In the case of extension cables for thermocouples a guide or individual conduit must be foreseen. Terminations between the device (or its associated transmitter) and the PLC connection, should be kept to a minimum. Usually the wires are not terminated in the panel, but go directly to the input module to prevent losses.
- ss) Separate conduit or metal dividers shall be used to isolate the following classifications:
- Voltages above the single-phase AC voltage or the equivalent DC voltage value and all motor leads
 - Single-phase AC or the equivalent DC Control voltage
 - Low voltage (50 Volts and below), analog signals, and communications
- tt) All the contactors and auxiliary relays must be provided with noise suppression filter. If necessary, the relevant Maintenance Area must be consulted.
- uu) Any machine and/or equipment above 15 kW rated power consumption must have a minimum inductive power factor of 0.94 and a maximum of 0.94 (capacitive).
- vv) All the non geometrical instruments included on the project by the Supplier must be listed, as well as the ones requested on the "Technical Order", on a report describing the operation range in subject and the maximum allowable error of the instrument.
- ww) All the instruments for geometrical control listed on the "Technical Order" and included by the Supplier, must comply with the acceptance requirements defined on Metrology's Laboratory Instruction (SOP 000979).
- xx) All conduits shall be securely held in place and supported at each end. Threadless fittings not approved. The openings of all conduit fittings shall be readily accessible;
- yy) Junction boxes shall be provided with gasketed covers. All junction boxes shall be readily accessible and continuous hinged.
- zz) All microprocessor-based equipment shall be supplied with all documentation, programming software, and dedicated terminals necessary to program, maintain, troubleshoot and run the system. Programming software shall be supplied with the original disks and licensed to the local plant.
- aaa) Electrical components and devices shall be suitable for their intended use. [IEC 60204-1:2009 clause 4.2.1]

- bbb) Where possible, the electrical equipment should be located in clean and dry areas, easily accessible for service and maintenance. [IEC 60204-1:2009 clause 11.1, modified]
- ccc) Undesirable effects of vibration, shock and bump (including those generated by the machine and its associated equipment and those created by the physical environment) shall be avoided by the selection of suitable equipment, by mounting it away from the machine, or by the use of anti-vibration mountings. [IEC 60204-1:2009 clause 4.4.8]
- ddd) The terminations of cables shall be adequately supported to prevent mechanical stresses at the terminations of the conductors. [IEC 60204-1:2009 clause 13.1.2]
- A compression gland will provide a good support in most cases. All cables that leave a cable duct should be supported by a compression gland.

eee) Grounding

- ✓ A copper or approved equivalent corrosion-resistant conductor shall be used for grounding purposes.
- ✓ Any metallic part that belongs or not to the machine and/or equipment, normally not subjected to the current load of the circuit, must be connected to the ground through the drivers of grounding. The same will be connected to the dissipation grounding electrode, which are immersed in the soil, creating the security grounding, "protection". Standard: IEC 60364-5 and NBR 5410:2004 item 5.1.2.2.3 (for Brazil)
- ✓ The system of connecting machine and/or equipment must follow the configuration NG-S (neutral and ground separated); this system matches the system of EMBRACO. Standard IEC 60364-5 and NBR 5410 item 4.2.2.2.1 (for Brazil)
- ✓ Grounding by attaching the device to the machine and/or equipment with bolts or other approved means shall be considered satisfactory if all paint and dirt is removed from joint surfaces.
- ✓ Conductors may be insulated or bare and shall be protected from mechanical damage by means equivalent to those provided for live conductors. If any insulated machine and/or equipment ground conductor is used, the insulation shall be green/yellow.
- ✓ All exposed non-current-carrying metal parts of control enclosures, motors, conduit, control stations, resilient mounted equipment, and other devices and accessories shall be grounded.

- ✓ One conductor of a machine lighting circuit shall be grounded to the machine.
- ✓ All junction boxes and non-insulated devices shall have a green/yellow ground wire connected to the main enclosure. Metallic conduit shall not be considered for a ground return path.

4.4.4.4. General Wiring Best Practices

This specific chapter is related to the Wiring Best Practices that compulsorily shall be followed so as to get the EMBRACO's compliance in terms of Electrical Installation.

Deviations from IEC 60204-1 Standard, along with this Corporate Standard, shall be previously agreed to in writing between the Supplier and EMBRACO.

4.4.4.4.1. Conductors and Cable Runs

The connection of two or more conductors to one terminal is permitted only in those cases where the terminal is designed for that purpose. However, only one protective conductor shall be connected to one terminal connecting point. [IEC 60204-1:2009 clause 13.1.1]

Conductors and cables shall be run from terminal to terminal without splices or joints, i.e. cables shall be terminated only in terminals of a terminal row, in terminals of electrical equipment, or in terminals of a plug/socket combination. [IEC 60204-1:2009 clause 13.1.2, modified]

When spare conductors are provided, they shall be connected to spare terminal blocks, ground, or isolated in such a manner as to prevent contact with live parts. [IEC 60204-1:2009 clause 13.4.7, modified]

4.4.4.4.2. Cable in Protected Area

When a cable runs in a protected area where there are no moving parts, such as behind a cover plate, the cable may be laid by one of the following means: [IEC 60204-1:2009 clause 13.4.2, modified]

- in cable ducts;
- in cable tubes;
- in cable conduits;
- in the frame; or
- under a frame piece, if properly attached with anchors and clip strips. The anchors plate shall be fixed with screw.

The use of compartments or cable trunking systems within the column or base of a machine to enclose conductors is permitted provided the compartments or cable trunking systems

are isolated from coolant or oil reservoirs and are entirely enclosed. Conductors run in enclosed compartments and cable trunking systems shall be so secured and arranged that they are not subject to damage. [IEC 60204-1:2009 clause 13.5.7]

4.4.4.4.3. Cable in Unprotected Area

When a cable is run through an unprotected area (no mechanical and/or chemical protection), such as areas where the operator has access or service is done regularly, or in unprotected areas closer than 25 mm to a moving object or an open area, the cable shall, if possible, be totally covered. If this last one is not practicable, it is recommended that the distance where the cable is run unprotected should be minimized, preferably to not more than 100 mm. [IEC 60204-1:2009 clause 13.4.2 modified]

The use of compartments or cable trunking systems within the column or base of a machine to enclose conductors is permitted provided the compartments or cable trunking systems are isolated from coolant or oil reservoirs and are entirely enclosed. Conductors run in enclosed compartments and cable trunking systems shall be so secured and arranged that they are not subject to damage. [IEC 60204-1:2009 clause 13.5.7]

For cables close to moving objects, see also 4.4.4.4.8.

4.4.4.4.4. Flexible Cables

Flexible cables shall have Class 5 or Class 6 conductors, see IEC 60204-1:2009 Annex D table D.4.

NOTE (1): Class 6 conductors have smaller diameter strands and are more flexible than Class 5 conductors (see IEC 60204-1:2009 Annex D table D.4).

Cables that are subjected to severe duties shall be of adequate construction to protect against:

- abrasion due to mechanical handling and dragging across rough surfaces;
- kinking due to operation without guides;
- stress resulting from guide rollers and forced guiding, being wound and re-wound on cable drums.

NOTE (2): The operational life of the cable will be reduced where unfavorable operating conditions such as high tensile stress, small radii, bending into another plane and/or where frequent duty cycles coincide.

[IEC 60204-1:2009 clause 12.6.1, partly]

When dimensioning flexible cables, the mechanical strength shall be considered, see item 4.4.4.4.6.

Connections to devices mounted on doors or to other movable parts shall be made using flexible conductors in accordance with items 4.4.4.4.6 and 4.4.4.4.7 to allow for the frequent movement of the part. The conductors shall be anchored to the fixed part and to the movable part independently of the electrical connection. [IEC 60204-1:2009 clause 13.3, partly]

4.4.4.4.5. Conductors of Different Circuits

Conductors of different circuits may be laid side by side, may occupy the same duct (for example conduit, cable trunking system), or may be in the same multiconductor cable provided that the arrangement does not impair the proper functioning of the respective circuits. Where those circuits operate at different voltages, the conductors shall be separated by suitable barriers or shall be insulated for the highest voltage to which any conductor within the same duct can be subjected, for example line to line voltage for unearthed systems and phase to earth voltage for earthed systems. [IEC 60204-1:2009 clause 13.1.3]

The outer insulation of a cable is considered as such proper means.

It is recommended that power cables should be separated from control cables because of possible interference.

4.4.4.4.6. Conductors with Small Cross-Sectional Area

To maintain protection for cables with low mechanical strength, the design of cableways for cables with a cross section area of 0.5 mm² has to be carefully considered. Preferably, either cable ducts or cable conduits should be used. It is recommended to use 0.75 mm² cables. Cables to pre wired components may have smaller cross section than 0.5 mm². [IEC 60204-1:2009 clause 12.2, modified]

4.4.4.4.7. Conductor Dimensioning According to Mechanical Strength

To ensure adequate mechanical strength, the cross-sectional area of conductors should not be less than as shown in Table 2. However, conductors with smaller cross-sectional areas or other constructions than shown in Table 2 may be used in equipment provided adequate mechanical strength is achieved by other means and proper functioning is not impaired. [IEC 60204-1:2009 clause 12.2, modified]

Table 2: Minimum Cross-Sectional Areas of Copper Conductors

		Type of conductor, cable				
Location	Application	Single Core		Multicore		
		Flexible Class 5 or 6	Solid (class 1) or stranded (class 2)	Two core, shielded	Two core not shielded	Three or more cores, shielded or not
Wiring outside (protecting) enclosures	Power circuits, fixed	1,0	1,5	0,75	0,75	0,75
	Power circuits, subjected to frequent movements	1,0	-	0,75	0,75	0,75
	Control circuits	1,0	1,0	0,2	0,5	0,2
	Data communication	-	-	-	-	0,08
Wiring inside enclosures	Power circuits (connections not moved)	0,75	0,75	0,75	0,75	0,75
	Control circuits	0,2	0,2	0,2	0,2	0,2
	Data communication	-	-	-	-	0,08

Note: All cross-sections in mm²

[IEC 60204-1:2009 Table 5, modified]

Class 1 and class 2 conductors are primarily intended for use between rigid, non-moving parts.

All conductors that are subject to frequent movement (for example one movement per hour of machine operation) shall have flexible stranding of class 5 or class 6.

[IEC 60204-1:2009 clause 12.2, modified]

Note: Classification of conductors is given with details in IEC 60204-1:2009 Annex D table D.4.

4.4.4.4.8. Connection to Moving Elements

Connections to frequently moving parts shall be made using conductors in accordance with items 4.4.4.4.4, 4.4.4.4.6 and 4.4.4.4.7. Flexible cable and flexible conduit shall be so installed as to avoid excessive flexing and straining, particularly at the fittings.

Cables subject to movement shall be supported in such a way that there is neither mechanical strain on the connection points nor any sharp flexing. When this is achieved by the provision of a loop, it shall have sufficient length to provide for a bending radius of the cable of at least 10 times the diameter of the cable.

Flexible cables of machines shall be so installed or protected as to minimize the possibility of external damage due to factors that include the following cable use or potential abuse:

- being run over by the machine itself;
- being run over by vehicles or other machines;

- coming into contact with the machine structure during movements;
- running in and out on cable baskets, or on or off cable drums;
- acceleration forces and wind forces on festoon systems or suspended cables;
- excessive rubbing by cable collector;
- exposure to excessive radiated heat.

The cable sheath shall be resistant to the normal wear that can be expected from movement and to the effects of environmental contaminants (for example oil, water, coolants, dust).

Where cables subject to movement are close to moving parts, precautions shall be taken to maintain a space of at least 25 mm between the moving parts and the cables. Where that distance is not practicable, fixed barriers shall be provided between the cables and the moving parts.

The cable handling system shall be so designed that lateral cable angles do not exceed 5°, avoiding torsion in the cable when:

- being wound on and off cable drums; and
- approaching and leaving cable guidance devices.

Measures shall be taken to ensure that at least two turns of flexible cables always remain on a drum.

Devices serving to guide and carry a flexible cable shall be so designed that the inner bending radius at all points where the cable is bent is not less than the values given in Table 3, unless otherwise agreed with the cable manufacturer, taking into account the permissible tension and the expected fatigue life.

[IEC 60204-1:2009 clause 13.4.3]

Table 3: Minimum permitted bending radii for the forced guiding of flexible cables

Application	Cable diameter or thickness of flat cable (d) mm		
	d ≤ 8	8 < d ≤ 20	d > 20
Cable drums	6 d	6 d	8 d
Guide rollers	6 d	8 d	8 d
Festoon systems	6 d	6 d	8 d
All others	6 d	6 d	8 d

[IEC 60204-1:2009 table 8]

The straight section between two bends shall be at least 20 times the diameter of the cable. Where flexible conduit is adjacent to moving parts, the construction and supporting means shall prevent damage to the flexible conduit under all conditions of operation. Flexible conduit shall not be used for connections subject to rapid or frequent movements except when specifically designed for that purpose. [IEC 60204-1:2009 clause 13.4.3]

Multicore cables within cable tow chains shall have no more than 25 conductors.

4.4.4.4.9. Interconnection of Devices on the Machine

Where several machine-mounted switching devices (e.g. position sensors, push-buttons) are connected in series or in parallel, it is mandatory that the connections between those devices to be made through terminals forming intermediate test points (e.g. connection box with terminals). Such terminals shall be conveniently placed, tightened enough and resistant to vibration, adequately protected, and shown in documentation. [IEC 60204-1:2009 clause 13.4.4]

4.4.4.5. Ducts and Cable Trays

4.4.4.5.1. Design

All sharp edges, flash, burrs, rough surfaces, or threads, with which the insulation of the conductors may come in contact, shall be removed from ducts and fittings. [IEC 60204-1:2009 clause 13.5.1]

Drain holes of 6 mm diameter are permitted in cable ducts which are subject to accumulations of oil or moisture. [IEC 60204-1:2009 clause 13.5.1]

The thickness of the sheet material used shall be at least 1 mm if of steel, or of equivalent strength if of other material.

Cable ducts shall be provided with removable covers.

Cable ducts should preferably contain barriers for separation of power and control cables.

The environment determines the degree of protection.

4.4.4.5.2. Installation

Ducts and cable trays shall be rigidly supported and positioned at a sufficient distance from moving parts and in a manner which minimizes the risk of damage or wear. In areas where human passage is required, the ducts and cable trays shall be mounted at least 2 m above the working surface. [IEC 60204-1:2009 clause 13.5.1]

As much as possible, cable ducts shall not be located in wet zones.

In order to prevent confusion of conduits with oil, air, or water piping, it is recommended that the conduits be either physically separated or suitably identified. [IEC 60204-1:2009 clause 13.5.1]

If cable ducts are fitted against hot surfaces, non-metallic spacers shall be used.

All exposed conductive parts of the electrical equipment and the machine(s) e.g. cable ducts shall be connected to the protective bonding circuit. [IEC 60204-1:2009 clause 8.2.3, modified]

4.4.4.5.3. Filling Rate

On delivery, ducts supplied with the machine shall not be filled with cables above 70% of its space. [IEC 60204-1:2009 clause 13.5.2 modified]

4.4.4.6. Cable Conduits

4.4.4.6.1. Design

The purpose of cable conduits is to provide protection against water, oil, dust, and mechanical damage.

There shall be no risk of damage to the insulation of cables from sharp edges, rough surfaces, or sharp threads. [IEC 60204-1:2009 clause 13.5.1, modified]

4.4.4.6.2. Installation

Flexible cable conduits shall be fitted with proper compression glands. Open ends, if possible, shall be avoided. If open ends cannot be avoided, they shall be fitted facing downwards where possible. It is not permitted to fit an open end facing upwards in a wet environment. [IEC 60204-1:2009 clause 13.1.1, modified]

4.4.4.7. Compression Glands

The compression glands are to be fitted in the enclosure so that the degree of protection is not reduced. [IEC 60204-1:2009 clause 13.4.1]

If possible, compression glands are to be fitted facing downwards. It is not permitted to fit compression glands facing upwards in wet environment. [IEC 60204-1:2009 clause 13.1.1, modified]

All compression glands shall be used, thus spare inlets shall have a blank-off plug.

If more than one cable shall go through a cable gland, the cable gland shall then be designed for that purpose. Sealing in cable gland shall be made for the size and shape of the cable.

4.4.4.8. Connection Boxes

4.4.4.8.1. Design

Connection boxes and other boxes used for wiring purposes shall be readily accessible for maintenance. Those boxes shall provide protection against the ingress of solid bodies and liquids, taking into account the environment in which the machine is intended to operate. [IEC 60204-1:2009 clause 13.5.8]

Those boxes shall neither have opened but unused knockouts nor any other openings and shall be so constructed as to exclude materials such as dust, flyings, oil and coolant. [IEC 60204-1:2009 clause 13.5.8]

Connection boxes, preferably of aluminum, shall be used except in areas where the environment demands higher protection. In these areas, stainless steel connection boxes shall be used. [IEC 60204-1:2009 clause 11.4, modified]

First hand choice should be boxes with hinged cover. If screws are used for closing, these should be attached to the cover in a way that prevents accidental loss. Normally fasteners used to secure doors and covers should be of the captive type. [IEC 60204-1:2009 clause 11.4, modified]

There shall be at least 10% space left for terminals and cable glands for later modifications to the connection box. This is the same requirement as applied for later modifications in the electrical cabinet, see item 4.4.4.11.1.

4.4.4.8.2. Contents

Terminal blocks shall be placed in easily accessible connection boxes.

It is recommended that special bridge connectors are used when linking together several terminal blocks within a connection box.

Cable tails of sufficient length shall be left in the connection boxes to facilitate connection and disconnection. [IEC 60204-1:2009 clause 13.1.2]

4.4.4.9. Terminal Blocks

Screw type terminals shall be used, although this is not applicable to “controlgear” (main electrical switching device or main disconnecting device) where other types of terminals are allowed e.g. tension clamp connection terminals.

The following Connection Sequences shall be used for the following types of terminal in control circuits:

Type of Terminal:

- 1-storey/tier terminal block:
(used for control devices e.g. proximity switches, photocells).
- 2-storey/tier terminal block:
- 3-storey/tier terminal block:

Connection Sequence:

- signal, plus, minus
- signal, plus (signal at the top)
- signal, plus, minus (signal at the top)

Use the same terminal structure all over in the whole machine. Avoid mixing different type of terminals e.g. if you have selected 2-storey terminals, use these as much as practical all over in the whole machine.

Regarding connection sequence for power circuits, the following sequence applies, see Figure 13; L1, L2, L3, N, PE.

When designing long strips of terminal blocks, the thickness tolerance of the terminal blocks has to be considered in order to precisely dimension it.

Terminal blocks for power circuits should be separated from those for control circuits by use of barriers (terminal endplates). [IEC 60204-1:2009 clause 11.2.2]

Regarding colors on terminals, Beige colored terminals shall be used for distribution of both Control and Power Circuits.

4.4.4.10. Electric Motors

4.4.4.10.1. Installation

Each motor and its associated couplings, belts and pulleys or chains shall be installed so that they are adequately protected and easily accessible for inspection, maintenance, adjustment and alignment, lubrication, and replacement. The motor mounting arrangement shall be such that all fastening elements can be easily removed, and terminal boxes are accessible. [IEC 60204-1:2009 clause 14.4]

Motors shall be installed so that proper cooling is ensured, and the temperature rise remains within the limits of the insulation class. [IEC 60204-1:2009 clause 14.4]

Moving parts associated with the motor, which present a hazard shall be guarded or enclosed, considering the same easiness of inspections, maintenance and so on, in order to reduce the risk. For risk assessment, see EHS Manual TST 00067 or contact the responsible area.

4.4.4.10.2. Over-Temperature Protection

The provision of motors with over-temperature protection (see IEC 60034-11) is recommended in situations where the cooling can be impaired (for example dusty environments). Depending upon the type of motor, protection under stalled rotor or loss of phase conditions is not always ensured by over-temperature protection, and in this way, additional protection should then be provided for a safe and reliable operation. [IEC 60204-1:2009 clause 7.3.3]

Over-temperature protection is also recommended for motors that cannot be overloaded, for example torque motors, motion drives that are either protected by mechanical overload

protection devices or are adequately dimensioned, where the possibility of over-temperature exists, for example due to reduced cooling. [IEC 60204-1:2009 clause 7.3.3]

4.4.4.10.3. Over-Speed Protection

Overspeed protection shall be provided where overspeeding can occur and could possibly cause a hazardous situation taking into account measures in accordance with IEC 60204-1:2009 clause 9.3.2.

Overspeed protection shall initiate appropriate control responses and shall prevent automatic restarting.

The overspeed protection should operate in such a manner that the mechanical speed limit of the motor or its load is not exceeded.

NOTE: This protection can consist, for example, of a centrifugal switch or speed limit monitor. [IEC 60204-1:2009 clause 7.6]

4.4.4.10.4. Marking Signs

Motors shall be marked with a nameplate stating the manufacturer's name, trade mark, or other identification symbol besides the normal technical specifications already included, as voltage, current and so on. If possible, this nameplate shall be directly visible. See Section 4.4.2 for more details. [IEC 60204-1:2009 clause 16.4]

It is recommended that in cases when reversal of the direction of rotation can produce a hazardous condition for personnel or cause damage to the machine, a direction arrow shall be attached near the motor where it is clearly visible, anyway its direction identification is a good practice and shall be applied wherever it's possible. See Section 4.4.2 for more details.

4.4.4.11. Electrical Panels

4.4.4.11.1. Design

Enclosures shall be constructed using materials capable of withstanding the mechanical, electrical and thermal stresses as well as the effects of humidity and other environmental factors that are likely to be encountered in normal service. [IEC 60204-1:2009 clause 11.4]

Non-electrical parts and devices, not directly associated with the electrical equipment, shall not be located within enclosures containing controlgear. Devices such as solenoid valves should be separated from other electrical equipment (for example in a separate compartment). [IEC 60204-1:2009 clause 11.2.2]

Do not mix electrical devices with compressed air or any other non-related elements.

There shall be no opening between enclosures containing electrical equipment and compartments containing coolant, lubricating or hydraulic fluids, or compartments from where oil other liquids, or dust can penetrate. [IEC 60204-1:2009 clause 11.4, modified]

Draining holes, if needed, shall not affect the protection degree.

Heavy electrical cabinets shall be provided with suitable means for handling by cranes or similar equipment. [IEC 60204-1:2009 clause 4.6, modified]

For later modifications, at least 10% extra space (15% is the desirable as already mentioned in the Section 4.4.4.3 item b), number 3)) shall be left in the electrical cabinet for addition to each sub system. See Section 4.4.4.3 items b) and c) for more details.

4.4.4.11.2. Environmental Requirements (Ambient)

Degree of Protection:	Dry environment	min IP54
	Cleaned with low-pressure water jets (hosing)	min IP55
	Protected against fine dust	min IP65
	[IEC 60204-1:2009 clause 11.3]	
	See also 4.4.4.12.	

Ambient Air Temperature:	Electrical equipment shall be capable of operating correctly in the intended ambient air temperature. The minimum requirement for all electrical equipment is correct operation between air temperatures of +5 °C and +40 °C. For very hot environments (for example hot climates) and for cold environments, additional measures are recommended. [IEC 60204-1:2009 clause 4.4.3]	
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Humidity:	The electrical equipment shall be capable of operating correctly when the relative humidity does not exceed 50 % at a maximum temperature of +40 °C. Higher relative humidity may be permitted at lower temperature (for example 90 % at 20 °C). Harmful effects of occasional condensation shall be avoided by design of the equipment or, where necessary, by additional measures (for example built-in heaters, air conditioners, drain holes). [IEC 60204-1:2009 clause 4.4.4]	
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Altitude:	Electrical equipment shall be capable of operating correctly at altitudes up to 1000 m above mean sea level. [IEC 60204-1:2009 clause 4.4.5]	
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4.4.4.12. Degree of Protection

The environment where the component is placed will determine the degree of protection. In some applications, the environment may justify a higher or lower degree of protection. [IEC 60204-1:2009 clause 11.3 modified]

The following protection classes are usually recommended, but it needs pre-assessment:

- compression glands, minimum IP 65;
- connection boxes, minimum IP 65;
- external lighting fittings, minimum IP 65;
- control devices (i.e. proximity switches, photocells, etc.), minimum IP 67;
- motors, minimum IP 54.

Note: (IP classes according to IEC 60529)

The degrees of protection against ingress of water are covered by IEC 60529. Additional protective measures can be necessary against other liquids. [IEC 60204-1:2009 clause 11.3]

Regarding, degree of protection for electrical cabinet see 4.4.4.11.2.

4.4.4.13. Interference

Another important factor to consider and it is worth stressing a bit more, is interference. It can in general be defined as not desired electrical influence on an electrical system. This can lead to an undesired action or the absence of an action in the control system.

The equipment shall not generate electromagnetic disturbances above levels that are appropriate for its intended operating environment. In addition, the equipment shall have a level of immunity to electromagnetic disturbances so that it can function in its intended environment. [IEC 60204-1:2009 clause 4.4.2]

Different types of interference:

- ✓ Circuit noise - Sparks in the circuits due to switching devices such as contactors;
- ✓ Electrostatic discharge - Personal influence by touching devices such as operator panels;
- ✓ Radio interference - Mostly high-frequency noise from devices such as motion control systems. As the motion control system is such a big noise source, a special attention has to be paid in this standard regarding the installation. A motion control system could for example be frequency converters, soft starters, servo systems, etc;
- ✓ Electromagnetic field - Too close use of disturbing devices, such as walkie-talkies and mobile telephones.

Effective actions against interference shall be applied in the electrical installations:

- ✓ Separation of cables - Cables with voltages higher than 48 VAC/DC (motor-, lightning-, power cables) shall be separated from control cables (24 V, 4-20 mA, 0-10 V and communication cables);
- ✓ Grounding - The conductivity between devices (control cabinet, motors, MCC – Motor Control Center, pipes) in a control system shall be good;
- ✓ Screening - Cables for communication and sensitive signals shall be screened. Also the cable between motor and motion control system shall be screened (the manufacturers installation instruction shall be followed). As an EMC (Electromagnetic Compatibility) rule, screens shall be connected at both ends, see EMC Directive (2004/108/EC);
- ✓ It is extremely important that grounding and screening is carried out in a correct manner, as incorrect grounding and screening can make the control system more susceptible to interference;
- ✓ Filters.

To avoid interference on the system and to suppress disturbances from components, such as a motion control system, the design and installation of the electrical system shall be done in a correct way, following the already much known best practices.

The electrical cabinet must conform with the European Community EMC Directive (89/336 EEC).

The whole machine including electrical cabinet must conform with the European Community EMC Directive (2004/108/EC).

4.4.5. Andon – Indication & Signaling

The *Andon* system for Indication and Signaling is a manufacturing term referring to a system to notify management, maintenance, and other workers, of commonly, a quality or process problem. The alert can be activated manually by a worker using a button, or may be activated automatically by the production machinery itself.

It gives the worker the ability and moreover the empowerment to stop production, when an anomaly is found, and immediately calls for assistance. Please see Corporate Document TRM 003613 – Criteria to trigger help chain or Section 4.4.3.2 item e), for specific information on the EMBRACO Requirements of the defined deviations to stop the production flow and ask for any help. Work is stopped until a solution has been found. The alerts should be logged to a database so that they can be studied as part of EMBRACO's continuous-improvement program, otherwise it should be manually recorded in the deviation board.

As we all know, in order to conform with the CE Marking, the Machinery Directive 2006/42/EC must be applied whether building new or retrofitting used machinery. Recapping what we have seen so far, in order to satisfy what has been specified in the present Corporate Standard, the Supplier has to consider also the definitions indicated on European and International specifications, as e.g. ISO 12100, IEC 60204-1 and in all the harmonized standard applicable, since compliance with these mentioned standards provides one means of conformity with the most requirements of the Machinery Directive.

Thus as part of Machinery Directive Requirements, visual signals, such as flashing lights, and acoustic signals, such as sirens, shall be also used, besides what was mentioned before regarding *Andon*, to warn of an impending hazardous event, such as machine start-up. The exposed person shall, in this cited case, have the time and the means to avoid hazardous event, for instance, during such machinery starting up.

4.4.5.1. Information and Indication - Directive 2006/42/EC

Based on Directive 2006/42/EC, clauses 1.7 and 3.6, all machinery must have signs and/or instruction plates concerning use, adjustment and maintenance, wherever necessary, so as to ensure the health and safety of persons. They must be chosen, designed and constructed in such a way as to be clearly visible and indelible.

The information needed to control machinery must be provided in a form that is unambiguous and easily understood. It must not be excessive to the extent of overloading the operator.

Visual display units or any other interactive means of communication between the operator and the machine must be easily understood and easy to use through:

- ✓ A system of light signals relevant to the intended conditions of use;
- ✓ An acoustic warning device to alert persons.

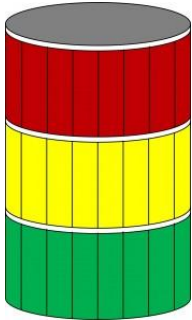
The operator must have facilities to check the operation of such warning devices at all times.

The requirements of the specific Community Directives concerning colors and safety signals must be complied with.

Machinery must be constructed in such a way that the warning and signaling devices cannot be disabled unintentionally. Where it is essential for safety, such devices must be provided with the means to check that they are in good working order and their failure must be made apparent to the operator.

Common **Indication and Signaling** configurations include four main different types in Embraco:

4.4.5.2. 1st - Alarm and Status Annunciation



These **Mandatory** lights correspond to a **Stack of Colored Lights**, which warn the status of a work area or mainly a single machine, the latter as the most usual application. As a fictitious example Green indicates a normal condition. Yellow signifies a need for help, and red means production has stopped, or soon will. The red light is frequently accompanied by an audible alarm. Most of those Light Annunciation Devices are linked to computer systems to track problems as already mentioned before, and others can, for instance, stop a moving assembly line when turned on.

Unless otherwise previously agreed in writing between the Supplier and EMBRACO, indicator lights shall be color-coded with respect to the **condition** (status) of the machine or process in accordance with the Table 4, which means that it is purely a specific **machine wise** Alarm and Status Annunciation Light. The color, in this way, to be displayed by indicators shall be chosen with regard to the information to be conveyed, assigning different meanings to the colors following the condition of the process criterion as bellow. [IEC 60204-1:2009 clause 10.3.2 partly and modified]

Table 4: Colors for indicator lights and their meanings with respect to the condition of the machine

Color	Meaning	Explanation	Action by Operator	Examples of Application
Red	Emergency Danger Prohibition	Hazardous condition	Immediate action to deal with hazardous condition (for example switching off the machine supply, being alert to the hazardous condition and staying clear of the machine)	Emergency stop Protective stop (Safety mats, Light barriers) Door open (Machine Running) Excessive vibration Safeguard suspended Safety related circuit malfunction
Yellow	Caution Warning Abnormal	Impending/Imminent critical condition Indication of a condition that requires warning Abnormal condition	Monitoring and/or intervention (for example by re-establishing the intended function) In some cases the machine will be automatically stopped	0-10 V Signal fault 24 VDC low 4-20 mA Signal fault Empty magazine Low machine capacity Network fault (Device Net, EtherNet, MES communic., HMI communic., Profibus, etc) Compressor jam PLC forced PLC internal fault

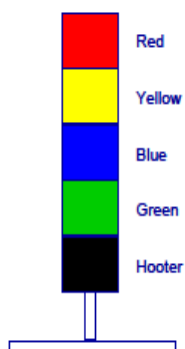
				Door open (Machine Stopped) Light curtain tripped Start warning (Flashing)
Blue	Mandatory	Indication of a condition that requires action by the operator	Mandatory action	Low level of magazine PLC battery low Ready to step-up Set-up incomplete Surge protection consumed General low priority alarm active External help request Call for Scheduling or maintenance personnel assistance Waiting for Service Call or Raw Materials
Green	Normal	Normal condition	Optional	Good Production Machine ready for start or working in normal condition Automatic Cycle Mode
WHITE	Neutral	Other conditions; may be used whenever doubt exists about the application of RED, YELLOW, GREEN, BLUE	Monitoring. Minor failure that has no direct effect on the production, but needs the operators or maintenance attention	Production Rate Batch Complete Cycle Done Machine Service Interval Due Calling attention of operator personnel

Other meanings deviating therefrom (refer to IEC 60073) may be assigned based on one of the following criteria:

- ✓ **Safety** of persons and environment;
- ✓ **State** of the machine.

IEC 60073 addresses machine state color-coding & acoustic alerting, which can be applied to devices including panel pilot lights & stack lights. Machine operator intervention is typically required in red and yellow machine states, as these are normally errors or warnings. Manual intervention is possibly necessary in blue and white conditions.

The reasons for using such color-codes are mainly to decrease the mental work-load of an operator and/or exposed persons.



Indicating towers for Alarms and Status Annunciation on machines shall have the applicable colors in the following order from the top down: RED, YELLOW, BLUE, GREEN and WHITE, but this last one is not normally applied at EMBRACO, except if some additional and very important information is needed and thus applying it as user-defined conditions specific to a certain machine or

process, often related to productivity monitoring. [IEC 60204-1:2009 clause 10.3.2 partly and modified]

Normally only one lamp shall be lit at the same time. However, the green lamp can be lit at any time except with the red one.

A steady light is normally used for indicator lights, however for further distinction or information and especially to give additional emphasis, flashing lights and displays shall be provided for the following purposes:

- ✓ To attract attention;
- ✓ To request immediate action;
- ✓ To indicate a discrepancy between the command and actual state;
- ✓ To indicate a change in process (flashing during transition).

By letting a signal flash, i.e. having it continuously switching between "on" and "off", the human perception (attention-getting qualities of the signal) is usually increased, and a feeling of **urgency** is often obtained.

In this way it is recommended that higher frequency flashing lights or display be used for higher priority information (see IEC 60073, clause 4.2.3.2, for recommended flashing rates and pulse/pause ratios in details).

The use of a PLC can allow for a 'Slow' and 'Fast' Flash Rate, with approximately equal "on" and "off" intervals, to indicate even more conditions as well:

- ✓ 0,4 – 0,8 Hz is a typical flash rate for slow flashing;
- ✓ 1,4 – 2,8 Hz is a typical flash rate for normal;
- ✓ 4 Hz is typical for a fast flash rate.

Note: see IEC 60073, clause 4.2.3.2, for recommended flashing rates and pulse/pause ratios in details

The logic of flashing and alarm management shall be something similar to the following:

- ✓ The yellow lamp shall flash during the "Warning Before Start" conditions, see item 4.4.5.7;
- ✓ Flashing the green lamp shall not be utilized, since no urgency can ever appear in normal conditions;
- ✓ When an alarm occurs, the corresponding lamp (blue, yellow or red, in some cases if necessary also the white one) shall start flashing. After pressing the alarm reset, and the alarm is no longer present, the lamp shall be switched off. Otherwise if the alarm is still present, the lamp shall show a steady light;

- ✓ In case of an alarm, not yet reset, being overridden by another new alarm with a higher priority, the first alarm shall always come back with a flashing light when the new higher priority alarm has been reset (steady light) and is no longer present (turned off);
- ✓ If there are only remaining (acknowledged) alarms in the alarm list, only the lamp with the highest priority level shall be lit. When a new (unacknowledged) alarm occurs the corresponding LED-lamp shall start blinking even if there are alarms with higher priority in the list, since all of them have been already acknowledged, except the newest one, which will flash.

Computer based HMI and Operator Panels shall use the same classification and colors in the alarm list as for the Main Stack Light visual alarm status.

Where flashing lights or displays are used to provide higher priority information, audible warning devices should also be provided.

New red and some of the yellow and blue alarms shall be announced by an alarm siren, according to the criticality, mainly the ones that will soon stop the machine. Alarm signal shall have a time limit, according to the criticality as well. Sound shall be chosen so there is clear distinction from other audible warnings such as "start warnings", see item 4.4.5.7. It shall be possible to hear the siren from all locations in the machine area.

The remaining three types for **Indication and Signaling** configurations include *Andon* applications at Embraco Global, which shall strictly conform to the instructions comprised in the TRM 003608 - ELS 4 Help Chain Training, as follows:

4.4.5.3. 2nd – An *Andon* for each Machine



This is a **Mandatory *Andon* Stack Light** of just two different colors, which according to the respective Light Status; it's going to convey a message following the Embraco *Andon* Rules for the superior level signals, related to the Section 4.4.3.2 item e). Any further information, please see TRM 003608 - ELS 4 Help Chain Training for detailed specification.

4.4.5.4. 3rd - An *Andon* Single Red Light



This is a **Mandatory *Andon* Red Light** that its status shall correspond to the current situation of a **work area**, signaling with just one lamp three different status, whether it is off or flashing or continuously lit.

Please see Global document TOL 000098 – Help Chain Operational Flow, for specific information on the EMBRACO Requirements so as to implement it following all the defined technical specifications. The recommended corporate specification is a Siemens 8WD5300-1AB red light (*GiroFlex*). Any further information, please see TRM 003608 - ELS 4 Help Chain Training for detailed specification.

4.4.5.5. 4th - An *Andon* Display or *Andon* Board

The centerpiece in this case is a signboard incorporating signal lights to indicate which workstation has the problem. The alert can be activated manually by a worker using a pullcord or normally a button, or may be activated automatically by the production equipment itself.

The board shows a summary of many work stations. There are two basic uses for this type of display:



- Firstly it can be used to signal when each station on an assembly line is ready to shift. It's most likely to see this set-up for assembly lines that manually advance products.



- It can be used to show which stations have a problem. When an *andon* pushbutton is activated at a station, it also may illuminate a light on an *andon* display, according to the respective information intended to be conveyed.

Any further information, please see TRM 003608 - ELS 4 Help Chain Training for detailed specification.

4.4.5.6. Selection & Installation Considerations

Unless otherwise previously agreed in writing between the Supplier and EMBRACO, each machine shall have at least one Stack Light or Alarm Beacon, according to item 4.4.5.2, along with mandatory *Andon* Light Devices, according to items 4.4.5.3 and 4.4.5.4. Any further information, please see TRM 003608 - ELS 4 Help Chain Training for detailed specification.

Indicator lights and displays shall be selected and installed in such a manner as to be visible from the normal position of the operator. See IEC 61310-1 for more details.

Designers must consider the risks of sensorial saturation which may result from too frequent emissions of visual and/or acoustic signals, which may also lead to defeating the purpose of the warning devices.

Consultations with appropriate skilled personnel whether are External Specialists, EMBRACO's Specialists or Engineers, are often necessary.

The visual signal shall be:

- ✓ placed so that it is in the person's field of vision;
- ✓ of suitable brightness and color-contrast compared to its background.

To be readily detected, visual signals in general shall conform to the following requirements:

- a) The positions of signals and light sources shall be selected so that the display is visible from all necessary viewing positions;
- b) Active safety-related signals shall be positioned so that they are visible to operators from working positions, and to exposed persons, and shall have as wide a viewing angle as needed for safe detection;
- c) Visual displays which have a limited viewing angle shall be positioned in such a way as to be readable from all positions where it is needed for safe detection;
- d) Passive visual signals such as safety signs, supplementary labels and markings shall be so placed that those who need to be informed are able to see the signals without having to move in such a way as to increase the risk to themselves and/or to others.

Figure 14 shows zones of recommended and acceptable, respectively, vertical and horizontal fields of vision, according to IEC 61310-1, clause 4.2.2.

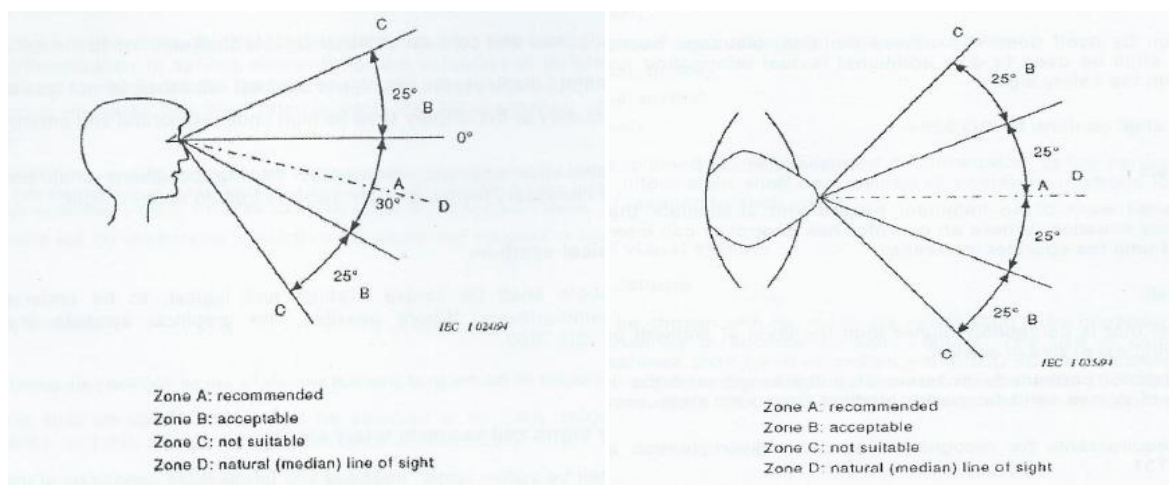


Figure 14: Zones of Fields of Vision Vertical and Horizontal

The brightness, color and contrast of visual signals shall conform to the following, based on IEC 61310-1, clause 4.2.3:

- a) For light-emitting displays, the brightness contrast ratio shall be not less than 6:1;
- b) The image quality of the display shall be high under all normal and emergency observation conditions;
- c) All anticipated (for example, emergency) viewing conditions shall be catered for by provision of necessary illumination for displays that do not emit light.

When applying Indicating Tower or Alarm Beacons it shall contain:

1. relevant lamps in the order of, and in accordance with, clause 4.4.5.2; and
2. one acoustic signal device situated either below the lamps or on top (depending on brand).

The signals must be seen and/or heard over the full machine line, when dealing with big ones, off course.

Alarm Beacons with acoustic signal devices should, for human signal perception reasons, cover a radius not larger than 5 meters, i.e. there shall be not more than 10 meters between such consecutive alarm beacons.

A recommendation is that the beacons shall be attached on the platform toe plate's outside or a similar well visible position, in terms of height, where no such platform exists.

Consider diagonal location across the machine where two beacons are required.

Typical voltages from major manufacturers of Stack Lights include 24 VDC, 115 VAC, 220 VAC and 12 VDC is sometimes available too. However the 24 VDC is the preferred voltage and shall be used whenever it is possible.

Indicator Lights shall use built-in LEDs. LEDs provide rich color & exceptional brightness at low currents, with exceptionally long life. Major manufacturers of Stack Lights will use LEDs from high quality manufacturers like Osram or Cree. The SMT (Surface Mount Technology) LEDs perform very well in high shock load environments, and are therefore preferable to LEDs with long leads.

It's very important to pay attention to the fact that Indicator Light Circuits used for warning lights shall be fitted with facilities to check the operability of these lights. "Lamp test" function shall test all lamps including possible hooters/buzzers. [IEC 60204-1:2009 clause 10.3.1 partly]

For hardwired installations, consideration should be given to circuits where the Stack Light will be installed along with inductive loads. In general, it is not best engineering practice to wire Stack Lights in parallel with Solenoids and other inductive loads since the voltage spike created by a collapsing coil must get absorbed somewhere.

Basically, depending on the machine size, there shall be along with the Indicating Towers in the Main Visual Alarm Column place of the Operator, also a Local Visual Alarm Column for each important section of the machine.

Local warnings/indications, when applied, shall not use the Main Visual Alarm Column, but rather be independent. Local warnings/indications shall use the same combinations of colors from item 4.4.5.2 on an own indication Stack Light Column.

A separate kind of warning lamp, just comprising a yellow flash, along with an acoustic warning, mounted next to the dangerous movement part of the machine, shall be used to warn before and/or during hazardous movement e.g. trolley movements, in the case it really worth it, based on the machine dimensions. Audible warning device mounted locally shall sound before start and during hazardous movement, see item 4.4.5.7.

Andons are very powerful tools if they are used correctly. According to the experience the best *andons* are visible from at least 3 meters away, respecting the directions from the Figure 14, and they are accompanied by a **clear quick reaction plan**.

4.4.5.7. Acoustic Signals

The addition of a buzzer adds priority by providing audible stimulus and is effective in capturing an operator's immediate attention.

Audible Buzzer: Most manufacturers offer integral buzzers with their products. Buzzers are usually offered in the 80-105db sound pressure rating and are most useful when they include a means of dampening the sound to fit the installation area. They should be "annoying" but not "deafening" to an operator.

Acoustic codes may be used, when:

- ✓ it is necessary to attract the attention of the operator;
- ✓ the information to be coded is short, simple, and transitory;
- ✓ the information requires an immediate or time-based response;
- ✓ the application of visual codes is restricted;
- ✓ the criticality of a situation makes a supplementary or redundant information necessary.

An acoustic signal may consist of pure or complex tones, noise or spoken message. An acoustic signal shall mark the onset and the duration of a hazardous situation or warn of an imminent hazard.

Acoustic signals shall be audible to and readily identifiable by operators and exposed persons in the intended signal reception area, and under the anticipated ambient noise conditions. The signals shall be clearly different from the signal for emergency evacuation (see ISO 8201).

Different kinds of acoustic signals shall be unequivocally distinguishable from each other.

Hearing limitation shall be taken into account where ear protectors or earphones are used and in cases of hearing-impaired personnel.

To prevent overloading the operators with sounds, the number of different kinds of sound in a given application shall be limited to the minimum practicable.

Where an operator has control or can intervene, the signal shall continue at least until the operator intervenes.

An acoustic signal shall in summary:

- ✓ have a sound level that is perceptibly higher than the level of ambient noise so that it is audible without being excessive or painful;
- ✓ be easily recognizable, particularly in terms of pulse length and the interval between pulses or groups of pulses, and be clearly distinct from any other acoustic signal and ambient noises;
- ✓ conform to the requirements for recognition, acoustic, discrimination and unambiguity specified in ISO 7731.

In the other hand, Acoustic Danger signals shall take precedence concerning recognition over all other acoustic signals. The meaning of the acoustic danger signal shall be unambiguous. Acoustic danger signals and signals serving other purposes shall not be similar.

Acoustic danger signals are usually clearly audible if their A-weighted sound levels exceed the level of ambient noise by 15 dB or more, and the A-weighted level of the signal is equal to or greater than 65 dB.

The acoustic danger signal should be based on frequencies in the 300 to 3000 Hz range. In general, pulsating acoustic danger signals should be preferred to signals that are constant in time. The pulse repetition frequency shall be in the range from 0.2 Hz to 5 Hz.

An Important acoustic signal to be deemed is the one that shall sound during the "Warning before Start" conditions: A warning, audible and visible, shall be given during at least 3 seconds prior to start i.e. before applying the Automatic Cycle Mode, based mainly on the machine dimensions, which means, on the following machine lines as example:

- Transfers;
- Presses;
- Sizeable machines with interlocking guard and platform; and

- Other machines with interlocking guard and where there is no clear visibility of the machine from the operator panel when the operator takes two steps in any direction.

The warning shall also be given in the following situations:

- during stepping up a machine into production prior to entering such steps which would present a hazard or hazardous situation if no guards would be in place;
- before inching or jogging.

NOTE: For machines where persons can enter completely into the danger zone the warning period shall be adapted either to:

- the actual time required for a person to safely exit the safeguarded space; or
- the actual time required for operator(s) to actuate a means to stop the reset process and prevent restart from within the danger zone(s).

For detailed requirements on danger signals for work areas, see also ISO 7731.

Requirements for the definition of danger and non-danger signals with sound are given in ISO 11429.

A final assessment and certification has to be done by EHS personnel so as to evaluate the impact of the acoustic signal in the ambient noise condition of the installation area.

4.4.6. Push-buttons

Push buttons shall be:

- ✓ Readily accessible for service and maintenance;
- ✓ Mounted in such a manner as to minimize the possibility of damage from activities such as material handling.

The actuators of hand-operated control devices shall be selected and installed so that:

- ✓ They are not less than 0,6 m above the servicing level (level on which persons stand when operating or maintaining the electrical equipment) and are within easy reach of the normal working position of the operator;
- ✓ The operator is not placed in a hazardous situation when operating them;
- ✓ The possibility of unintentional actuation is minimized.

The actuators of foot-operated control devices shall be selected and installed so that:

- ✓ They are within easy reach of the normal working position of the operator;
- ✓ The operator is not placed in a hazardous situation when operating them;

Push button actuators shall be color-coded in accordance with Table 5, and the definition of its colors is described below:

- ✓ "Emergency" red: actuated in situations such as emergency stop, initiation of emergency function and emergency switching off actuators;

Note: the color RED for the emergency stop actuator shall not depend on the illumination of its light








- ✓ "Normal condition" red: actuated in event of a normal condition for machine stop;


Note: it is recommended that normal condition red is not used near an emergency operation device.

- ✓ "Abnormal" yellow: actuated in abnormal conditions such as quick stop, short stop, intervention to suppress abnormal condition and intervention to restart and interrupted automatic cycle;
- ✓ "Bypass" yellow: it is also actuated in abnormal conditions but with an important bypass function;
- ✓ "Mandatory" Blue: actuated in conditions requiring mandatory actions, such as resets in general, failure alarms, external help request, call for scheduling or maintenance assistance and waiting for service call or raw materials;
- ✓ "Normal" green: actuated to initiate normal conditions, when machine is ready for start working in normal conditions;
- ✓ White: actuated for general **initiation of functions**, and cause operation while they are actuated and cease the operation when they are released. Some examples of white push-button application are: general START/ON, speed selections, jog/inch, speed X, toggle functions ON/OFF, step-up, step-down, calling attention of operator personnel (starts an acoustic signal), lamp test, pushbutton for machine starting (according to pre-evaluation);
- ✓ Black: actuated for general **ending of functions**, such as general STOP/OFF;
- ✓ General information:
 - Where the same color WHITE or BLACK is used for various functions (for example WHITE for START/ON and for STOP/OFF actuators) a supplementary means of coding (for example shape, position, and symbol) shall be used for the identification of push-button actuators. See also IEC 60204-1:2009 clause 9.2.6.4.
 - Illuminated push-button actuators shall be color-coded in accordance with Table 4 and Table 5.
 - Where there is difficulty in assigning an appropriate color, WHITE shall be used.
 - Push button actuators shall be color-coded in accordance with Table 5.

[IEC 60204-1:2009 clause 10.2.1 and 10.4 modified]

Table 5: Color-coding for push-button actuators, signal lamps and their meanings

Color	Meaning	Explanation	Examples of Application
Red 	Emergency	Actuate in the event of a hazardous situation or emergency	Emergency stop Initiation of emergency function Emergency switching off actuators
Red 	Stop	Actuate in the event of a normal condition for stop Signaling the event of a hazardous situation, emergency or failure	Pushbutton for Machine Stopping Red lamp for machine emergency stop signaling Failure Alarm X
Yellow 	Abnormal	Actuate in the event of an abnormal condition	Quick stop Short stop Intervention to suppress abnormal condition Intervention to restart an interrupted automatic cycle
Yellow 	Abnormal	Actuate in the event of an abnormal condition	By pass of important function
Blue 	Mandatory	Actuate for a condition requiring mandatory action	Reset function Emergency stop reset Protective stop reset Safety device reset Failure Alarm External help request Call for Scheduling or maintenance personnel assistance Waiting for Service Call or Raw Materials
Green 	Normal	Actuate to initiate normal conditions	Good Production Automatic Cycle Mode Machine ready for start or working in normal condition Pushbutton for Machine Starting (According to pre-evaluation)
WHITE 	No specific meaning assigned	For general initiation of functions except for emergency stop	General START/ON Cooling Fan ON Devices ON

			Power On Speed selections Jog/Inch Speed X Slow speed Toggle functions (ON/OFF) Step-up Step-down Open Request Calling attention of operator personnel (Starts an acoustic Signal) Lamp test Pushbutton for Machine Starting (According to pre-evaluation)
BLACK 			General STOP/OFF Cooling Fan OFF (Example) Devices OFF

The same color scheme should be considered when designing configurable push-buttons on HMI or video display screens. [IEC 60204-1:2009 clauses 10.2.1 and 10.4 & IEC 60073 clause 5.2.3.1 modified]

Push-buttons and similar control devices that, when operated, alternately initiate and stop motion shall only be provided for functions which cannot result in a hazardous situation. [IEC 60204-1:2009 clause 9.2.6.4]

The following is valid for all push-buttons except Emergency-stop (see 4.4.6.1), Quick stop (see 4.4.6.2), Key switch (see 4.4.6.9) and Selector switch (see 4.4.6.10) described later in this Section:

- ✓ Push-buttons described below shall be hardwired and preferably of "square type" with built-in LED-lamp;
- ✓ They shall fit Ø 22mm mounting hole and with momentary action (spring return);
- ✓ Any latching function shall be made in the PLC with indication of state in the push-button;
- ✓ Toggle functions (e.g. Auto/Man) are made with one push-button. On/Off functions are made with 2 separate push-buttons;
- ✓ The lens shall be preferably transparent to make it possible to place a textual or graphical marking directly in the push-button cover.

4.4.6.1. Emergency Stop



Push-button for emergency stop shall be of the red mushroom type: with mechanical rotary release, with a yellow circular background and with red textual commentary "Emergency Stop" below the button. It is recommended to keep same model throughout the line and even better throughout a plant.

For detailed technical information, consult EHS Manual TST 000067.

4.4.6.2. Quick Stop



Push-button for quick stop shall be yellow, round and raised type with momentary action. Push-button shall have a white circular background with blue textual commentary "Quick Stop" below the push-button.

4.4.6.3. Emergency Stop Reset



The reset button shall be blue, illuminated and mounted at the main panel. The operating signs for emergency stop reset depend of the condition, which may be:

- ✓ Blinking: one or more Emergency stop push-buttons are actuated. In this case, it needs to be reset locally by pulling the actual Emergency stop button;
- ✓ Firm light: Emergency stop is activated, ready to be reset.

4.4.6.4. Main Protective Stop Reset



The reset button shall be blue, illuminated and mounted at the main panel. The operating signs for main protective stop reset depend of the condition, which may be:

- ✓ Blinking: one or more protective zones are actuated, and needs to be locally reset;
- ✓ Firm light: protective stop is activated and all line drives have been stopped. Ready to reset.

4.4.6.5. Locally Protective Stop Request

The reset button shall be blue, illuminated and mounted out of the reach of the protected area. The minimum acceptable is one for each protective area. Push-button shall be located so that a clear view of the protected area is provided to ensure that no person is in the protected area.



The operating procedures for locally protective stop request depend of the condition, which may be:

- ✓ Blinking: one or more protective zones are actuated, e.g. door open;
- ✓ Firm light: safety function has been activated by one of the protective device. Machine is ready to reset.

4.4.6.6. Open Request Push-button

The opening request push-button shall be white, illuminated and mounted next to the area that is protected.



The operating signs for open request depend of the condition, which may be as example:

- ✓ Blinking: request is performed (will go off after 2 seconds if request is not granted);
- ✓ Request is granted, lock is open (will go off if door is not opened within ten seconds).

4.4.6.7. Bypass Push-button

The bypass push-button shall be yellow, illuminated and mounted next to area that is protected. This is to access protected area during running safe speed if programmed so, jog or other functionality. Push-button shall be located to ensure that there is a clear view of the person working in the hazardous area. The operating signs for bypass push-button depend of the condition, which may be as example: (**Note:** any bypass function has to be formally approved in writing by EHS)



- ✓ No light: it is not allowed to open the protective door;
- ✓ Blinking: bypassing and one of the protections is open, not allowed to release bypass push button. Close protection and reset to get firm light (some protections have auto reset);
- ✓ Firm light: machine stopped, it is ok to open the protective door or gate without using bypass push-button.

4.4.6.8. Restart Tripped Objects



The reset button shall be blue, illuminated and mounted at the main panel. The operating signs for restart tripped objects depend of the condition, which is:

- ✓ Firm light: tripped objects in machine.

4.4.6.9. Key Switch



Key switch can only be activated by a key. It is used in situations where access needs to be restricted of the switch's functions, e.g. Control Voltage.

4.4.6.10. Selector Switch



Selector switch are used where fixed positions are necessary, e.g. Machine Light. It must not be used as machine control.

4.4.6.11. Layout of Pushbuttons



Pushbuttons shall be arranged in a logical and intuitive way.

Relation between buttons shall as far as possible reflect the physical placement of the function in the machine.

"Off" buttons shall be placed below or to the right of corresponding "On" button.



Emergency Stop and Quick Stop buttons shall be placed in the upper right or the lower right corner of a panel; whichever is most convenient from access point of view without high risk for accidental actuation.



Quick stop shall be preferably placed below the Emergency stop, whenever it's possible.

4.4.6.12. Marking

All components used by the operator shall have signs specifying its function. It is recommended to use engraved aluminum signs with symbols or black text. Exceptions can be made by using the components own marking facility, e.g. text in transparent pushbutton covers.

4.4.6.13. Language

All Push buttons text shall be in the local official language, of the country, site that machines and equipment are to be used. Any other needs may be agreed upon purchasing agreement, according to Section 3.3.

4.4.7. Machines and Equipment Electrical Safety Signs

This chapter is to be applied along with the EHS Manual TST 00067, since this part here is to complement and cover only safety issues specifically related to Electrical Safety Signs, giving special attention to that, due to Regulation demands as well as to meet the "Coding of Visual Signals" requirements, see item 3.6.1, for the concept of "Visual Management" within EMBRACO's Continuous Improvement Program.

The European Machinery Directive 2006/42/EC, annex 1, clause 1.1.2 item b, has a three-tier approach to providing a safe machine and equipment, which are:

- Eliminate or reduce the risks as far as possible;
- Take the necessary protection measure in relation to risks that cannot be eliminated;
- Inform users of the residual risks due to shortcomings of the protective measures adopted, indicate whether any particular training is required and specify any need to provide personal protective equipment.

This part of the Corporate Standard considers the third approach when the mentioned steps 1 and 2 cannot be adopted in any way, regarding Electrical Safety Signs in Machines and Equipment. Potential hazards that exist during normal use and reasonably foreseeable misuse, and are not obvious, should be warned about. The regulation ISO 12100 parts 1 and 2, which are harmonized under the Machinery Directive, states in clause 8.4 item c):

- Signs or written warnings only saying "danger" shall not be used;
- Markings, signs and written warnings shall be readily understandable and unambiguous, especially as regards the part of the function(s) of the machine which they are related to;
- Readily understandable signs (pictograms) should be used in preference to written warnings;
- Signs and pictograms should only be used if they are understood in the culture in which the machinery is to be used;
- Written warnings shall be drawn up in the language(s) of the country in which the machine will be used for the first time and, on request, in the language(s) understood by operators. Any other needs may be agreed upon purchasing agreement, according to Section 3.3.

Note: in some countries the requirement to use specific language(s) is covered by legal requirements.

Anyone who could reasonably come in contact with the machine and equipment has to be warned against the hazards both in normal use and as well as during reasonably foreseeable misuse. Only when the hazard is open, evident and obvious to the user or the use is in the worst case unforeseeable, there may not be a duty to warn with the use of a safety sign.

The manufacturer has a continuing duty to identify new or increased potential hazards after the machine and equipment is placed on the market. For example, some unforeseeable uses or misuses may now be considered foreseeable based on actual field usage. In those cases, the manufacturer may have a duty to add additional warnings to new machines and equipment and possibly update safety signs on machines and equipment already in the field. That is really of pretty much importance.

The target audience for the safety signs is the operators and maintenance personnel that use the machine and equipment and should always be trained for their tasks. The market for the machines to be delivered to EMBRACO is global and thus international, therefore supplementary safety information texts should be kept to a minimum to avoid translation to other languages, as much as possible.

The safety sign shall be placed readily visible to the intended user and alert the user of the potential hazard in time to avoid it. Place the safety sign near the hazard. It might be necessary to place a safety sign for a potential hazard both on the outside of a door and on the equipment inside, because when the door is open, the hazard is not evident and the safety sign on the door is not visible.

Choice of materials and attachment method shall take into account the foreseeable environment of use and the expected life of the machine and or equipment to ensure color stability and safety sign legibility at all times.

Which material to be used for safety sign, is defined in ISO 17398, "Classification, performance and durability of safety signs". Information identifying the presence, location and content of safety signs shall be provided in the "Safety Precaution Chapter" of the technical manuals accompanying the machines and equipment. Safety signs shall be additionally reproduced in the "Safety Precautions Chapter" for easy acknowledgement and realizing it by seeing how it looks like, according to the information to be conveyed. For additional information on the demanded manuals to EMBRACO, see Section 3.7.3.

Information on maintenance and replacement of safety signs shall also be provided in the maintenance manuals. In the Spare Part List, the safety signs order number must also be found. See also IEC 60204 series as regards marking of electrical equipment.

4.4.7.1. General

According to machinery directive 2006/42/EC, posting of signs on machine should be done in immediate proximity to the danger referred to, and be well visible. The sign must be expected to remain and be legible during the entire life of the machine and equipment.

Safety signs shall be created and applied in accordance with EHS Manual TST 00067 recommendations. Warning signs, nameplates, markings, and identification plates shall be of sufficient durability to withstand the physical environment involved.

The specific conditions valid for each occurrence of a safety sign shall be explained in the "Safety Precaution Section" of the respective manuals.

The general principle for safety signs worldwide within the ISO and EN communities is that symbols without any text shall be affixed to machinery. Instructions in the applicable language shall be provided instead. On the tables below, the Machines and Equipment Electrical ISO Safety Signs are going to be shown.

Note: where a warning safety sign needs explanation, the text shall be given in instruction manuals and, thus, the safety sign "Read Instruction Manual" shall be affixed combined with and next to the warning safety sign.

Table 6: Power Supply ISO Signs







Power Supply		
	 Hazardous voltage 6 kV. Will shock, burn, or cause death. Follow lockout procedure before maintenance.	50x50 100x100
		50x25
	 Hazardous voltage. Will shock, burn, or cause death. Follow lockout procedure before maintenance.	50x50 100x100
	 Hazardous voltage. Can shock, burn, or cause death. Read Maintenance Manual (MTM) before using this socket outlet.	50x50 100x100 35x35

Table 7: Residual Voltage ISO Signs

Residual voltage		
	<p>⚠ DANGER</p> <p>Hazardous residual voltage on capacitors.</p> <p>Will shock, burn or cause death.</p> <p>Do not touch until safe.</p> <p>Follow instructions for safe work practices.</p>	50x60
	<p>⚠ WARNING</p> <p>Hazardous voltage with power supply disconnecter switched off.</p> <p>Can shock, burn, or cause death.</p> <p>Do not touch.</p>	50x50 100x100
	<p>⚠ WARNING</p> <p>Hazardous voltage could be present with power supply disconnecter switched off.</p> <p>Can shock, burn, or cause death.</p> <p>Orange conductors supplied from an external source.</p> <p>Follow lockout procedure before maintenance.</p>	50x50 100x100
	<p>⚠ WARNING</p> <p>Hazardous voltage could be present with power supply disconnecter switched off.</p> <p>Can shock, burn or cause death.</p> <p>Conductors supplied from an external source.</p> <p>Follow lockout procedure before maintenance.</p>	50x50 100x100

Table 8: Hot Surface ISO Sign


Hot Surfaces/ Areas		
	<p>⚠ WARNING</p> <p>Hot surface</p> <p>Do not touch. Follow lockout procedure before maintenance.</p>	<p>50x50</p> <p>100x100</p>

Table 9: Magnetic Field ISO Sign


Strong Magnetic Fields		
	<p>⚠ WARNING</p> <p>Magnetic field</p> <p>Interaction with metallic objects can cause injury. Follow instructions for safe work practices.</p>	<p>50x50</p>

Table 10: Laser ISO Sign



Laser		
	<p>⚠ CAUTION</p> <p>Laser radiation</p> <p>Do not stare into beam. Class 2 laser product. Read Operation Manual (OPM) before working with this product.</p>	<p>50x50</p>

Table 11: Water ISO Sign

Water		
	<p>⚠ DANGER</p> <p>Electrical hazard. Contact with water will cause electric shock. Do NOT touch with wet hands. Always unplug when not in use.</p>	<p>⚠ DANGER</p> <p>Electrical Hazard</p> <p>The contact with water will cause electric shock. Do NOT touch with wet hands. Always unplug when not in use</p>

4.4.7.2. Caution Signs **⚠ CAUTION**

Caution indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury. It may also be used to alert against unsafe practices. It should be used to prevent arising danger caused by water spraying of machine details, or where contact would lead to severe damage to persons. The following sign represents a caution sign.

Note: information regarding handling should not be used as compensation for constructional deficiencies.

4.4.7.2.1. Laser Radiation

According to Table 10, the laser radiation tag is used to advise the worker who is near to or dealing with a laser beam equipment. The message says that the employee shall not look directly into the beam, because there is a class 2 laser product over there. The Symbol "Read Operation Manual (OPM) before working with this product" shall be applied along with the laser attention one and the respective instruction about the necessary care shall be included in the Operation Manual (OPM) accordingly.



4.4.7.3. Warning Signs **⚠ WARNING**

Warning signs indicate a potentially hazardous situation which, if not avoided, could result in death or serious injury. They are used to warn against an existing danger, e.g. Warm surface, closed-in air, etc. In cases where protection would prevent handling when the machine is in operation, but where danger still occurs, warning signs should be used. Some types of warning signs application can be found below.

Note: Information regarding handling should not be used as compensation for constructional deficiencies.

4.4.7.3.1. Residual Voltage



For the Table 7: Residual Voltage ISO Signs, these signs are related to enclosures which do not clearly show that they contain electrical devices and it shall be marked with a black lightning flash on a yellow background within a black triangle, but when **Hazardous voltage could be present even with power supply disconnecter switched off**. Additionally a label shall be placed close to the main disconnecter switch to state where the

External Voltage comes from and it also shall be identified all the circuits and terminals that remain with live potential. All electrical cabinets and enclosures which do not clearly show that they contain electrical devices shall be marked with a warning sign in accordance with the mentioned symbol. It shall be followed in three main situations, in this Residual Voltage Case, which are:

- If there is no clear indication of live potential;
- If there is the indication of orange conductors with active potential, supplied by an external source;
- If there is the indication of active potential, supplied by an external source (no orange conductors).

The warning sign may be omitted for (it shall be agreed with EHS a priori):

- An enclosure, electrical panel, equipped with a visible and identifiable, by every common person, supply disconnecting device (supply disconnecter);
- An operator-machine interface or control station;
- A single device with its own enclosure (for example machine mounted transducers or electric motors).

[IEC 60204-1:2009 clause 16.2.1 modified]

For those Residual Voltage Symbols, supplementary messages shall be compulsorily added along with, according to Table 7. For more information, see also item 4.4.7.5.5.

4.4.7.3.2. Identification of Socket Outlet

According to Table 6, all Socket Outlet shall have identification of Electrical Shock Risk, Figure 15. The message implicitly says Hazardous Voltage: can shock, burn, or cause death. The Symbol itself means "Read Maintenance Manual (MTM) before using this socket outlet"; and the respective instruction about the necessary care shall be included in the Maintenance Manual (MTM) accordingly. A RCD must be mounted to protect the wall socket outlet. And these two units must be placed close to each other. The tag (50x50 mm), (35x-35 mm) must also be placed close to those units.

To prevent problems, the socket outlet is compulsorily connected to the residual current device, protecting users against electrical shock if there is an earth fault in the connected equipment. The residual current device must be tested each time before the socket outlet is being used. The MTM shall also explain how to perform the test



Figure 15: Socket Outlet Safety Sign



Figure 16: Outlet Socket Application

Standard Code	Part	Revision	Confidentiality	Date	Creator Name	Approver Name	Responsible Area
TST 000138	GL0	04	Public	29/01/2015	Edson P. Ferreira	Sergio Maganhoto	Corporate Assets

procedure of the RCD. The Figure 16 shows an example of application of the sign: the residual current device, the safety tag, the socket outlet and their locations.

4.4.7.3.3. Strong Magnetic Fields



According to Table 9, the magnetic field sign is used to represent that the place where the worker is going into has a magnetic field. The sign represents that an interaction with metallic objects can cause injury, and the worker must follow the instructions for safe work practices. Persons doing use of pacemaker shall keep distance of the delimited area.

4.4.7.3.4. Thermal Conditions

Heat generating components (for example heat sinks, power resistors) shall be so located that the temperature of each component in the vicinity remains within the permitted limit. [IEC 60204-1:2009 clause 11.2.3]

Equipment that, in normal or abnormal operation, can attain a surface temperature sufficient to cause a risk of fire or harmful effect to an enclosure material shall:

- Be located within an enclosure that will withstand, without risk of fire or harmful effect, such temperatures as may be generated;
- Be mounted and located at a sufficient distance from adjacent equipment so as to allow safe dissipation of heat; and
- Be otherwise screened by material that can withstand, without risk of fire or harmful effect, the heat emitted by the equipment.

Note: warning label may be necessary, According to Table 8
 [IEC 60204-1:2009 clause 11.4]

Heat conditions for electrical cabinets depend upon the following:



- Heat flows over the surface of the electrical cabinet;
- Electrical equipment heat (energy) losses;
- Exchange with ambient air;
- Actions that have been taken to keep the temperature within the required limit;
- The humidity inside and outside the electrical cabinet.

Depending on those present conditions, the following solutions can be chosen to keep the temperature within the required limit, see also Section 4.4.4.3 item c) 1:

- Heating element;

- Natural air flow (filter only);
- Fan with filter (the fan should always blow only filtered air into the cabinet);
- Heat exchanger (water/air mostly, but in some cases air/air);
- Active cooling (air conditioning).

As pollution, which means dust, dirt and so on, may not be dispersed to zones with stricter hygiene requirements, air intakes and air outlets must be positioned so that the air streams do not increase the spread of pollution, dust and dirt to the manufacturing environment.

4.4.7.3.5. Terminal Block Protection and Signs



Figure 17: Live Potential Protective Cover and Sign



Figure 18: Live Potential Protective Cover

Whether even with the main disconnecter switched off, there is still active potential on the terminals; additional alternatives shall be taken in order to mitigate its risks. In these cases, an electrical warning sign must be applied on each terminal with active potential, Figure 17, where it warns and protects, at the same time, against access to live terminals. Additional Transparent Protection Cover shall be added in order to avoid touching it unintentionally, thus ensuring full protection against electric shock on the terminal blocks, Figure 18. See also item 4.4.4.3 a).

4.4.7.4. Danger Signs **⚠ DANGER**

Danger signs indicate an imminently hazardous situation which, if not avoided, will result in death or serious injury. Some types of danger signs application can be found below.

4.4.7.4.1. Hazardous Residual Voltage on Capacitors



The sign on the left shall be used in a hazardous residual voltage on capacitors situation, according to Table 7. The effect of contact in a situation like this may cause shock, burn or death. After the power supply disconnecter is turned off, residual voltage remains in

the capacitor circuits, and this sign shall be used in situations like that. When looking into this sign, the worker must wait five minutes before opening the enclosure containing these circuits. Ensure that no residual voltage remains on the capacitors before touching them.

4.4.7.4.2. Hazardous Voltage: Low Voltage



According to Table 6, by using this sign, differently from the same sign used when WARNING about dangerous classification in the item 4.4.7.3.1 and following the same recommendations therefrom, apart from the Residual Voltage Issues, there where there was the possibility of shock, burn or cause death, the main objective here is otherwise to let the workers know that by not following the correct procedures, it will certainly shock, burn or cause death, and the

worker shall follow the lockout procedure before maintenance.

4.4.7.4.3. Hazardous Voltage: High Voltage



According to Table 6, by using this sign, the main objective is to let the workers know that by not following the correct procedures, it will certainly shock, burn or cause death, because there is a voltage higher than 1kV on the region (6kV in the image example), so the worker shall follow the lockout procedure before maintenance. This is certainly a danger situation.

4.4.7.4.4. Electrical Hazard: Contact with Water



According to Table 11, this sign must be used when the contact between water and the region will cause an electric shock. In these cases, never touch the region with wet hands, and when not using, always unplug.

4.4.7.5. Machines and Equipment Supplementary Electrical Safety Messages

Sometimes, only the electrical safety sign is not enough to prevent an unsafe act. In these cases, it is recommended to use some **supplementary messages** along with the signs and

wherever necessary to be placed. By doing that, the understanding of the personnel is going to be easier, avoiding incidents and accidents. Some of these examples of supplementary messages are going to be shown as follows, but reminding that are just as examples of reference utilization.

4.4.7.5.1. Hot Surfaces **⚠ CAUTION**

- May cause burns;
- The assembly housing and components around the “ultraviolet light” assembly are hot. Allow components to cool down before maintenance.

4.4.7.5.2. Strong Magnetic Field **⚠ WARNING**

- Can cause serious injuries to persons with pacemakers. Maintain at least 300 mm distance;
- The magnet can attract tools and other metal objects causing pinch, cut, or impact. Keep metal objects away from the magnet.

4.4.7.5.3. Hazardous Voltage: Socket Outlet **⚠ WARNING**

- Can shock, burn, or cause death. Read the Maintenance Manual (MTM) before using this socket outlet;
- The socket outlet is connected to a residual current device to protect users against electrical shock if there is an earth fault in the connected equipment. The residual current device must be tested each time before the socket outlet is being used. See the Maintenance Manual (MTM) for test procedure.

4.4.7.5.4. Hazardous Voltage and Moving Machinery **⚠ DANGER**

- The power supply disconnecter must be turned off and secured with a lock before any maintenance;
- The key to the lock must be removed by the technician and retained in his/her possession until all work is completed.

4.4.7.5.5. Hazardous Voltage with Power Supply Switched Off **⚠ DANGER**

- Circuits identified by orange-colored conductors are not disconnected by the main power supply disconnecter. The location of the power supply disconnecter of these circuits is described in the Maintenance Manual (MTM) procedures that include work on these types of circuit;
- Certain maintenance procedures may require power supply systems to be on. These exceptions are clearly stated in the Maintenance Manual (MTM).

4.4.7.5.6. Hazardous Voltage: Residual Voltage **⚠ DANGER**

- Will shock, burn, or cause death;
- After the power supply disconnecter is turned off, residual voltage remains in the capacitor circuits;
- Wait five minutes before opening the enclosure containing these circuits;
- Ensure that no residual voltage remains on the capacitors before touching them.

4.4.7.5.7. Hazardous Voltage: Electrical Cabinet **⚠ DANGER**

- Will shock, burn, or cause death. Parts behind doors to electrical enclosures may be live. The power supply disconnecter must be turned off and secured with a lock before performing maintenance inside the electrical cabinet;
- The key to the lock must be removed by the technician and retained in his/her possession until all work is completed;
- The use of a key or a tool is necessary to access to the electrical cabinet;
- Make sure that the electrical cabinet doors are closed after working inside the electrical cabinet. Doors with locks must be locked;
- When opening the doors to the electrical cabinet, live parts inside the enclosure are disconnected via an interlock.

4.4.7.6. Wiring Color Identification Label

A sign for identification of single conductor color and its use shall be located on the inside of the electrical cabinet "main door" or in "all doors" if applicable, in an eye's height position, Figure 19. If there are also analog signals and safety devices inside the electrical panel, it shall also be shown in the same label. Identification tags shall be legible, permanent, and appropriate for the physical environment. It shall be fully in conformity with Table 1.

IDENTIFICATION OF SINGLE CONDUCTORS	
Earth conductors	Green and Yellow
Neutral conductors	Light Blue
A.C. or D.C. Power circuits	Black
A.C. Control circuits	Red
D.C. Control circuits	Blue
Circuits from an external supply	Orange
90459-7229	

Figure 19: Conductors and Circuits Identification

4.5. Utilities Installation

This chapter deals with the installation for water, steam and compressed air which belong to the machine and/or equipment except for what has already been included under chapters 4.1, 4.2 and 4.3.

4.5.1. Materials and Brands Homologated By EMBRACO

The list of homologated material's manufacturers and brands are in the Section 6.6, Annexes F's, so as to limit the unnecessary and uneconomical diversity of components in the respective site from EMBRACO. The preferable components to be used in the project are the ones listed in the First Choice Brand Column of the respective tables. The use of components placed in the Second Choice Brand Column shall be previously justified and agreed with the leadership of the respective Maintenance area involved, which the machine and/or equipment are to be delivered to, just to avoid any unexpected and unpleasant outcome afterwards. The use of components that are not homologated by EMBRACO shall be previously authorized in writing by the leadership of the respective Maintenance area involved.

The component lists in the Annexes F's are divided by each different country, site, thus it must be paid special attention to the component list to the respective country, site it belongs to.

5. Environment, health and safety (EHS)

For any safety, health and environment definition it is required to follow the instructions and the guidelines described in the EHS Manual (TST 000067 + TEM 000840). In case of any doubt about it, the EHS area must be consulted.

Annex A2 – CHINA

DELIVERY OF TECHNICAL DOCUMENTATION			
THIS SHEET DETERMINE WHICH PAPERS MUST BE DELIVERED BY THE SUPPLIER TO EMBRACO WITH THE PROPOSAL FOR MACHINE AND/OR EQUIPMENT AS WELL AS IN THE NEXT STEPS, AS ITS APPLICATION FOR PURCHASE			
Deadline	Machine	Copy Paper	Media Electronics
1-Together, with the Proposal	<ul style="list-style-type: none"> -Detailed description of the machine/equipment, with diagrams and drawings, through catalogs or other appropriate means showing the system construction; -Drawings of the foundation (Presses or Special Machines/Equipment); - An outline of the utilities points with their estimated values of consumption (TEM 000329 – Data Sheet for Equipment Installation, Registration or Reallocation); - Drawings showing the principle of the devices, with their description. 	1 1 1 1	CD/DVD/USB
2-Before the manufacture of machine and/or equipment starts (for approval)	<ul style="list-style-type: none"> -Electric scheme with bill of material (including brand, model, production code, specification, manufacturer, number); -Electronic scheme with bill of material (including brand, model, production code, specification, manufacturer, number); -Hydraulic scheme with bill of material (including brand, model, production code, specification, manufacturer, number); -Pneumatic scheme with bill of material (including brand, model, production code, specification, manufacturer, number); -Plan of tools with bill of material (including brand, model, production code, specification, manufacturer, number); -Design of the device operations; -Machine assembly/layout /parts(every part for checking) drawings with bill of industry standard production, including brand, model, production code, specification, manufacturer, number; -List of utilities and their consumption. 	1 1 1 1 1 1 1 1 1	CD/DVD/USB
3-Before the Installation Process (Tryout is the limit date)	<ul style="list-style-type: none"> - Machine specification sheet (serial number, model, date and country of manufacturing, manufacturer, power, voltage, current, frequency); - Lay-out of the machine with the weights of the units; - Installation Manual, instructions for transport and assembly; - Checklist of planned maintenance, including preventive maintenance and lubrication maintenance (Electric/Electronic/Mechanical); - Recommended Spare Parts List according to EMBRACO's Standard. 	1 1 1 1 1	CD/DVD/USB
4-At the delivery of the machine and/or equipment (definitive documents / As built)	<ul style="list-style-type: none"> - Electric scheme with bill of material (including brand, model, production code, specification, manufacturer, number, etc.); - Electronic scheme with bill of material (including brand, model, production code, specification, manufacturer, number, etc.); - Hydraulic scheme with bill of material, (including brand, model, production code, specification, manufacturer, number, etc.); - Pneumatic scheme with bill of material, (including brand, model, production code, specification, manufacturer, number, etc.); - Drawings of the devices/machine parts; - Drawings of special tools; - Functional diagram of the machine; - Plan / layout of lubrication, including position photos; - Instructions / operation manual; - Machine and Equipment manuals / component supplied by third parties; - Instructions / maintenance manual including troubleshooting; - Instructions / Maintenance plan, including operation standard; - Construction drawings of wearing parts; - Automation program backup with comments (PLC/CNC/IHM); - Plan of tools; - Protocol of geometric measurement (in the Try-out and in the 	2 2 2 2 2 2 1 1 1 1 1 1 1 1 1 1 1	CD/DVD/USB

	delivery of the Machine); - Protocol for noise measurement in the motorized systems; - Guarantee certificate. - Study of capability Cmk; - Thermograph analysis report; - Other files demanded in technical proposal.	1 1 1 1 1	
Note: For apparatus and line manufacturing instruments, must be provided operation manual, instrumentation, maintenance and electrical / electronic schemes.			

Annex A3 – SLOVAKIA

DELIVERY OF TECHNICAL DOCUMENTATION			
THIS SHEET DETERMINE WHICH PAPERS MUST BE DELIVERED BY THE SUPPLIER TO EMBRACO WITH THE PROPOSAL FOR MACHINE AND/OR EQUIPMENT AS WELL AS IN THE NEXT STEPS, AS ITS APPLICATION FOR PURCHASE			
Deadline	Machine	Copy Paper	Media Electronics
1-Together, with the Proposal	-Detailed description of the machine/equipment, with diagrams and drawings, through catalogs or other appropriate means showing the system construction; -Drawings of the foundation (Presses or Special Machines/Equipment); - An outline of the utilities points with their estimated values of consumption (TEM 000329 – Data Sheet for Equipment Installation, Registration or Reallocation); - Drawings showing the principle of the devices, with their description.	1 1 1 1	CD/DVD/USB
2-Before the manufacture of machine and/or equipment starts (for approval)	-Electric scheme with bill of material, including brand, model, production code, specification, manufacturer, number; -Electronic scheme with bill of material, including brand, model, production code, specification, manufacturer, number; -Hydraulic scheme with bill of material, including brand, model, production code, specification, manufacturer, number; -Pneumatic scheme with bill of material, including brand, model, production code, specification, manufacturer, number; -Plan of tools with bill of material, including brand, model, production code, specification, manufacturer, number; -Design of the device operations; -Machine assembly/layout /parts (every part for checking) drawings with bill of industry standard production, including brand, model, production code, specification, manufacturer, number; -List of utilities and their consumption.	1 1 1 1 1 1 1 1 1	CD/DVD/USB
3-Before the Installation Process (Tryout is the limit date)	- Machine specification sheet (serial number, model, date and country of manufacturing, manufacturer, power, voltage, current, frequency); - Lay-out of the machine with the weights of the units; - Installation Manual, instructions for transport and assembly; - Checklist of planned maintenance, including preventive maintenance and lubrication maintenance (Electric/Electronic/Mechanical); - Recommended Spare Parts List according to Embraco's Standard.	1 1 1 1 1	CD/DVD/USB
4-At the delivery of the machine and/or equipment (definitive documents / As built)	- Electric scheme with bill of material, including brand, model, production code, specification, manufacturer, number, etc.; - Electronic scheme with bill of material, including brand, model, production code, specification, manufacturer, number, etc.; - Hydraulic scheme with bill of material, including brand, model, production code, specification, manufacturer, number, etc.; - Pneumatic scheme with bill of material, including brand, model, production code, specification, manufacturer, number, etc.; - Drawings of the devices/machine parts; - Drawings of special tools; - Functional diagram of the machine;	2 2 2 2 2 2 2 1	CD/DVD/USB

	- Plan / layout of lubrication, including position photos;	1	
	- Instructions / operation manual;	1	
	- Machine and Equipment manuals / component supplied by third parties;	1	
	- Instructions / maintenance manual including troubleshooting;	1	
	- Instructions / Maintenance plan, including operation standard;	1	
	- Construction drawings of wearing parts;	1	
	- Automation program backup with comments (PLC/CNC/IHM);	1	
	- Plan of tools;	1	
	- Protocol of geometric measurement (in the Try-out and in the delivery of the Machine);	1	
	- Protocol for noise measurement in the motorized systems;	1	
	- Guarantee certificate;	1	
	- Study of capability Cmk;	1	
	- Thermograph analysis report.	1	
	- Other files demanded in technical proposal	1	

Note: For apparatus and line manufacturing instruments, must be provided operation manual, instrumentation, maintenance and electrical / electronic schemes.

6.2. Materials And Brands Homologated By EMBRACO – Mechanical Installation / Lubrication

Annex B - BRAZIL

MECHANICAL INSTALLATION/LUBRICATION		
MATERIAL	FIRST CHOICE BRAND – BR	SECOND CHOICE BRAND -BR
Ball screw	Star	THK / Rosa
Bearings	SKF	NSK / SKF / Timken / INA
Conveyor belt	Mecúrio	Goodyear
Couplings (DIN 116/DIN 740)	HDA/Falk	Stromag / Flender / Transmotechnica / Metalflex / Gumi
Cranes/ Hoist	Demag	Abus / Feba / Stahl
Follower Bearing	INA	McGill
Gripper	Gimatic	Schunk / Festo / Schrader
Linear guides	Schneeberger	Rosa / THK
Lubrication system: Automatic grease lubrication system with gas propulsion for isolated points	SKF	SKF
Lubrication system: timer controlled manually/automatically by a central lubrication system (DIN ISO 5170)	Eximport	Eximport (Willy Vogel) / Woerner, Soned / Jock
Planetary reduction	Harmonic Drive	
Precision bearings	FAG	Barden / Gamet / GMN / RHP / SNFA
Protection and guide for hydraulic/pneumatic hoses	Kabelschlepp	Igus / Fesma
Reduction gears and motor reducers	SEW	Bonfiglioli / Flender
Roller chains and gear wheels (DIN 8187/ISO 606)	Daido	Regina
Spindle	Weiss	GMN
Telescopic protection for guideways	Kabelschlepp	Igus
Transmission belts - Flat	Extremultus	Gates / Mercúrio
Transmission belts - Synchronizing (ISO 5294 / ISO 5296)	Gates	Megadyne / Daiko / Goodyear
Transmission belts - V Belt (DIN 2217)	Gates	Goodyear / Habasit
Vibration dampers	Vibrachok	Vibrastop
Vibration feeding systems	Norma	Schaeffler
Welding torch	Binzel	Binzel

Annex B1 - MEXICO

MECHANICAL INSTALLATION/LUBRICATION		
MATERIAL	FIRST CHOICE BRAND - MX	SECOND CHOICE BRAND – MX
Ball screw	SKF	THK
Bearings	SKF	Barden / FAG / Gamet / GMN / INA, NSK / NTN / RHP / SKF / SNFA / Timken
Conveyor belt	TBD	TBD
Couplings (DIN 116/DIN 740)	HDA or FALK	HDA / FALK / FLENDER / LOVE JOY
Cranes/ Hoist	TBD	TBD
Follower Bearing	TBD	TBD
Gripper	Gimatic	Schunk / Festo / Schrader
Linear guides	SKF	THK
Lubrication system: Automatic grease lubrication system with gas propulsion for isolated points	SKF	SKF
Lubrication system: timer controlled manually/automatically by a central lubrication system (DIN ISO 5170)	Lincoln	Graco
Planetary reduction	TBD	TBD
Precision bearings	SKF	Barden / Gamet / GMN / RHP / SNFA
Protection and guide for hydraulic/pneumatic hoses	Igus	Igus
Reduction gears and motor reducers	Bonfiglioli / Baldor	Motovario / Flender / SEW / Sumitomo
Roller chains and gear wheels (DIN 8187/ISO 606)	Martin	Linkbelt / SKF / Dodge / Ingus
Spindle	TBD	TBD
Telescopic protection for guideways	Kabelschlepp	Igus
Transmission belts - Flat	Goodyear	Gates / Flexco / Habasit
Transmission belts - Synchronizing (ISO 5294 / ISO 5296)	Optibelt	Goodyear / Gates
Transmission belts - V Belt (DIN 2217)	Goodyear	Black Gold / Bando / Gates / Dayko
Vibration dampers	Vibrachok	Vibrastop
Vibration feeding systems	RNA	NORMA
Welding Torch	TBD	TBD

Annex B2 – CHINA

MECHANICAL INSTALLATION/LUBRICATION		
MATERIAL	FIRST CHOICE BRAND - CN	SECOND CHOICE BRAND - CN
Ball screw	HIWIN	THK/SKF/STAR
Bearings	SKF	FAG / INA,/NSK / SNFA
Conveyor belt	Optibelt	MEGADDYNE,Gates
Couplings (DIN 116/DIN 740)	TBD	TBD
Follower Bearing	SKF	FAG / INA,/NSK / SNFA
Gripper	Gimatic	Schunk / Festo /
Linear guides	HIWIN	THK/SKF/STAR
Lubrication system: Automatic grease lubrication system with gas propulsion for isolated points	SKF	SKF
Lubrication system: timer controlled manually/automatically by a central lubrication system (DIN ISO 5170)	SKF	SKF
Planetary reduction	TBD	TBD
Precision bearings	FAG	GMN / RHP / SNFA/SKF
Protection and guide for hydraulic/pneumatic hoses	TBD	TBD
Reduction gears and motor reducers	SEW	Bonfiglioli
Roller chains and gear wheels (DIN 8187/ISO 606)	TBD	TBD
Telescopic protection for guideways	TBD	TBD
Transmission belts - Flat	Optibelt	MEGADDYNE,Gates
Transmission belts - Synchronizing (ISO 5294 / ISO 5296)	MEGADDYNE	Optibelt
Transmission belts - V Belt (DIN 2217)	Optibelt	MEGADDYNE,Gates
Vibration dampers	ACE	FESTO/SMC
Vibration feeding systems	TBD	TBD

Annex B3 – SLOVAKIA

MECHANICAL INSTALLATION/LUBRICATION		
MATERIAL	FIRST CHOICE BRAND – SK	SECOND CHOICE BRAND - SK
Ball screw	SKF	KSK, BOSCH, REXROTH, HIWIN
Bearings	SKF	INA, TIMKEN, NADELA, SNFA, FAG
Conveyor belt	TECHPLAST	MTPP, REXNORTH, BIBUS, BRAMMER
Couplings (DIN 116/DIN 740)	SKF	ROTEX, GATES, WARNER ELECTRIC, MAYR, LENZE, KTR
Follower Bearing	——	——
Gripper	SCHUNK	SOMMER AUTOMATIC, OMIL, GIMATIC, TECNOMORS
Linear guides	SKF	SCHNNEBERGER, REXROTH, HIVIN, IKO, AMPO
Lubrication system: Automatic grease lubrication system with gas propulsion for isolated points	TRIBOTEC	VOGEL, FESTO, SMC
Lubrication system: timer controlled manually/automatically by a central lubrication system (DIN ISO 5170)	TRIBOTEC	VOGEL, FESTO, SMC
Planetary reduction	HARMONICDRIVE	ELMOTEC, AMPO
Precision bearings	FAG	GAMETBEARINGS, NADELLA, TIMKEN, SKF
Protection and guide for hydraulic/pneumatic hoses	IGUS	HYDAC
Reduction gears and motor reducers	BONFIGLIOLY	NORTH, SEW, EURODRIVE, TACTOMAT, AUTOROTOR, WEISS, ROSSI
Roller chains and gear wheels (DIN 8187/ISO 606)	REXNORTH	ULMER, KBM, MTPP
Telescopic protection for guideways	HENNLICH	HENNIG, SETEZA, BBF
Transmission belts - Flat	MEGABELT	GATES, OPTIBELT, KBM, BRAMMER
Transmission belts - Synchronizing (ISO 5294 / ISO 5296)	TAGEX	MEGABELT, GATES, OPTIBELT, BRAMMER, KBM
Transmission belts - V Belt (DIN 2217)	MEGABELT	GATES, OPTIBELT, BRAMMER, KBM
Vibration dampers	TECHPLAST	FABORY, STEINEL, FESTO, SMC
Vibration feeding systems	SKIPALA	BROWING, FESTO, SMC

6.3. Materials And Brands Homologated By EMBRACO – Hydraulic Installation

Annex C – BRAZIL

HYDRAULIC INSTALLATION		
MATERIAL	FIRST CHOICE BRAND - BR	SECOND CHOICE BRAND - BR
Ball valves, two ways	Parker	Mipel / GBR
Connections	Parker	Dinamix
Cylinders (ISO 6020/II)	Parker	Bosh Rexroth
Directional and control valves (DIN 24340 and ISO 4401)	Parker	Bosh Rexroth
Fast coupling	Parker	Bosh Rexroth
Filters	TBD	TBD
Heat exchanger	Alfalaval	Hydac / Danfoss
Hoses	Parker	Manulli / Aeroquip
Hydraulic brake unit	Parker	ACE
Hydraulic motors	Parker	Bosh Rexroth / Danfoss
Hydraulic oil Pumps	Parker	Bosh Rexroth / Vikers
Manifolds	TBD	TBD
Oil level indicators	HDA	Hidrafil
Pressure accumulators	Parker	Bosch Rexroth / Ferbotec
Pressure gauge connector	Parker	Wika
Pressure indication and control device: Digital control indicator 3 1/2 digits, feeding 220 VAC, input of 4 to 20ma	IFM	Wika / Danfoss
Pressure indication and control device: Pressure transducer with output signal of 4 to 20 mA, input voltage of 24 Vdc	IFM	Wika / Gefran
Seamless pipes and fittings	Parker	Ermeto
Vacuum pumps	Edwards	Edwards

Annex C1 - MEXICO

HYDRAULIC INSTALLATION		
MATERIAL	FIRST CHOICE BRAND - MX	SECOND CHOICE BRAND - MX
Ball valves, two ways	Apollo	Dynaquip Controls
Connections	Parker	Gresen / Herion / Norgren / Eaton Aeroquip / Ssp
Cylinders (ISO 6020/II)	Parker, Bosch Rexroth	Miller Fluid Power
Directional and control valves (DIN 24340 and ISO 4401)	Vickers, Parker, Bosch Rexroth	ATOS / Continental Hydraulics
Fast coupling	Parker	Nitto Kohki / Eaton Aeroquip / Safeway
Filters	Parker / Hy-Pro / Hydac / Donaldson	MP Filtri / Baldwin Filters
Heat exchanger	Lovejoy	asaHydraulik
Hoses	Parker / Gates	Herion / Norgren
Hydraulic brake unit	Bosch	Parker
Hydraulic motors	Vickers / Parker / Bosch Rexroth	Oilgear / Denison Hydraulics / Bucher Hydraulics / Haldex Barnes / Danfoss
Hydraulic oil Pumps	Vickers / Parker / Bosch Rexroth	Oilgear / Denison Hydraulics
Manifolds	Parker / Vickers / Bosch Rexroth	SUN Hydraulics
Oil level indicators	Lube	Lube
Pressure accumulators	Parker	Vickers / Hydac
Pressure gauge connector	Apollo	Apollo
Pressure indication and control device: Digital control indicator 3 1/2 digits, feeding 220 VAC, input of 4 to 20ma	IFM	IFM
Pressure indication and control device: Pressure transducer with output signal of 4 to 20 mA, input voltage of 24 Vdc	WIKA / IFM efector	Danfoss / Dwyer
Seamless pipes and fittings	TBD	TBD
Vacuum pumps	Edwards	Edwards

Annex C2 - CHINA

HYDRAULIC INSTALLATION		
MATERIAL	FIRST CHOICE BRAND - CN	SECOND CHOICE BRAND - CN
Connections	Parker	Rexroth/Parker
Cylinders (ISO 6020/II)	Rexroth	Parker
Directional and control valves (DIN 24340 and ISO 4401)	Rexroth	Yuken,Vickers
Fast coupling	Parker	Rexroth/Rotex
Filters	Hydac	Rexroth/Parker/Leemin
Heat exchanger	Ruiming	Danfoss
Hoses	Parker / Gates	Herion / Norgren
Hydraulic brake unit	Parker	Bosch
Hydraulic motors	Rexroth	Parker /Vickers
Hydraulic oil Pumps	Rexroth	Parker/ Vickers /Yuken
Manifolds	Rexroth	Parker / Vickers
Oil level indicators	Hydac	Leemin
Pressure accumulators	Hydac	Vickers / Parker
Pressure gauge connector	shanghai	Apollo/EMB
Pressure indication and control device: Digital control indicator 3 1/2 digits, feeding 220 VAC, input of 4 to 20ma	IFM	VIGA/EMB
Pressure indication and control device: Pressure transducer with output signal of 4 to 20 mA, input voltage of 24 Vdc	IFM	VIGA/EMB
Seamless pipes and fittings	TBD	TBD
Vacuum pumps	Edwards	Leybold

Annex C3 - SLOVAKIA

HYDRAULIC INSTALLATION		
MATERIAL	FIRST CHOICE BRAND - SK	SECOND CHOICE BRAND - SK
Connections	HANSAFLEX	REXROTH, IFM
Cylinders (ISO 6020/II)	REXROTH	HYDAC, FESTO, SMC
Directional and control valves (DIN 24340 and ISO 4401)	REXROTH	VICKERS, FESTO, SMC
Fast coupling	HANSAFLEX	PARKER, FESTO, SMC
Filters	HYDAC	MPFILTRY, FESTO, SMC
Heat exchanger	EMMEGY	SESSINO
Hoses	HANSAFLEX	MEGABELT, HYDAC
Hydraulic brake unit	——	——
Hydraulic motors	REXROTH	BOSCH, VICKERS, HYDAC
Hydraulic oil Pumps	REXROTH	BOSCH, VICKERS, FAMIBA, BERARMA, VIVOIL
Manifolds	REXROTH	VICKERS
Oil level indicators	HYDAC	MPM CONTACT, MPFILTRY
Pressure accumulators	HYDAC	REXROTH
Pressure gauge connector	——	——
Pressure indication and control device: Digital control indicator 3 1/2 digits, feeding 220 VAC, input of 4 to 20ma	REXROTH	IFM, FESTO
Pressure indication and control device: Pressure transducer with output signal of 4 to 20 mA, input voltage of 24 Vdc	IFM	FESTO
Seamless pipes and fittings	HANSAFLEX	——
Vacuum pumps	ALBERTINA PACKAGING	——

6.4. Materials And Brands Homologated By EMBRACO – Pneumatic Installation

Annex D - BRAZIL

PNEUMATIC INSTALLATION		
MATERIAL	FIRST CHOICE BRAND - BR	SECOND CHOICE BRAND - BR
Cylinders diameter 8 to 25 mm, cylinders diameter 32 to 125 mm, preparation units and accessories (tubes, connections, mufflers, etc...).	Parker	Festo
Direction and control valves	Parker	Festo
Hoses	TBD	TBD
Hydro Pneumatic Cylinder	Tox Pressotechnik	Tox Pressotechnik
Retention valves	TBD	TBD

Annex D1 – MEXICO

PNEUMATIC INSTALLATION		
MATERIAL	FIRST CHOICE BRAND - MX	SECOND CHOICE BRAND - MX
Cylinders diameter 8 to 25 mm, cylinders diameter 32 to 125 mm, preparation units and accessories (tubes, connections, mufflers, etc...).	Festo	Parker / Smc
Direction and control valves	Festo	Parker / Rexroth / Smc
Hoses	Festo	Smc / Norgren
Hydro Pneumatic Cylinder	TBD	TBD
Retention valves	Festo	Parker / Rexroth / Smc

Annex D2 - CHINA

PNEUMATIC INSTALLATION		
MATERIAL	FIRST CHOICE BRAND - CN	SECOND CHOICE BRAND - CN
Cylinders diameter 8 to 25 mm, cylinders diameter 32 to 125 mm, preparation units and accessories (tubes, connections, mufflers, etc...).	Festo	Smc
Valves	Festo	Smc
Hoses	Festo	Smc
Pneumatic cylinders control	Tox	Tox
Valve terminals with net communication	Festo	Smc
Assembly tools	Festo	Smc

Annex D3 - SLOVAKIA

PNEUMATIC INSTALLATION		
MATERIAL	FIRST CHOICE BRAND - SK	SECOND CHOICE BRAND - SK
Cylinders diameter 8 to 25 mm, cylinders diameter 32 to 125 mm, preparation units and accessories (tubes, connections, mufflers, etc...)	FESTO	SMC
Valves	FESTO	SMC
Hoses	FESTO	SMC
Pneumatic cylinders control	FESTO	SMC
Valve terminals with net communication	FESTO	SMC
Assembly tools	TONA	BAHCO

6.5. Materials And Brands Homologated By EMBRACO – Electric / Electronic Installation

Annex E – BRAZIL

ELECTRIC / ELECTRONIC INSTALLATION		
MATERIAL	FIRST CHOICE BRAND - BR	SECOND CHOICE BRAND - BR
AC Power Source	Associated Research	Associated Research
AC/AC converters (Inverters)	WEG	ABB / Siemens
AC/DC converters	Siemens	WEG/Boschrexroth / Yaskawa
Alternating current motors with squirrel cage rotor	WEG	Siemens
Ammeter, voltmeter, wattmeter	Hartmann & Braun	Yokogawa / GEFRA
Andon Stack Light and Horn	TBD	TBD
Andon Single Red Light	SIEMENS 8WD5300-1AB	-
Auxiliary contactors /mini-contactors	TBD	TBD
Bar Code Reader	Symbol / SICK	Honeywell
Cable Ties and Fixings	Hellermannntyton	Hellermannntyton
Computer Numeric Control - CNC	Siemens	GE Fanuc
Connecting terminal: operating voltage - maximum 750 V, group C, VDE	Conexel	Phoenix
Control and temperature monitoring devices	Hartmann & Braun	Gefran / West
Control contactors	Siemens	Weg / telemecanique
Control for pneumatic cylinders	Sick	Festo / Balluf
Counters	Veeder Root	Coel / Robertshaw
Direct current motors	WEG	Siemens
Disconnection (sectioning) switches tripolar (with activation under load)	Simens	ABB / Klockner-Moeller
Distributed periphery	Siemens	Rockwell
Electric Assembly Tools	Atlas Copco	Desoutter
Electric plugs to use in maintenance mono-phase ZP + T	Pial Legrand	Siemens / Steck
Electric plugs to use in maintenance tri-phase 4P + T	Pial Legrand	Siemens / Steck
Electrical and electronic cabinets	Rittal	Taunus
Electrical and electronic cabinets for aggressive environments	Rittal	Taunus
Electromagnetic brakes/couplings	Stromag	Unitec
Electronic sensors	Sick	Banner / Balluff
Electronic time relays	Coel	Siemens
Emergency button self-monitored (mushroom with or without switch) red color (diameters 22 mm and 30 mm), positive (direct) opening operation from device Consult EHS Manual (TST 000067 + TEM 000840) for additional Information	Allen Bradley	WEG / Siemens / Telemecanique / ACE Schmersal
Encoder	Diadur	Veeder / Root
Fuse holder	Siemens	WEG
Fuses	Siemens	WEG
Gateways	Siemens Scalance XM416-4C	-
Grafic recorders	Hartmann & Braun	Yokogawa
Industrial nets	Profibus DP	Device NET
Industrial PC's with solid state HD	Workstation	Siemens / Advantech

Instrumentation Networks	TBD	Field Bus / Profibus DP
Interruption switches tripolar (with activation under load)	Siemens	Klockner Moeller
Level, temperature and flow sensors	TBD	TBD
Light curtain, area monitor laser (PLS), safety relays Consult EHS Manual (TST 000067 + TEM 000840) for additional Information	Sick	Banner / Pilz
Lighted switch socket (diameters 22 mm and 30 mm)	Blindex	Siemens
Linear Positioning Systems	Siemens	Mitsubishi
Magnetic sensors (accepted only with socket)	Sick	Festo / Turk / SMC
Man Machine Interfaces	Siemens	RockWell / ESA
Measuring systems: Use data acquisition and control architecture via PC. Note: This item always needs to be evaluated by Metrology (Industrial Support).	National Instruments	Software: Lab View
Mechanical Limit switch	Balluff	Kap / Euchner
Mechanical Multi limit switch	Balluff	Kap / Euchner / Omron
Mode selector switch (diameters 22 mm y 30 mm)	TBD	TBD
Mode Switch (always with load)	Blindex	Kraus & Naimer / Semitrans
Motors with braking system	WEG	SEW / Siemens
Multi-plugs (above 4 pins for control) (protection class DIN VDE 0470 Pt. 1/IEC 529)	Conexel	KAP / Phoenix / Harting
Optical activation buttons	Banner	Turk
PC's with solid state HD	HP	IBM / Compaq
PDA	Short Distance - Symbol 3190 Long Distance - Symbol 9190 Vehicular - Symbol 5090	Short Distance - Symbol 3190 Long Distance - Symbol 9190 Vehicular - Symbol 5090
Photoelectric sensors (not for safety related applications)	Sick	Banner / Balluff
Power contactors	Siemens	WEG
Power Supply	Siemens	Murrelektronik
Pressure switch (accepted only with socket according to DIN 43650)	IFM	Allen Bradley / Balluf
Pressure transducers	TBD	Danfoss / Hytronic / Smar / Sodmex / Wika
Programmable logical controllers	Siemens	Allen Bradley / WEG
Protection against short circuit	Siemens	WEG
Protection and guides for electric hoses	TBD	TBD
Proximity switch	Sick	Banner / Balluff
Push button (diameter 22 mm and 30 mm)	Blindex	Weg / Siemens / Telemecanique / ACE Schmersal
RF ID Identification System	Siemens (Moby-X)	Balogh / Balluf / BOSCH / Datalogic
Robots	Kuka	ABB / IAI
Safety nets Consult EHS Manual (TST 000067 + TEM 000840) for additional Information	Siemens	PILZ / Leuze
Safety Programmable Logic Controllers Consult EHS Manual (TST 000067 + TEM 000840) for additional Information	Pilz	Leuze
Safety Relays Consult EHS Manual (TST 000067 +	TBD	TBD

TEM 000840) for additional Information		
Selection switch key (diameters 22 mm and 30 mm)	Blindex	Semitrans / Siemens / WEG
Selection switch with lock key (diameters: 22 mm and 30 mm)	Blindex	Semitrans / Siemens / WEG
Sensor Networks	TBD	ASI / Interbus
Servo actuators (AC) / servo motors (AC)	Siemens	WEG / GE Fanuc
Signaling device with socket (diameters 22 mm and 30 mm)	Blindex	Siemens / WEG
Signaling push button device with socket (diameters 22 mm and 30 mm)	TBD	TBD
Socket auxiliary/mini-contactors	Sick	Siemens / WEG
Soft Starter	WEG	Siemens
Solid-state auxiliary relays	Siemens	Phoenix
Stepper motor and respective electronic command	Sincro	Boschrexroth
Supervisory software	Siemens	Rockwell
Temperature Indicator and Controller	TBD	TBD
Terminal crossing: operating voltage - maximum 750 V, group C, VDE	Conexel	Phoenix
Test Stations	TBD	TBD
Thermal bimetallic relays for engine protection	Siemens	WEG
Thermistor protection relays for various equipment	TBD	TBD
Thermocouples, extension/compensation wires and cables and fittings	ECIL	Concistec
Thermo-magnetic circuit-breaker tripolar	Klockner-Moeller	Siemens, WEG
Thermostats	Robertshaw	Danfoss / Honeywell
Transformer	WEG	WEG
Vibration sensor	IFM	Bruel & Kjaer
Weighing Balance	Alfa Instrumentos	KELMER

Annex E1 - MEXICO

ELECTRIC / ELECTRONIC INSTALLATION		
MATERIAL	FIRST CHOICE BRAND - MX	SECOND CHOICE BRAND - MX
AC Power Source	TBD	TBD
AC/AC converters (Inverters)	Siemens	Allen bradley / ABB
AC/DC converters	Siemens	Siemens
Alternating current motors with squirrel cage rotor	Baldor	Siemens
Ammeter, voltmeter, wattmeter	HARTMANN	HARTMANN
Andon Stack Light and Horn	TBD	TBD
Andon Single Red Light	SIEMENS 8WD5300-1AB	-
Auxiliary contactors /mini-contactors	Siemens	Allen bradley / SCHNEIDER
Bar Code Readers	Symbol	Symbol
Cable Ties and Fixings	TBD	TBD
Computer Numerical Control - CNC's	Siemens	FANUC
Connecting terminal: operating voltage - maximum 750 V, group C, VDE	Phoenix	Legrand / Conexel
Control and temperature monitoring devices	TBD	TBD
Control contactors	Siemens	Allen bradley / SCHNEIDER

Control for pneumatic cylinders (Sensors for pneumatic cylinders)	Festo	SMC / NORGREEN
Counters	Omron	Siemens
Direct current motors	Baldor	Siemens / Reliance Electric
Disconnection (sectioning) switches tripolar (with activation under load)	TBD	TBD
Distributed periphery	Siemens	Rockwell
Electric Assembly Tools	TBD	TBD
Electric plugs to use in maintenance single-phase ZP + T	Legrand	Phoenix contact
Electric plugs to use in maintenance three-phase 4P + T	Legrand	Phoenix contact
Electrical and electronic cabinets for aggressive environments	Rittal	Himel / Taunus
Electromagnetic brakes/couplings	UNITEK	UNITECK
Electronic sensors (accepted only with socket)	Festo	SMC / NORGREEN
Electronic time relays	Omron	FINDER / Siemens
Electrical and electronic cabinets	Rittal	Himel / Taunus
Emergency button self-monitored (mushroom with or without switch) red color (diameters 22 mm and 30 mm), positive (direct) opening operation from device Consult EHS Manual (TST 000067 + TEM 000840) for additional Information	Siemens	Telemecanique / Omron / Allen Bradley
Encoder	BEI	SICK
Fuse Holder	Siemens	Siemens
Fuses	Siemens	Siemens
Gateways	Siemens Scalance XM416-4C	-
Graphic recorders	HARTMANN	HARTMANN
Industrial nets	Profibus	Device NT
Industrial PC's with solid state HD	Workstation	Siemens / Advantech
Instrumentation Networks	TBD	Field Bus / Profibus DP
Interruption section switch tripolar (with activation over load)	Siemens	Allen bradley / ABB
Level, temperature and flow sensors	IFM	IFM
Light curtain, area monitor laser (PLS), safety relays Consult EHS Manual (TST 000067 + TEM 000840) for additional Information	SICK	SICK
Lighted switch socket (diameters 22 mm and 30 mm)	TBD	TBD
Linear Positioning Systems	Siemens	Balluf / Diadur
Magnetic sensors (accepted only with socket)	Festo	SMC / NORGREEN
Man Machine Interfaces	Siemens	Rockwell / Proface
Measuring systems: Use data acquisition and control architecture via PC. Note: This item always needs to be evaluated by Metrology (Industrial Support).	National Instruments	Software: Lab View
Mechanical Limit switch	Balluf	Allen bradley / Omron
Mechanical Multi limit switch	Balluf	Allen bradley / Omron
Mode selector switch (diameters 22 mm y 30 mm)	Siemens	Allen bradley / ABB
Mode Switch (always with load)	Siemens	Allen bradley / ABB
Motors with braking system	SEW	Siemens / Reliance electric
Multi-plugs (above 4 pins for control) (protection class DIN VDE 0470 Pt. 1/IEC 529)	Phoenix	Legrand

Optical activation buttons	SICK	Banner / Omron
PC's with solid state HD	HP	Compaq / Ibm
PDA	Short Distance - Symbol 3190 Long Distance - Symbol 9190 Vehicular - Symbol 5090	Short Distance - Symbol 3190 Long Distance - Symbol 9190 Vehicular - Symbol 5090
Photoelectric sensors (not for safety related applications)	SICK	BANNER / Omron
Power contactors	Siemens	Allen bradley / SCHNEIDER
Power Supply	Siemens	Murrelektronik
Pressure switch (accepted only with socket according to DIN 43650)	IFM	ASCO / Danfoss
Pressure transducers	TBD	TBD
Programmable logical controllers	Siemens	Allen bradley
Protection against short-circuit	Siemens	Rittal
Protection and guides for electric hoses	IGUS	Murr
Proximity switch (accepted only with socket)	IFM	Balluff / SICK
Push button (diameter 22 mm and 30 mm)	Siemens	Telemecanique / Omron / Allen Bradley
RF ID Identification System	Siemens (Moby-X)	Siemens / Pepperl Fuchs / BALOGH
Robots	Fanuc	ABB
Safety nets Consult EHS Manual (TST 000067 + TEM 000840) for additional Information	SICK	SICK
Safety Programmable Logic Controllers Consult EHS Manual (TST 000067 + TEM 000840) for additional Information	Pilz	Allen Bradley
Safety Relays Consult EHS Manual (TST 000067 + TEM 000840) for additional Information	Siemens	Pilz
Selection switch key (diameters 22 mm and 30 mm)	Siemens	Allen bradley / ABB
Selection switch with lock key (diameters: 22 mm and 30 mm)	Siemens	Allen bradley / ABB
Sensor Networks	TBD	ASI / Interbus
Servo Control Systems / servo actuators (AC) / servo motors (AC)	Siemens	GE-Fanuc / WEG
Signaling device with socket (diameters 22 mm and 30 mm)	Siemens	Telemecanique / Omron
Signaling push button device with socket (diameters 22 mm and 30 mm)	Siemens	Telemecanique / Omron / Allen bradley
Socket auxiliary/mini-contactors	TBD	TBD
Soft Starter	Siemens	ABB
Solid-state auxiliary relays	FINDER	OMRON / Allen Bradley
Step motor and respective electronic command	Siemens	Hindramat
Supervisory System	Win CC / Protool	RSView 32
Temperature Indicator and Controller	Watlow	Omron / Eurotherm
Terminal crossing: operating voltage - maximum 750 V, group C, VDE	Phoenix	Legrand / Conexel
Test Stations	TBD	TBD
Thermal bimetallic relays for motor protection	Siemens	Allen bradley / ABB
Thermistor protection relays for various equipment	Siemens	Omron
Thermocouples, extension/compensation wires and cables and fittings	ECIL	JUMO

Thermomagnetic tripolar circuit-breaker	Siemens	Allen bradley / ABB
Thermostats	Honeywell	Honeywell / Omron / JUMO
Transformer	WEG	Siemens
Vibration sensor	IFM	BALLUFF / SICK
Weighing Balance	TBD	TBD

Annex E2 – CHINA

ELECTRIC / ELECTRONIC INSTALLATION		
MATERIAL	FIRST CHOICE BRAND - CN	SECOND CHOICE BRAND - CN
AC/AC converters (Inverters)	Siemens	ABB, YASKAWA
AC/DC converters	Siemens	ABB, Schneider
Alternating current motors with squirrel cage rotor	WEG	Siemens、国产电机
Ammeter, voltmeter, wattmeter	GEFRAN	Eurotherm
Andon Stack Light and Horn	TBD	TBD
Andon Single Red Light	SIEMENS 8WD5300-1AB	-
Control and temperature monitoring devices	GEFRAN	Eurotherm
Control button (diameter 22 mm and 30 mm)	Siemens	Schneider
Control contactors	Siemens	Schneider
Control for pneumatic cylinders	Festo	SMC
Counters	OMRON	Coel
Direct current motors	ABB	Siemens
Disconnection (sectioning) switches tripolar (with activation under load)	Siemens	ABB
Distributed periphery	Siemens	Rockwell
Electric plugs to use in maintenance monophasic ZP + T	Siemens	Schneider
Electric plugs to use in maintenance triphase 4P + T	Siemens	Schneider
Electrical and electronic cabinets	Rittal	Taunus
Electrical and electronic cabinets for aggressive environments	Rittal	Taunus
Electromagnetic brakes/couplings	TBD	TBD
Electronic sensors (accepted only with socket)	Balluff	Contrinex
Electronic time relays	Siemens	OMRON
Emergency button (mushroom (mold) with or without switch) red color (diameters 22 mm and 30 mm)	Siemens	Schneider
Encoder	HEIDENHAIN	OMRON
Fuse Holder	Siemens	WEG
Fuses	Siemens	WEG
Gateways	Siemens Scalance XM416-4C	-
Identification System	Siemens	Sick
Industrial nets	Profibus DP	Device NET, ASI
Industrial PCs	Siemens	Advantech
Interruption switches tripolar (with activation under load)	Siemens	Klockner Moeller, Contrinex
Light curtain, area monitor laser (PLS), safety relays	Sick	Keyence
Lighted switch socket (diameters 22 mm and 30 mm)	Siemens	Schneider
Limit switch	Balluff	OMRON
Linear Positioning Systems	HEIDENHAIN	
Magnetic sensors (accepted only with socket)	Festo	SMC
Man Machine Interfaces	Siemens	Interface

Measuring systems: Use data acquisition and control architecture via PC. Note: This item always needs to be evaluated by Metrology (Industrial Support).	National Instruments	-
Mode Switch (always with load)	Siemens	Schneider
Motor with braking system	Siemens	SEW
Multi limit switch	Balluff	OMRON
Multi-plugs (above 4 pins for control) (protection class DIN VDE 0470 Pt. 1/IEC 529)	Phoenix	Harting
Optical activation buttons	Banner	Turk
PCs	HP	HP、Lenovo、研华
Power contactors	Siemens	Schneider
Power Supply	Siemens	Schneider
Pressure switch (accepted only with socket according to DIN 43650):	IFM	IFM、OMRON
Programmable logical controllers	Siemens	OMRON (FANUC and MITSUBISHI only under previous formal approval)
Protection against short-circuit	Siemens	Schneider
Proximity switch (accepted only with socket)	Contrinex	Baumer
Robots	ABB	EPSON
Safety nets	Siemens	schmersal
Safety Programmable Logic Controllers	Pilz	Siemens
Selection switch key (diameters 22 mm and 30 mm)	Schneider	Siemens
Selection switch with Yale type key (diameters: 22 mm and 30 mm)	Schneider	Siemens
Servo actuators (AC) / servo motors (AC)	Siemens	SANYO/Fanuc/Yaskawa
Signaling device with socket (diameters 22 mm and 30 mm)	Schneider	Siemens
Socket auxiliary/mini-contactors	Sick	Siemens
Soft Starter	Siemens	-
Solid-state relays	Siemens	Phoenix
Step motor and respective electronic command	Siemens	Boschrexroth
Supervision software	Siemens	Rockwell
Thermal bimetallic relays for motor protection	Siemens	Schneider
Terminal crossing: operating voltage - maximum 750 V, group C, VDE	Phoenix	Conexel
Thermistor protection relays for various equipment	Siemens	Schneider
Thermo-magnetic circuit-breaker tripolar	Siemens	Schneider
Thermostats	Danfoss	Honeywell
Vibration sensor	Bruel & Kjaer	-

Annex E3 – SLOVAKIA

ELECTRIC / ELECTRONIC INSTALLATION		
MATERIAL	FIRST CHOICE BRAND – SK	SECOND CHOICE BRAND - SK
AC/AC converters (Inverters)	SIEMENS	IFM
AC/DC converters	SIEMENS	IFM
Alternating current motors with squirrel cage rotor	SIEMENS	MGM, MEZ, SEW
Ammeter, voltmeter, wattmeter	—	—
Andon Stack Light and Horn	TBD	TBD
Andon Single Red Light	SIEMENS 8WD5300-1AB	—
Control and temperature monitoring devices	MIDDEX	—
Control button (diameter 22 mm and 30 mm)	MOELER	SIEMENS

Control contactors	EATON	SIEMENS
Control for pneumatic cylinders	FESTO	PARKER, SMC
Counters	GUBLER	——
Direct current motors	SIEMENS	——
Disconnection (sectioning) switches tripolar (with activation under load)	EATON	SIEMENS
Distributed periphery	SIEMENS	FANUC
Electric plugs to use in maintenance monophasic 2P + T	SCAME	EATON
Electric plugs to use in maintenance triphase 4P + T	SCAME	EATON
Electrical and electronic cabinets	RITTAL	——
Electrical and electronic cabinets for aggressive environments	RITTAL	——
Electromagnetic brakes / couplings	VARNER	LENZE
Electronic sensors (accepted only with socket)	IFM	BALLUFF, SICK
Electronic time relays	OMRON	FINDER
Emergency button (mushroom (mold) with or without switch) red color (diameters 22 mm and 30 mm)	EATON	SIEMENS
Encoder	SIEMENS	PLR, ELCIS, BAR
Fuse Holder	OEZ	——
Fuses	OEZ	BUSSMANN, ETI, SIBA, ESKA
Gateways	Siemens Scalance XM416-4C	-
Identification System	SIEMENS	BALLUFF
Industrial nets	——	——
Industrial PCs	SIEMENS	P+R, FANUC
Interruption switches tripolar (with activation under load)	EATON	SIEMENS
Light curtain, area monitor laser (PLS), safety relays	HONEYWELL	IFM, ROCKWELL
Lighted switch socket (diameters 22 mm and 30 mm)	——	——
Limit switch	SIEMENS	BALLUFF, EATON
Linear Positioning Systems	SCHEEBERGER	FESTO, IAI
Magnetic sensors (accepted only with socket)	IFM	FESTO
Man Machine Interfaces	SIEMENS	G FALUK
Measuring systems: Use data acquisition and control architecture via PC. Note: This item always needs to be evaluated by Metrology (Industrial Support)	HEIDENHEIN	——
Mode Switch (always with load)	EATON	SIEMENS
Motor with braking system	MGM	SIEMENS, LENZE, SEW, KEBOLD
Multi limit switch	BALLUFF	SIEMENS
Multi-plugs (above 4 pins for control) (protection class DIN VDE 0470 Pt. 1/IEC 529)	HARDING	SIEMENS
Optical activation buttons	——	——
PCs	HP	LENOVO
Power contactors	SIEMENS	EATON
Power Supply	SIEMENS	IFM, MUR
Pressure switch (accepted only with socket according to DIN 43650)	EATON	IFM, EUROSCHWITZ
Programmable logical controllers	SIEMENS	——
Protection against short-circuit	EATON	SIEMENS
Proximity switch (accepted only with socket)	——	——
Robots	ABB	——

Safety nets	—	—
Safety Programmable Logic Controllers	PILZ	—
Selection switch key (diameters 22 mm and 30 mm)	—	—
Selection switch with Yale type key (diameters: 22 mm and 30 mm)	—	—
Servo actuators (AC) / servo motors (AC)	SIEMENS	BOSCH, BAR
Signaling device with socket (diameters 22 mm and 30 mm)	EATON	—
Socket auxiliary/mini-contactors	EATON	—
Soft Starter	SIEMENS	—
Solid-state relays	OMRON	SIEMENS, FINDER, SCHRACK
Step motor and respective electronic command	SIEMENS	—
Supervision software	OCTAVIS	—
Thermal bimetallic relays for motor protection	EATON	SIEMENS
Terminal crossing: operating voltage - maximum 750 V, group C, VDE	EATON	WEIDMULLER
Thermistor protection relays for various equipment	—	—
Thermo-magnetic circuit-breaker tripolar	EATON	SIEMENS
Thermostats	—	—
Vibration sensor	IFM	ADASH

6.6. Materials And Brands Homologated By EMBRACO – Utilities Installation

Annex F - BRAZIL

UTILITIES INSTALLATION		
MATERIAL	FIRST CHOICE BRAND - BR	SECOND CHOICE BRAND - BR
Air/electrical actuators	GBR	Walmicro / Keystone
Blocking/regulating valve (ball valve, globe valve, butterfly valve, plug valve, etc...)	GBR	Mipel / Niagara
Centrifugal pumps	KSB	Worthington / ABS
Compressed air/steam purifier (purger)	Spirax Sarco	Gestra
Diaphragm pump	Wilden	ARO
Equipment and components for combustion, adjustment, controlling and safety of natural gas	Krom Schröder	Maxon
Filters: Coalescent	Parker	Vemag
Filters: Y	GBR	Gesta / Sarco
Flexible hoses	Parker	Aeroquip
Gauges	Wika	IFM / Gfran
Gear pump	TBD	Hero / Triglav
Heat exchanger	TBD	Evacon / Freimar / Igase / Pyro, Starco / CHS / AlfaLaval
Multistage Pumps	FIP	CAPRARI / LOWARA
Pipes and fittings: Carbon / Galvanized steel	Parker	Tupy / Mannesman

Pipes and fittings: Stainless Steel	Dibinox	Fittinox
Pressure transducers	IFM	Wika
Safety valves / pressure controllers	Norgreen	Norgreen
Solenoid valves	Parker	Ascoval / Danfoss
Thermometers	IFM	Wika
Tubes/fittings for instrumentation	Ermeto	Metal Detroit
Tubings / Instrumentation fittings	Parker	Ermeto
Various control instruments (level, pressure, flow)	IFM	Wika

Annex F1 – MEXICO

UTILITIES INSTALLATION		
MATERIAL	FIRST CHOICE BRAND - CN	SECOND CHOICE BRAND - CN
Air/electrical actuators	TBD	TBD
Blocking/regulating valve (ball valve, globe valve, butterfly valve, plug valve, etc...)	TBD	TBD
Centrifugal pumps	TBD	TBD
Compressed air/steam purifier (purger)	TBD	TBD
Diaphragm pump	TBD	TBD
Equipment and components for combustion, adjustment, controlling and safety of natural gas	TBD	TBD
Filters: Coalescent	TBD	TBD
Filters: Y	TBD	TBD
Flexible hoses	TBD	TBD
Gauges	TBD	TBD
Gear pump	TBD	TBD
Heat exchanger	TBD	TBD
Multistage Pumps	TBD	TBD
Pipes and fittings: Carbon / Galvanized steel	TBD	TBD
Pipes and fittings: Stainless Steel	TBD	TBD
Pressure transducers	TBD	TBD
Safety valves / pressure controllers	TBD	TBD
Solenoid valves	TBD	TBD
Thermometers	TBD	TBD
Tubes/fittings for instrumentation	TBD	TBD
Tubings / Instrumentation fittings	TBD	TBD
Various control instruments (level, pressure, flow)	TBD	TBD

Annex F2 – CHINA

UTILITIES INSTALLATION

MATERIAL	FIRST CHOICE BRAND - CN	SECOND CHOICE BRAND – CN
Air/electrical actuators	SIEMENS 西门子	Domestic
Blocking/regulating valve (ball valve, globe valve, butterfly valve, plug valve, etc...)	furuite/弗瑞特	domestic
Centrifugal pumps	GRUNDFOS/格兰富	nanfangbengye/南方泵业
Compressed air/steam purifier (purger)	Atlas	Ingersollrand
Diaphragm pump	shanglun/上轮	weima/威马
Equipment and components for combustion, adjustment, controlling and safety of natural gas	RIELLO/利雅路	HONEYWELL/霍尼韦尔
Filters: Coalescent	INCO/英科盛世	pneumatech/纽曼泰克
Filters: Y	domestic	domestic
Gauges	BLD/布莱迪	domestic
Heat exchanger	Nanhaiwantong 南海万通	Afalaval/阿法拉伐
Pipes and fittings: Carbon/Galvanized steel	Lida/利达	domestic
Pipes and fittings: Stainless Steel	Reynold/雷诺	domestic
Pressure transducers	VEGA	Domestic
Safety valves/pressure controllers	laoshan/崂山	Domestic
Solenoid valves	yunjiu/永久	Domestic
Thermometers	Fluke	Domestic
Tubes/fittings for instrumentation	FESTO	SMC
Tubings / Instrumentation fittings	BLD/布莱迪	Domestic
Various control instruments (level, pressure, flow)	ALLOP/格乐普	VEGA

Annex F3 – SLOVAKIA

UTILITIES INSTALATION		
MATERIAL	FIRST CHOICE BRAND - SK	SECOND CHOICE BRAND - SK
Air / electrical actuators	TRIBOTEC	LUBTEC
Blocking/regulating valve (ball valve, globe valve, butterfly valve, plug valve, etc...)	TRIBOTEC	LUBTEC
Centrifugal pumps	GRUNDFOS	EBARA
Compressed air/steam purifier (purger)	KARCHER	——
Diaphragm pump	WILDEN	——
Equipment and components for combustion, adjustment, controlling and safety of natural gas	RIELLO	——
Filters: Coalescent	LOSMA	——
Filters: Y	HYDAC	——
Gauges	HYDAC	——
Heat exchanger	HYDAC	——
Pipes and fittings: Carbon/Galvanized steel	REXROTH	——
Pipes and fittings: Stainless Steel	REXROTH	——
Pressure transducers	REXROTH	——
Safety valves / pressure controllers	REXROTH	——
Solenoid valves	REXROTH	——
Thermometers	REXROTH	——
Tubes / fittings for instrumentation	REXROTH	——
Tubings / Instrumentation fittings	REXROTH	——
Various control instruments (level, pressure, flow)	REXROTH	——

7. Acceptance

The purchase of the machine is conditioned by the agreement with this document. Once Supplier and EMBRACO sign and stamp this document, the acquisition can follow its normal steps.

For Supplier Agreement:

By selecting one of these options, signing and stamping on this page, the Supplier agrees with EMBRACO Standard Machine and Equipment Specification Manual and undertakes to deliver a machine according to its requirements. In case of derogations, describe each one below. All derogations not described below will be maintained as mandatory requirement on the purchase order.

Regarding the EMBRACO document Standard Machine and Equipment Specification Manual, the Supplier position is:

- ☐ Totally agreed
- ☐ Agreed with derogations (describe the derogations below)

Item	Derogation Description

Date

Legal Representative Signature and Stamp

For EMBRACO Agreement:

By signing and stamping on this page, EMBRACO agrees with Supplier compliance with the EMBRACO Standard Machine and Equipment Specification Manual, even in eventual derogations described above.

Date

Legal Representative Signature and Stamp