

## **Section L STANDARD SPECIFICATION FOR CONTROL & INSTRUMENTATION (C&I) WORK**

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## **S200 STANDARD SPECIFICATION FOR C&I INSTALLATIONS**

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**1. GENERAL ASPECTS**

- 1.1 In this document the term "Contractor" shall mean the Contractor appointed in terms of this document, irrespective of whether the contract is a direct contract with the owner or a sub-contract with a Principal Contractor.
- 1.2 If, at any stage, the Contractor wishes to deviate from these specifications, he may do so only by way of concession from the Engineer in writing
- 1.3 Prices offered for equipment specified by trade names or catalogue references shall be for the type and manufacture specifically. If alternatives want to be offered, the onus shall be on the Contractor to prove that such alternatives are equivalent to the Item specified and meet with the approval of the Engineer in writing. The decision whether the offered items are acceptable shall rest solely with the Engineer. The cost implications of such alternatives shall be deemed to have been allowed for in the tendered amount.
- 1.4 Tenderers are required to fully complete the Schedules of Equipment and Materials offered, and include the catalogue numbers and other information by which the materials may be identified. Technical brochures of the equipment offered may be submitted with the tender however after tender award a comprehensive data pack containing full technical documentation shall be submitted for approval by the Engineer.
- 1.5 Tenderers shall only offer equipment for which proven backup is available in South Africa.
- 1.6 The Project Specification, also referred to as the Detail Specification, shall take preference over this General specification and where any conflict exists the project Specification shall take preference.
- 1.7 Should the Tenderer become aware of any discrepancies or uncertainties in these specifications, he shall notify the Engineer in writing requesting a suitable ruling in terms of the contract.
- 1.8 Only technicians and artisans with adequate and applicable training and experience shall be used to carry out the work on this contract as substantiated by references requested in the tender document schedules.
- 1.9 All materials and equipment used shall be of new manufacture.
- 1.10 If requested by the Engineer, the Contractor shall submit samples of cables, terminals, labels,

trunks and other construction materials which he proposes to use on the installation for the Engineer's approval.

- 1.11 All materials and equipment used shall be suitable for the environmental conditions and service for which it is specified and intended to be used.

Installation work may not commence unless all materials have been approved by the Engineer

It shall be the Contractor's responsibility to ensure that equipment is suitably sized to that it can be brought to its position of installation and installed there.

Dimensions taken from drawings shall not be used to purchase lengths of trays, trunks, cables etc. The actual runs shall be measured on site before procurement commences

The Contractor shall make allowance for any other Contractors' works that may be in progress concurrent with his own activities on site.

Any damage to existing services, structures, equipment or protective coatings, caused by the Contractor shall be made good by the Contractor at his own costs.

The Contractor shall keep his work area clear, neat and tidy and prevent pollution caused by off-cuts, excess materials or spillages of fuels and lubricants, etc. in accordance with the contract approved Health and Safety plan.

## **2. NATIONAL AND OTHER SPECIFICATIONS**

- 2.1 The installation shall be carried out in accordance with the latest revision of the following:
- 2.2 SANS 10142-1:2008. "The Wiring of Premises, Part 1 Low Voltage Installations".
- 2.3 IEC 62305 "Lightning Protection of Equipment".
- 2.4 The Occupational Health and Safety Act, 1993.
- 2.5 The Municipal Bylaws and any special conditions of the local Supply Authority in the relevant area.
- 2.6 The local Fire Safety Regulations and the requirements of the Local Fire Chief.
- 2.7 The regulations of the local Department of Communications.

## **3. DOCUMENTATION AND TRAINING**

- 3.1 The Engineers drawings covering the various sections of the installation are listed in the schedule of drawings. The working drawings of the Contract shall, however, consist of :

- 3.1.1 The Engineer's drawings.
- 3.1.2 The Architect's drawings.
- 3.1.3 The Structural Engineer's drawings.
- 3.1.4 The Engineer's drawings of the other disciplines, as applicable.
- 3.1.5 The drawings of other services installations that are relevant for coordination and installation.
- 3.1.6 The installation drawings of other contractors and subcontractors where applicable.
- 3.1.7 The Contractor's construction drawings as discussed below
- 3.2 Unless otherwise specified, three sets of the Engineer's drawings will be issued to the Contractor for planning purposes. Any further copies may be purchased from the Engineer. The Contractor shall produce construction drawings based on the issued Engineer's drawings but adapted to represent the actual equipment and plant to be installed.
- 3.3 The Contractor shall submit one set of construction drawings to the Engineer for examination and to demonstrate compliance with the Contract. Construction drawings shall include drawings, diagrams, illustrations, schedules, performance charts, brochures and other data which are prepared by the Services Contractor, Manufacturer, Supplier or Distributor and shall, together, illustrate the entire C&I component of the work. No part of the works shall be installed before construction drawings representing that portion of the works have been submitted to the Engineer, the Engineer has reviewed these and has given the Contractor permission to proceed.
- 3.4 The Engineer's examination of construction drawings or samples shall not relieve the Contractor of responsibility for any deviation from the requirements of this Contract unless the Contractor has informed the Engineer in writing of such deviations at the time of submission of construction drawings or samples and the Engineer has given written approval for the specific deviation, nor shall the Engineer's examination relieve the Services Contractor of responsibility for errors or omissions in the construction drawings or samples or for responsibility for erection or installation fit.
- 3.5 The Contractor shall submit to the Engineer one set of marked-up structural drawings, or other drawings, showing changes and/or additional requirements to be made in the structure in order to

- accommodate equipment installed under this Contract,
- 3.6 It shall be the Contractor's sole responsibility to compile the as built drawings
- 3.7 Drawings to be entitled "AS.BUILT" shall bear the signature of the Contractor and the date of issue.
- 3.8 The Contractor shall obtain from the Engineer, if available, an electronic copy of the Engineers' drawings, which have been drawn on a PC based CAD system for the preparation of "As-Built" drawings to be provided by the Contractor. One set of paper prints of the as-built drawings shall be provided for verification by the Engineer. The physical electronic media containing the C&I "As-Built" drawings shall be provided to the Engineer upon completion of the contract by the Contractor.
- 3.9 A set of final layout and schematic "As-built" drawings shall be mounted towards the end of the contract in a purpose made frame inside a door, or where no doors are fitted, to the front plate of the cabinet of all equipment supplied and installed under the contract. The frame shall be adequately sized to receive the equivalent of one AO size drawing folded to a nominal size of A4.
- 3.10 The Contractor shall submit to the Engineer two Operations and Maintenance manuals bound between hard covers including the following :-
- 1 Wiring diagrams cross-referred to the drawings described above, and to the Engineer's layout and schematic drawings.
  - 2 Dimensioned drawings of the layout of the equipment and systems
  - 3 All Test Certificates for tests done at the factories and on the site.
  - 4 Detailed system and equipment descriptions.
  - 5 Operating instructions.
  - 6 Maintenance, adjustment and calibration instructions with preventive maintenance schedule and fault finding procedures.
  - 7 Spare parts list with names and address of component suppliers and a list of recommended spare components to be kept in stock.

- 8 Original licensed copies of all software related to supplied and installed equipment and two electronic copies of all software configuration, programming and settings related to supplied and installed equipment

The Contractor shall submit one preliminary copy of the Operations and Maintenance manual(s) to the Engineer for scrutiny before the final copies are made.

- 3.11 The Contractor shall provide thorough training of the employer's staff in the operating and technical maintenance of the contract works. The Contractor shall keep a record of attendance for any training sessions and shall submit these to the Engineer.

- 3.12 When specified in the project specification the Contractor shall allow in his price for the provision of 2 sets of photographs to be taken on a monthly basis, for the duration of the contract, of all the areas and equipment where the Contractor is involved.

One set of the photographs shall be handed each month to the Engineers' Representative at the site meetings.

These photographs may be used for the evaluation of claims.

- 3.13 The installation will not be accepted until the manuals have been approved by the • Engineer and handed over to the client.

- 3.14 Electronic Media

When specified in the Project Specification , the Contractor shall allow for scanning all hard copies of manuals, drawings etc. and storing these in pdf format.

#### **4. LAYOUT OF INSTALLATION**

- 4.1 Field cables, which must be connected to equipment which is mounted in an enclosure of any kind (box, console, panel etc.), shall terminate on screw type terminal strips and shall not be wired directly to the equipment.

- 4.2 All wiring must be contained within conduit or trunking or within metal enclosed equipment or installed on cable rack, tray or wire mesh.

- 4.3 When two or more parallel rows of terminal blocks are used, the clear space between the blocks shall be at least 120 mm. Terminal blocks shall be rail mounted.

- 4.4 Where two or more pieces of C&I equipment in close proximity to each other in the field have

similar signal or electrical supply voltages, use shall be made of a junction box to group the equipment cables to common multicore or multi-pair cables which may be wired to the centralized control room equipment.

- 4.5 Cable entries into outdoor junction boxes shall be bottom-entry only.
- 4.6 Cables carrying low voltage alternating current (power or ON/OFF signals) may only be run on the same cable supports as analogue signal cables if the spacing between the cables is at least 300 mm for unscreened cable, or 100mm if individually and overall screened cables are used. Low voltage signals and power/audio output signals may not be run in the same cable without the permission of the Engineer. Discrete control and instrument current loop signals may not be run on the same cable unless the cable has been specifically designed for such purpose.

## **5. INSPECTION, TESTING AND COMMISSIONING**

- 5.1 The Engineer shall be allowed reasonable access for inspection to any equipment which is being manufactured for this contract.
- 5.2 All equipment, cabinets, consoles etc, upon completion, must be inspected by the Engineer at the manufacturer's premises prior to delivery to site. Seven days' notice must be given to the Engineer before the date when such inspection is required.
- 5.3 The Engineer may inspect the work at any stage of erection, and the Contractor shall provide such facilities (including tools and instruments) as reasonably may be required to perform such inspection. Such inspection by the Engineer shall not relieve the Contractor of ensuring that the works are completed in all aspects in accordance with specifications.
- 5.4 In the event that tests fail, the Contractor shall remedy such failures at his own costs and if re-testing and inspection is required by the Engineer, all time, travelling and related disbursement for the Engineer to attend the test and inspections shall be for the Contractor's account. The government gazetted ECSA rates current at the time shall apply.

## **6. MAINTENANCE UNDER THE CONTRACT**

- 6.1 During the defects liability period the Contractor shall visit the site (over and above such visits as may become necessary due to system breakdowns), at six-monthly intervals to ascertain that the system is working as specified.
- 6.2 Within 14 days of each such visit the Contractor shall submit a short report to the Engineer which



shall include details of all faults that were found as well as a statement that such faults were rectified. The report shall include a signature by the Engineer's representative on site confirming that the visit took place.

- 6.3 At the end of the defect liability period, the Contractor shall analyse these findings in a "Close-out report" to the Engineer, in which he shall include any recommendations with regard to the ongoing operation and maintenance of the system.

## **7. POST CONTRACT MAINTENANCE AGREEMENT**

- 7.1 If required by the Contract, Contractors shall be able and willing to maintain their installed equipment for a period of at least five years (or as specified) after completion of the contract.

## **8. CABLES AND WIRES**

- 8.1 All general wiring shall be multi-stranded copper conductors of minimum thickness of 0,5 mm<sup>2</sup> with colour-fast PVC insulation.
- 8.2 All cables quoted shall be supplied in quantities which allow for a reasonable amount of wastage.
- 8.3 No multicore cable shall be fully utilised. A minimum of 2 cores / 1 pair or 10% of the cores, whichever is the greater shall be left available as spare.
- 8.4 All cabling shall be arranged for maximum accessibility and shall allow for equipment removal without disturbing other operating equipment or disfiguring wiring.
- 8.5 Installed cabling shall not visually obstruct or physically prevent access to any other equipment.
- 8.6 No cabling shall be installed directly in concrete or brickwork.
- 8.7 Only Steel Wire Armoured (SWA) or Corrugated Tape protected cables may be buried directly in the ground. Unarmoured cable shall be installed in conduit, trunking or on rack, tray or mesh cable support systems.
- 8.8 Cables within buildings are to be carried on overhead cable trays attached to the building frame or other supports.
- 8.9 When cables are being laid great care shall be taken to avoid twisting, kinking, excessive tension, mechanical pressure and sharp bending beyond the specified limits of the cable manufacturer.

- 8.10 Cables shall run parallel to one another when installed on the same cable support system.
- 8.11 Only approved lubricants to assist in the drawing in of cable into conduit shall be permitted.
- 8.12 At all cable ends compression gland fittings shall be used.
- 8.13 Every cable shall have a label attached at each end as identification.
- 8.14 Slotted cable trunking shall be used inside cabinets wherever possible.
- 8.15 Wire bundle runs in consoles, etc shall be bound with nylon cable ties at intervals not exceeding five bundle diameters.
- 8.16 Bundles shall have uniform appearance, circular cross sections, and shall be securely fastened to the panel framework

## **9. CABLE AND WIRE TERMINATING AND MOUNTING HARDWARE**

- 9.1 All terminations shall be via screw type Terminal Strips and multiple wires per terminal is not permitted.
- 9.2 Every terminal strip shall be uniquely numbered/named and every terminal shall be uniquely numbered
- 9.3 No joints will be allowed in cables or wires between terminations.
- 9.4 All cable cores and wires shall be numbered at all termination points with "slip-on" interlocking type cable markers. Split ferrule types will not be acceptable. In the case of multi-core cables each core shall be numbered or colour coded.
- 9.5 Wherever possible, terminations of cable cores and wires shall be made using spade, pin or bootlace ferrule type crimp-on lugs.  
Lugs may only be crimped with controlled pressure crimping tools of correct size for the lug used.
- 9.6 Thin, collapsing pipe type ferrules shall not be used.
- 9.7 High quality wire strippers shall always be used, and care taken not to damage the strands or omit

- strands from the lugs.
- 9.8 Terminals shall be located so that all connections can be made easily.
- 9.9 Metal wireways shall be electrically continuous.
- 9.10 Cable and wireways supports shall be spaced adequately to avoid sagging between supports. Cable trays and wireways shall be firmly fastened to such supports.
- 9.11 Any bending, jagged edges or any other forms of damage or deformation of cable trays or wireways shall be made good, before cables are installed.
- 9.12 Conduit shall be thoroughly cleaned and have all burrs removed before the drawing in of any cable. End caps shall be provided at all open ends of conduiting.
- 9.13 Where outlet boxes, draw boxes, etc, are to be mounted in highly visible areas special attention shall be given to their aesthetic appearance.
- 9.14 Cable routes shall be chosen to avoid high temperatures and other hazards.  
All main cable routes shall be vermin-proofed and all openings shall be sealed with cable seal blocks or fireproof and vermin proof expanding foam.
- 9.15 Where cable support systems are joined together, same supplier jointing kits consisting of galvanized or cadmium plated bolts, nuts and brackets shall be used. Welding is not permitted.
- 9.16 Any cable tray shall be supported at every change in direction of the cable tray route. The minimum radius of any bend of the tray is to suit the minimum bending radius of the largest cable on the tray.
- 9.17 Cable trays shall be firmly secured in position in such a manner to cause as little obstruction to walkways etc., as possible.
- 9.18 Hangers, supports and anchors for wireways and equipment, shall be designed and installed with regard to appearance and convenience as well as for adequate strength and rigidity. Only professional quality fixing materials and methods shall be used. Nails and glue are not acceptable.

**10. SURGE PROTECTION**

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- 10.1 In view of the expected lightning and switching transients and the regulation of the available 230VAC supply the supply shall be regarded as an industrial supply.
- 10.2 The Tenderer shall therefore allow for additional surge suppression and voltage stabilisation equipment if this is required to protect his offered equipment and/or to guarantee its correct and reliable operation.
- Equipment which is connected to signal lines of any type which run for any distance outside a building, shall, if technically feasible, be surge protected to survive twenty 8/20 microsecond current impulses with maximum amplitude of 10 kA when applied in common mode between the signal lines connected together and to the system earth.
- In addition, the protected equipment shall be able to survive 20 8/20 microsecond current impulses with maximum amplitude of 2 kA when applied in differential mode.
- In the case where surge protection equipment is factory fitted into the equipment being offered, but is found to be inadequate to meet this specification, additional external protection shall be provided.
- 10.3 Equipment which is connected to signal lines of any type of which the entire length of the run is within the same building and for which the signal cable is longer than 30 m, shall be protected as in 10.2, except that the maximum amplitude for the common mode test shall be 2 kA and the maximum amplitude for the differential mode test shall be 500 A.
- 10.4 Surge protection devices shall be chosen in such a way that the protected circuit shall still function to specification in spite of the introduction of series and/or shunt impedances by the protecting devices.
- 10.5 The above test specifications are based on recommendations of the Council for Scientific and Industrial Research (CSIR report No Ek185/6/1.)
- 11. EQUIPMENT AND JUNCTION BOXES**
- 11.1 Equipment and junction boxes shall be of steel or GRP construction or as specified in the Project Specification '.
- 11.2 All steel shall be primed, undercoated and gloss finished with epoxy or polyurethane paint.
- 11.3 All boxes shall have a box name or number on the cover.
- 11.4 Junction Boxes for indoor use shall be at least IP 52 rated.

- 11.5 Junction Boxes for outdoor use shall be at least IP 65 rated.
- 11.6 All junction boxes shall provide the facility to fully terminate any multi- core cable entering the box.
- 11.7 Junction Boxes which are exposed to the sun, shall be installed facing south or else shall be fitted with a shading cover.
- 11.8 Junction Boxes shall be mounted with their sides true vertical and horizontal.

**12. CABINETS, CONSOLES AND CONTROL PANELS (METAL WORK)**

- 12.1 Cabinets, consoles, control panels or desks shall be of mild steel, aluminium, solid wood or stainless steel construction, or as specified in the Project Specification
- 12.2 The frames and panels shall be rigid and not flex unduly under forces which may be applied during normal usage.
- 12.3 Cabinets, consoles and panels shall be of fully enclosed construction with removable gland plates for incoming connections. -
- 12.4 Sectional panels, etc shall have open end(s) to permit bolting to adjacent sections. Where later addition of an adjacent section is envisaged, temporary side plates shall be fastened to sectional panels, etc.
- 12.5 Cabinets, consoles and panels for equipment which generate heat, shall have suitably sized louvers in the top and bottom of the doors plus ventilation fans if required. For panels with high heat load and severe environmental conditions, the requirement for louvers and fans shall be replaced with split unit circulating air panel coolers.
- 12.6 Louvers shall be covered internally with close-weave non-ferrous mesh.
- 12.7 Cabinets, consoles and panels shall have flush full height and full width doors with lift-off hinges on the back.
- 12.8 Doors shall be of the lever handle latch type with integral locks and common keys.
- 12.9 Access panels shall be provided on all cabinets, consoles and panels for access to any part of the cabinet, front, rear, top or bottom.

- 12.10 All adjoining edges shall have formed radii of 5 to 10 mm.
- 12.11 All faces shall be flat to within 2 mm over any 760 x 760 mm.
- 12.12 Gaps between adjacent units shall be not more than 2 mm.
- 12.13 Individual tolerance in height and length shall be not more than 3 mm.
- 12.14 Each panel, console or cabinet shall be capable of free standing and shall be mounted onto a separately constructed plinth.
- 12.15 Adjoining units shall, where required, have openings for passing cables, etc through their mating ends.
- 12.16 Plinths shall have provision made for bolting to floor and for bolting down of consoles, etc.
- 12.17 All finishes shall provide scratch free surfaces able to withstand high impact loads without chipping.
- 12.18 The finishes shall be colour fast and due consideration shall be taken of the area of operation of the cabinet, console, panel or rack when selecting the finish. Textured polyurethane or epoxy paint is an acceptable finish under most circumstances. On wood surfaces, melamine and formica are acceptable surfaces.
- 12.19 Sufficient space must be allowed around the installation to allow free access for maintenance purposes and to allow adequate ventilation, if required.

### **13. CONSTRUCTIONAL ASPECTS**

- 13.1 All holes, wireways, trenches, etc required for this installation and made by the Contractor shall be reinstated to the original condition.
- 13.2 In all cases where the Contractor uses facilities provided by others, it is the responsibility of the Contractor to ensure that these are provided correctly to match his requirements. If discrepancies are found, these shall be brought to the attention of the Engineer immediately and prior to the installation of equipment.
- 13.3 No facebrick or other finished surfaces may be chased without the permission of the Engineer.

13.4 No cutting of structural concrete will be permitted without the permission of the Engineer.

13.5 The Contractor shall provide and erect all necessary scaffolding for this contract. Scaffolding erected by another Contractor may be utilised by the Contractor provided suitable arrangements are made with the other Contractor.

#### **14. EARTHING**

14.1 The screens of analogue or high speed digital signal cables shall be continuous from field devices through to the control room panel and shall be connected to equipment earth onto special equipment earth busbars in the control room or control panel.

14.2 Instruments requiring the screen to be earthed locally at the sensing element, shall remain continuous to the control room and shall not be connected to the instrument earth or make contact with other screens at the junction box

14.3 The screens of all cable tails entering junction boxes shall be kept clear of system earth and shall be connected to the screen of the interconnecting multi-core cable

14.4 The case of each device shall be earthed to the system earth by mounting directly on a steel frame or by means of a third wire.

14.5 Steel frameworks of panels shall be strapped together and provision must be made for bolting to an incoming earthing cable separate from the system earth.

14.6 All power supply cables from the local cubicles, boxes, panels or MCC's are to have the armouring and earth core, if any, adequately bonded to the earth terminal or strip in the distribution board.

14.7 If an armoured signal cable is screened as well as being armoured, then the armouring shall be connected to system earth at both ends. If the cable is armoured but not screened, then the armouring must be used as if it was the screen.

14.8 All C&I equipment shall be bonded to a "clean" earth system. The Contractor shall establish the suitability of the provided system earth for connection of the C&I earth systems. The onus regarding the effectiveness of the systems remains on the Contractor.

#### **15. ELECTRICAL POWER SUPPLIES**

15.1 If an AC circuit runs from any one cabinet etc to another cabinet etc, or field equipment, then each

circuit shall be individually protected by means of a fuse or circuit breaker.

- 15.2 AC loads within a cabinet etc, shall be supplied from circuits which are individually protected by fuses or circuit breakers,.
- 15.3 All power distribution terminal blocks \_shall be covered by a shield marked "isolate Feeder Before Removing Shield".
- 15.4 Boards shall be wired such that when the main switch for a panel is switched off at the distribution board, no live incoming low voltage wiring shall be accessible in the panel.

**16. INSTALLATION OF EQUIPMENT**

- 16.1 Equipment shall be mounted for maximum accessibility and visibility.
- 16.2 Workmanship shall be of good quality and all cutting, drilling, welding, etc, shall be neatly finished off. Each completed installation, including supports, brackets and wiring shall present a clean, compact appearance.
- 16.3 All fixing hardware for field mounted equipment shall be finished off free from burrs or jagged edges.



## **S201 STANDARD SPECIFICATION FOR FIELD INSTRUMENTS**

1. Field instruments shall be suitable to withstand the conditions to be encountered on site and to perform the duties required of them
2. The field instruments are specified in detail in the detailed specification and listed in the schedule of quantities.

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**S202 STANDARD SPECIFICATION FOR PROGRAMMABLE LOGIC CONTROLLER (PLC )**

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## **1. GENERAL**

- 1.1 This specification has been developed to establish minimum requirements for a solid-state Programmable Logic Controller designed to provide high reliability in industrial applications. The internal wiring of the controller is to be fixed, with the logic functions it must perform in a given application to be programmed into its memory. The controller shall be supplied with the CPU, input/output scanner, inputs, outputs, memory, power supply, and all power and interface cables necessary to function as a complete and operable PLC system.  
The term "Programmable Automation Controller" is used interchangeably with the term "Programmable Logic Controller"
- 1.2 The objective of the PLC will be to improve reliability, maintainability, and efficiency by reducing operating costs and downtime.
- 1.3 The objective of the PLC will be to improve reliability, maintainability, and efficiency by reducing operating costs and downtime.
- 1.4 The specification shall be read in conjunction with the detailed specification and all areas of questions or noncompliance shall be submitted to the Engineer for review and approval.

## **2. SERVICE**

- 2.1 The supplier shall provide operating instruction manuals with adequate information pertaining to the following:
- A. System specifications
  - B. Electrical power requirements
  - C. Application considerations
  - D. Assembly and installation procedures
  - E. Power up procedures
  - F. Troubleshooting procedures
  - G. Programming procedures
  - H. Explanation of internal fault diagnostics
  - I. Shut down procedures
  - J. Recommended spare parts list

- 2.2 In cases where the supplier does the programming, the supplier shall provide a copy of all working programs on Compact Disk or DVD as well as a printed program listing.
- 2.3 The supplier shall provide a network of field sales and support personnel located in South Africa and globally.
- 2.4 The supplier shall provide product application assistance by trained and experienced engineers to assist the customer with program and system development through telephone consultation and on-site check-out, debug, and start-up assistance.
- 2.5 The supplier shall provide a customer training program designed to teach the customer's personnel in the understanding and application of the Programmable Automation Controller. The training program shall include training manuals and "hands-on" programming experience on a PLC of a type similar to that provided by the supplier.
- 2.6 The supplier shall have the capability to conduct on-site training programs at a location provided by the customer.
- 2.7 The supplier shall be capable of providing troubleshooting software.

### **3. ASSEMBLED SYSTEMS**

- 3.1 A supplier shall assume single source responsibility for system assembly. An assembled system may include mounting and wiring of relays, motor starters, transformers, and disconnecting means, or other control devices as specified by customer-supplied documentation.
- 3.2 The supplier shall provide mounting and wiring of the PLC system in a NEMA type 12 or other enclosure that may be specified.
- 3.3 If specified, the enclosure shall be able to accommodate an electrical service of 400 volt, 3 phase, 50 Hz. The enclosure shall have sufficient room for a 400 VAC (primary) to 115 VAC (secondary) control transformer to service the controller, inputs, and outputs.
- 3.4 The supplier shall be able to provide a sealed plastic window in the NEMA 12 enclosure door(s) for observing the controller and I/O status indicating lights.
- 3.5 The supplier shall have the capability to supply an enclosure with special paint and graphic displays.
- 3.6 The supplier shall wire all PLC inputs and outputs to customer-specified terminal blocks.

- 3.7 The assembled system shall include fuse blocks as sized by the customer's application.
- 3.8 Within the enclosure all I/O racks, processor racks, and power supplies shall be grounded to meet the manufacturer's specifications.
- 3.9 The supplier shall be able to provide within the enclosure a master control relay to de-energize each I/O module and inhibit machine motion. The master control relay must be de-energized directly by a hardwired emergency stop pushbutton or by failure of the Programmable Automation Controller.
- 3.10 If more than one controller is mounted within an enclosure, the capability must exist to share a single programming panel or line printer.
- 3.11 All pushbuttons, switches and other operator devices must be UL listed and/or CSA approved, and sufficiently large and durable to provide dependable, long life operation.
- 3.12 All cables (with associated plugs, connectors and receptacles) requiring user field installation shall be designed for commercial use to withstand an industrial environment.
- 3.13 Upon receipt of the purchase order, but prior to the start of the manufacturing of the equipment, the supplier shall submit drawings of the complete assembled system for approval by the purchaser or their consultant.
- 3.14 Drawings, which are returned to the supplier for correction or revision, shall be resubmitted for approval before starting fabrication of the work in question unless marked "approved as noted".
- 3.15 All drawings shall include page, sheet, and line numbers.
- 3.16 The first page of all drawings and schematics shall be a cover sheet consisting of a bill of material, purchase order number, manufacturer's job number, user's name, location, application, and shipping address.
- 3.17 The drawings shall include a mechanical layout detailing the overall external dimensions of the enclosure. The drawings shall include such pertinent information as location of door handles, windows, lifting lugs, and enclosure mounted items such as tachometer or current meters, cooling fans, etc.
- 3.18 The supplier shall provide documentation detailing the mounting of the controller, I/O racks, motor starters, disconnect switch, fuse blocks, wireways, etc. All materials shall be labeled to provide easy cross-reference to the Bill of Material listing.

- 3.19 Electrical prints detailing all hardwiring, done by the supplier, to devices such as relays, motor starters, disconnect switches, fuse blocks, etc. shall be provided with individual wire numbers and relay contact cross-reference designations.
- 3.20 Sections describing inputs shall designate input modules by name, rack, module, and terminal location.
- 3.21 Each limit switch, pushbutton, or other input device shall be connected to only one individual input point.
- 3.22 Each output device shall be connected to only one individual output point.
- 3.23 The last sheet in the set shall be for terminal block designations each containing their individual terminal numbers.
- 3.24 At the time the equipment is shipped, one (1) reproducible copy of each drawing mentioned above shall be provided with the equipment.

#### **4. DESIGN DESCRIPTION**

- 4.1 A major consideration of the System shall be its modular, field expandable design allowing the system to be tailored to the customer's machine and/or process control application. The capability shall exist to allow for expansion of the system by the addition of hardware and/or software.
- 4.2 Modules are defined herein as devices that plug into a chassis and are keyed to allow installation in only one direction. The design must prohibit upside down insertion of the modules as well as safeguard against the insertion of a module into the wrong slot or chassis via an electronic method for identifying a module. Electronic keying performs an electronic check to insure that the physical module is consistent with what was configured.
- 4.3 The PLC shall have downward compatibility whereby all new module designs can be interchanged with all similar modules in an effort to reduce obsolescence.
- 4.4 The PLC shall have the ability to be updated electronically to interface with new modules.
- 4.5 All hardware of the PLC shall operate at an ambient temperature of 0 to 60 degrees C (32 to 140 degrees F), with an ambient temperature rating for storage of -40 to +85 degrees C (-40 to +185 degrees F).
- 4.6 The PLC hardware shall function continuously in the relative humidity range of 5% to 95% with no condensation.
- 4.7 The PLC system shall be designed, manufactured and tested to operate in a high electrical noise environment.

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- 4.8 The PLC shall have the capability of addressing up to 128000 discrete points or 4000 analog points. It shall also have the ability to communicate with up to 250 connections that contain I/O. These calculations are based upon the connection limitation of the controller (i.e. 250 connections \* 16 channels per module = 4000 analog points) (i.e. 250 connections \* 16 slots \* 32 points per module = 128,000 digital points).
  - 4.9 Each input and output module shall be self-contained and housed within a chassis. These chassis, with their respective modules, shall contain up to 512 (16 modules x 32pts/module, using a 17 slot chassis) unique points.
  - 4.10 The PLC shall include as an optional feature the capability of addressing remote input and output modules on ControlNet, DeviceNet, EtherNet/IP and "RIO".
  - 4.11 The PLC shall use multiple independent, asynchronous scans. These concurrent scans shall be designated for processing of input and output information, program logic, and background processing of other controller functions. Input and output devices located in the same backplane (local I/O) as the CPU will produce at the rate of the configured RPI (Requested Packet Interval), and for discrete input modules enabled for Change Of State (COS), at the time any point changes state.
  - 4.12 The PLC shall have the ability to communicate with multiple remote I/O racks or devices configured with multiple I/O modules. Networks that allow remote I/O include "Remote I/O", ControlNet, EtherNet/IP, and DeviceNet.
  - 4.13 It shall be possible to communicate with remote I/O racks or other PACs via fiber optic cable by inserting fiber optic converters into the links. The fiber link must support distances up to 82,000 cable feet (25km). Redundant fiber optic cabling shall be an option.
  - 4.14 The PLC shall have the ability to support multiple data communications networks in the same chassis by using DH+, DH-485, HART, ControlNet, DeviceNet, Ethernet/IP, Programmable Multi Vendor Interface (RS232) modules, as well as other commonly used networks.
  - 4.15 The PLC shall have one dedicated 9-Pin D-shell serial port, which supports RS-232-C signals at baud rates from 110bps to 38.4Kbps. It shall be accessible in control logic and provide support for DF1 Master, DF1 Point to point, DF1 Slave, DF1 Radio Modem, Modbus Master/Slave, DH-485 (messaging only) and ASCII Read/Write communication protocols. Alternatively, it must be usable for programming and data monitoring purposes.

## 5. CONTROLLER HARDWARE

- 5.1 The Central processing Unit (CPU) shall be a self-contained unit, and will provide control program execution and support remote or local programming. This device will also supply I/O scanning and inter-controller and peripheral communication functions

- 5.2 The user program and data shall be contained in battery backed memory. The operating system firmware shall be contained in non-volatile memory. An option shall be possible to store both the user program and system firmware in a non-volatile memory for backup/restore purposes.
- 5.3 The operating system firmware can be updated via a separate update tool to allow for easy field updates. The controllers (Controllogix 1756-16x or equivalent) shall allow the operating system to be updated using a suitably configured CompactFlash card.
- 5.4 The controller shall contain a minimum of 2 Mbytes (5561) of user memory. The 556x controller memory size is fixed as follows:
- 5.5 In a single chassis system all system and signal power to the controller and support modules shall be distributed on a single backplane. No interconnecting wiring between these modules via plug-terminated jumpers shall be acceptable.
- 5.6 The front panel of the Controller shall include a holder and a connector for a lithium battery. The battery shall provide power backup for user programs and data when the main power supply is not available.
- 5.7 The front panel on the Controller shall include color indicators showing the following status information:
- Program or Run mode of the controller
  - The fault status of the controller.
  - I/O status
  - RS-232 activity
  - Battery status
  - Force LED
- 5.8 The front panel of the Controller shall include a mounted keyswitch. The key shall select the following Controller modes: RUN – No control logic edits possible, program always executing; PROGRAM – Programming allowed, program execution disabled; and REMOTE – Programming terminal can make edits and change controller mode, including test mode, whereby the logic executes and inputs are monitored, but edits are not permanently active unless assembled.
- 5.9 The front panel of the Controller shall include a 9-pin D-shell serial RS232 port, which supports DF1 Full Duplex, DF1 Half Duplex, DF1-Radio Modem, DH-485 (messaging only no programming) and ASCII Read/Write protocols.
- 5.10 All system modules, local and remote chassis shall be designed to provide for free airflow convection cooling. No internal fans or other means of cooling, except heat sinks, shall be permitted.



- 5.11 All system modules including the controller may be removed from the chassis or inserted in to the chassis while power is being supplied to the chassis without faulting the controller or damaging the modules. This is known as Removal and Insertion Under Power (RIUP). Alternately a software configurable option shall exist to fault the controller if required.

## **6. POWER SUPPLIES**

- 6.1 The PLC shall operate in compliance with an electrical service of 85 to 265 VAC (120 to 231 VAC nominal), single phase, in the frequency range from 47 to 63 Hz, or 18-32 VDC (24VDC nominal)
- 6.2 The manufacturer shall be able to provide as standard equipment a system power supply capable of converting AC standard low voltage line power to the DC power required to operate the PLC system.
- 6.3 A single main power supply shall have the capability of supplying power to the CPU and local input/output modules. Other power supplies shall provide power to remotely located racks.
- 6.4 The CPU within the system shall perform internal diagnostic checking and give visual indication to the user by illuminating a "green" (OK) indicator when no fault is detected and a "red" (OK) indicator (Blinking or Solid) when a fault is detected.
- 6.5 The power supply shall automatically shut down the PLC system whenever its output power is detected as exceeding 125% of its rated power.
- 6.6 The power supply shall monitor the incoming line voltage for proper levels. When the power supply is wired to utilize AC input, the system shall function properly within the range of 85 to 265 VAC. When the power supply is wired to utilize DC input, the system shall function properly within the range of 18 to 32 VDC.
- 6.7 The power supply shall provide surge protection, isolation, and outage carry-over of up to 6 cycles of the AC line (120-231VAC, 50/60Hz) or 40ms @ 24VDC.
- 6.8 Design features of the PLC power supply shall include a diagnostic indicator mounted in a position to be easily viewed by the user. This indicator shall provide the operator with the status of the DC power applied to the backplane. In addition, a means of disabling power to the CPU shall be possible from a power disconnect switch mounted in a position easily accessible by the operator.
- 6.9 At the time of power-up, the power supply shall inhibit operation of the controller and I/O modules until the DC voltages of the backplane are within specifications.
- 6.10 In addition to the electronic protection described above the power supply shall offer a failsafe fuse that is not accessible by the user.

## **7. PROGRAM CREATION AND STORAGE**

- 7.1 The program storage medium shall be of a battery backed RAM type.
- 7.2 The controller shall contain a minimum of 2 Mbytes (5561) of user memory.
- 7.3 Memory capacity shall be selectable to allow for the most economical match to the intended application. It shall be possible to upgrade to a controller with a larger memory size simply by saving the program, upgrading the controller (556x) and downloading the program to the new system without having to make any program changes.
- 7.4 Memory shall contain battery back-up capable of retaining all stored program data through a power cycle. A low battery condition must be detectable in ladder logic, but shall not automatically generate a major fault. A low battery condition will generate a minor fault and will be detectable in ladder logic.
- 7.5 The controller shall write all variable data to internal nonvolatile memory storage (Flash) during the power down cycle.
- 7.6 The controller shall provide the capability to use CompactFlash as nonvolatile memory storage. The CompactFlash card shall be available from the supplier as an industrial rated device suitable for use in the same environment as the controller.  
The controller shall have the ability to store the user program, controller firmware and firmware for all other modules residing in the same chassis to the CompactFlash card. Additionally when memory is restored a user selectable option to be restored in Run mode or Program mode shall be provided.
- 7.7 The controller shall have the capability to ensure, that if required modules in the chassis are flashed using the firmware files stored on the CompactFlash card, to the correct revision level for the project.
- 7.8 The CompactFlash shall support a Windows file system allowing multiple files to be stored on the card. The user can manually trigger the controller to save or load from CompactFlash and also configure the controller to load from CompactFlash on power up.
- 7.9 The operator should be able to backup volatile memory, including data and program logic onto a personal computer storage device.
- 7.10 All user memory in the controller not used for program storage shall be allocable from main memory for the purpose of data storage. The PLC system shall be capable of storing 3 data types:
1. Predefined
  2. User-defined
  3. Module-defined

Pre-defined include the following data types:

ALARM  
AXIS  
BOOL  
CAM  
CAM\_PROFILE  
CONTROL  
COUNTER  
DEADTIME  
DERIVATIVE  
DINT  
DISCRETE\_2STATE  
DISCRETE\_3STATE  
DOMINANT\_RESET  
DOMINANT\_SET  
FBD\_BIT\_FIELD\_DISTRIBUTE  
FBD\_BOOLEAN\_AND  
FBD\_BOOLEAN\_NOT  
FBD\_BOOLEAN\_OR  
FBD\_BOOLEAN\_XOR  
FBD\_COMPARE  
FBD\_CONVERT  
FBD\_COUNTER  
FBD\_LIMIT  
FBD\_LOGICAL  
FBD\_MASKED\_MOVE  
FBD\_MASK\_EQUAL  
FBD\_MATH  
FBD\_MATH\_ADVANCED  
FBD\_ONESHOT  
FBD\_TIMER  
FBD\_TRUNCATE  
FILTER\_HIGH\_PASS  
FILTER\_LOW\_PASS  
FILTER\_NOTCH  
FLIP\_FLOP\_D  
FLIP\_FLOP\_JK  
FUNCTION\_GENERATOR  
HL\_LIMIT  
INT

User-defined

User defined data is limited to structures. Each structure contains one or more data definitions called members.

Module-defined

Object includes a structure for each I/O module and system or module specific information (hidden from user).

- 7.11 Any data shall be able to be displayed in ASCII, Binary, Octal, Hexadecimal, or Decimal radices. Function-specific data types such as PID, Axis, Axis Group or Message shall have dedicated displays available annotating the meaning of specific control bits and words within them and allowing for selective control where appropriate.
- 7.12 If instructions or entire rungs are intentionally deleted from an existing logic program, the remaining program shall be automatically repositioned to fill this void. Whenever contacts or entire rungs are intentionally inserted into an existing program, the original program shall automatically be repositioned to accommodate the enlarged program. All rung comments shall maintain their original links.
- 7.13 It shall be possible to program application logic more than once into memory.
- 7.14 The number of times a normally open (N.O.) and/or normally closed (N.C.) contact of an internal output can be programmed shall be limited only by the memory capacity to store these instructions.
- 7.15 The number of times a timer or counter can be programmed shall be limited only by the memory capacity to store these instructions.
- 7.16 Controller programs shall have immediate access to the subelements of control structures by address and subelement mnemonic, such as timer accumulator value, timer done bit, or PID Process Variable value.

## 8. INTERFACING AND PERIPHERALS

- 8.1 The programming software shall be on a Windows 2000, Windows 2003, Windows 10 or Windows XP Professional workstation to be further known as "workstation".
- 8.2 The workstation shall have the capability to be remotely located a maximum of 10,000 cable feet (3048 meters) from the controller over DH+ at 57.6 K-Baud or a maximum of 3280 cable feet (1000 cable meters) from the controller over ControlNet. The workstation shall also be able to connect via Ethernet or RS232 for remote access.8.3
- 8.4 The means to indicate contact or output status shall be by intensification of the contact or output on the CRT screen. Each element's status shall be shown independently, regardless of circuit configuration.
- 8.5 The Programmable Controller system shall be able to interface with a data terminal, which is RS-232-C compatible (up to 38400 baud) to generate hard copy messages.
- 8.6 The system shall have the capability to interface to a floppy disk, CD-ROM, DVD and/or a hard disk for loading a user program into, or recording the

contents of, the controller's memory. It shall be possible to load or record the entire contents of memory.

8.7 It shall be possible to use Windows "copy/paste" to easily duplicate all or parts of the controller program within the same project or across multiple projects open on the same workstation.

8.8 The ability to create libraries of controller programs is required using the standard programming software.

9. **COMMUNICATION INTERFACES**

9.1 The PLC shall have communication interface modules for Ethernet/IP, ControlNet, DeviceNet, DH+, DH-485, Remote I/O (RIO), and RS232.

9.2 The Ethernet/IP interface shall support the following:

- Standard TCP/IP communications
- Standard Ethernet media ( 10base2, 10base5, 10baseT, 100baseT, fiber)
- CSMA/CD access method
- Subnet masking
- Standard repeaters, bridges, routers, host computers, peer PLC s.
- RJ-45 and AUI ports
- Bootp client
- Manual configuration using RSLogix5000, RSLinx, or BootP/DHCP Servers.
- Programmable controller messaging to peer controllers and workstations
- I/O Control

9.3 The Ethernet/IP interface shall support bridging between Ethernet/IP links within a ControlLogix chassis.

9.4 The Ethernet/IP interface shall support bridging to ControlNet, DH+, DH-485 and DeviceNet. Bridging allows for configuration (program up/download) and data collection.

9.5 The ControlNet Bridge module shall support network update times ranging from 2-100 milliseconds and be user selectable in one millisecond increments.

9.6 The manufacturer shall offer industry standard 5 megabit/sec ControlNet Producer/Consumer communication capabilities embedded in the PLC as defined by the ControlNet International 2.0 specification.

9.7 The ControlNet Bridge module shall be able to connect to approved quad shield Coax using approved BNC style connectors and Allen Bradley ControlNet taps.

9.8 The ControlNet bridge module shall support Ring, Linear, Tree, or Star bus topologies.

- 9.9 The ControlNet bridge module shall have an option of using single or redundant media.
- There shall be a software protocol layer that uses ControlNet as the transport mechanism to deliver packets of data to other programmable controllers that use the same protocol. This protocol handles the addressing and transfer of all the specific data file types in the programmable controller to allow for peer-to-peer messaging.
- The PLC shall allow the scheduling of data transfers between Peers as a function of the network without the need for programming message instructions in ladder. This transfer shall occur at user selectable and repeatable rates.
- 9.10 The ControlNet bridge module (1756-CNB/CNBR/CN2/CN2R) shall be certified as ControlNet compliant by ControlNet International or one of its approved certification agents.
- 9.11 The ControlNet bridge module shall support a maximum of 64 addressable nodes with a repeater, or 48 taps without a repeater. ControlNet supports 99 nodes per network, but one CNB/CNBR/CN2/ supports 64 nodes and the 1756-CN2R supports 100 connections. The number of addressable nodes a CNB/CNBR/CN2 can handle is based on configuration. Multiple CNB/CNBR/CN2 modules can be used to address 99 nodes.
- 9.12 The PLC shall have a standard programming instruction that allows peer-to-peer messaging with other controllers over the ControlNet network. The instruction shall be able to address any valid ControlNet node and also messages that need routing to other networks.
- 9.13 On-line programming and upload/downloads of control programs shall be able to occur over the ControlNet network.
- 9.14 The manufacturer shall offer MMI (Man Machine Interface) software for data acquisition, supervisory control, operator interface, and information management that obtain data from the PLC over the ControlNet, Ethernet/IP, DH+ or Serial communication network.
- 9.15 A ControlNet network can be extended by using repeaters. Repeaters shall be available in both coax and fiber optic varieties.
- 9.16 The ControlNet Bridge module shall support scheduled communications between nodes on a single ControlNet network. Also, unscheduled communications between nodes on the same or different networks shall be supported.
- 9.17 The ControlNet bridge module shall support multi keeper functionality.
- 9.18 The DeviceNet interface shall support the following:
- 9.19 The manufacturer shall offer industry standard 125/250/500 Kbaud DeviceNet Producer/Consumer communication capabilities as defined by the Open DeviceNet Vendor's Association (ODVA).

- 9.20 The DeviceNet Bridge module shall be able to connect to standard DeviceNet cabling and ODVA specified connectors.
- 9.21 The DeviceNet bridge module shall support Linear, Tree and Star bus topologies. Trees and Stars can be a max of 20 feet. All points of a tree or star are considered drops.
- 9.22 There shall be a software protocol layer that uses DeviceNet as the transport mechanism to deliver packets of data to peer devices.
- 9.23 The DeviceNet bridge module shall be certified as DeviceNet compliant by ODVA or one of its approved certification agents.
- 9.24 The DeviceNet bridge module shall support a maximum of 64 addressable nodes.
- 9.25 The DeviceNet bridge module shall allow access to a DeviceNet network from programmable controllers and host computers on ControlNet or Ethernet.
- 9.26 The manufacturer shall offer MMI (Man Machine Interface) software for data acquisition, supervisory control, operator interface, and information management that obtain data from the programmable controller over the DeviceNet network or by explicit messaging from ControlNet and Ethernet.
- 9.27 The DH/RIO interface shall support the following:
- Two channels of communications
  - Each channel independently configurable for DH+ or RIO
  - DH+ baud rate shall be 57.6, 115, 230 Kbaud
  - DH+ will support routing tables
  - RIO baud rates shall be 57.6, 115.2, 230.4 KBaud
  - Message error checking
  - Retries of unacknowledged messages
  - Diagnostic checks on other stations
- 9.28 The DH+ interface shall support bridging to/from ControlNet, EtherNet and DeviceNet.

## **10. PROGRAMMING TECHNIQUES**

- 10.1 The programming format shall be IEC 1131-3 compliant Ladder Diagram (LD), Function Block Diagram (FBD), Sequential Function Chart (SFC), and Structured Text (ST) languages.
- 10.2 The controller shall organize user applications as Tasks, which can be specified as continuous, periodic, or event based.
- 10.3 Periodic tasks shall run via an interrupt at a user-defined interval in one microsecond increments from 1 millisecond to 2000 seconds.

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| 10.4  | The interrupt mechanism of periodic and event tasks shall adhere to the IEC 1131-3 definition of pre-emptive multitasking.   |
| 10.5  | The controller shall be able to accommodate a maximum of 32 individual tasks of which one can be continuous.   |
| 10.6  | The periodic and event tasks shall have an associated, user assignable priority from one to fifteen (one being the highest priority), which specifies that task's relative execution priority in the multitasking hierarchy.   |
| 10.7  | The event task can be triggered by hardware events (an input point) or software events (event instruction).  |
| 10.8  | Each task shall have a user settable watchdog timeout which is unique to that task.  |
| 10.9  | Each task can include a maximum of 100 programs, which can be prioritized for execution within the task.   |
| 10.10 | Each program can include routines programmed in LD, FBD, SFC, or ST languages. One of the routines can be specified as the main routine and one can be specified as an optional fault routine. All routines shall be capable of being edited when on-line. The number of routines which can be contained in a program is limited only by memory. |
| 10.11 | Variables within the controller shall be referenced as unique, default or user defined tags.   |
| 10.12 | Tag naming convention shall adhere to specifications in IEC 1131-2.  |
| 10.13 | Tags may be created off-line, on-line and at the same time the routine logic is entered.   |
| 10.14 | The system shall have the capability to store user tags names in the controller.   |
| 10.15 | Tags shall be available to all tasks in the controller (Controller Scoped) or limited in scope to the routines within a single program (Program Scoped) as defined by the user.  |
| 10.16 | Any tag shall have the ability to be aliased by another tag, which is defined and has meaning to the user.   |
| 10.17 | The ability to program control logic via tags of the PLC shall exist.  |
| 10.18 | It shall be possible to program ladder diagram rungs with the following restrictions: <ul style="list-style-type: none"> <li>• series instruction count limited only by user memory</li> <li>• branch extensions limited only by user memory</li> <li>• branch nesting to six levels</li> </ul>  |
| 10.19 | The capability shall exist to interleave input and output instruction types on the same contiguous rung in the ladder diagram rungs.   |



- 10.20 The capability shall exist to change a contact from normally open to normally closed, add instructions, change referenced tags, etc. It shall not be necessary to delete and reprogram the entire ladder diagram rung.
- 10.21 It shall be possible to insert ladder diagram rungs anywhere in the program, even between existing rungs, insofar as there is sufficient memory to accommodate these additions.
- 10.22 A single program command or instruction shall suffice to delete an individual ladder diagram rung from memory. It shall not be necessary to delete the rung contact by contact.
- 10.23 A clock/calendar feature shall be included within the CPU. Access to the time and date shall be from the programming terminal or user program.
- 10.24 Latch functions shall be internal and programmable.
- 10.25 The system shall have the capability to address software timers and software counters in any combination and quantity up to the limit of available memory. All management of these instructions into memory shall be handled by the CPU. Instructions shall permit programming timers in the "ON" or "OFF" delay modes. Timer programming shall also include the capability to interrupt timing without resetting the timers. Counters shall be programmable using up-increment and down-increment.
- 10.26 Timer instructions shall have a time base of 1.0 milliseconds. The timing range of each timer shall be from 0 to 2,147,483,648 increments. It shall be possible to program and display separately the timer's preset and accumulated values.
- 10.27 The PLC shall use a signed double integer format ranging from -2,147,483,648 to +2,147,483,648 for data storage of the counter preset and accumulated values.
- 10.28 The PLC shall store data in the following formats:
- A. Boolean values (0 or 1).
  - B. Short Integer Numbers ranging from -128 to +127.
  - C. Integer Numbers ranging from -32,768 to +32,767.
  - D. Double Integer Numbers ranging from -2,147,483,648 to 2,147,483,647.
  - E. Floating Point Numbers consisting of eight significant digits. For numbers larger than eight digits, the CPU shall convert the number exponential form with a range of plus/minus 1.1754944 E -38 to plus/minus 3.402823 E +38.
- 10.29 The capability shall exist to organize data in the form of User Defined Data Structures. All aforementioned data types, as well as others, can be used in such structures along with embedded arrays and other User Defined Structures.

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- 10.30 The PLC shall have support for integer and floating point signed math functions consisting of addition, subtraction, multiplication, division, square root, negation, modulus, and absolute value.
  - 10.31 Trigonometric instructions supported must include Sine, Cosine, Tangent, Inverse Sine, Inverse Cosine, and Inverse Tangent. These instructions must fully support floating-point math.
  - 10.32 Additional floating point instructions supported must include Log 10, Natural Log, and Exponential.
  - 10.33 It shall be possible to complete complex, combined calculations in a single instruction, such as flow totalizing or equations of the format  $((A+((B-C)*D))|E)$ .
  - 10.34 File function instructions supported shall also include Sort, Average and Standard Deviation.
  - 10.35 Value arrays shall be limited in size only by the amount of available memory.
  - 10.36 Arrays shall be configurable with one, two or three dimensions.
  - 10.37 The CPU shall support indexed addressing of array elements.
  - 10.38 Array element manipulation instructions such "array copy" (COP), "array copy with data integrity" (CSP) and "array fill" (FLL), "array to array" (MOV), "element to array" (FAL), "array to element" (FAL), and "first in-first out" (FIFO) shall be supported by the system. The four function and math instructions and instructions for performing "logical OR", "logical AND", "exclusive OR", and comparison instructions such as "less than", "greater than", and "equal to" shall be included within the system. All instructions shall execute on either single words or array elements.
  - 10.39 For any module specifically associated with the Programmable Automation Controller, it shall be possible to configure operation and query the current status of all channels through controller scoped tags without any programming.
  - 10.40 The system shall contain instructions, which will construct word shift registers (SQI, SQO, and SQL). Additional instructions shall be provided to construct synchronous bit shift registers (BSR and BSL).
  - 10.41 The PLC shall have a jump instruction which will allow the programmer to jump over portions of the user program to a portion marked by a matching label instruction.
  - 10.42 The PLC shall have an embedded motion planner capable of doing coarse motion planning for up to 32 axes. This planner must be the highest priority task of the controller.
  - 10.43 The PLC shall have a ladder diagram instruction interface to the motion planner which allows the user to request that the motion planner create and execute a specific motion profile. The profile can be changed dynamically through the ladder diagram program.

- 10.44 The PLC shall provide a master system clock that will allow synchronization of all axes in the chassis local to the controller.
- 10.45 It shall be a function of the CPU to automatically manage all data types. For example, if a word stored in an Integer tag is transferred into a Floating Point tag, the CPU shall convert the integer value into floating point prior to executing the transfer.
- 10.46 In applications requiring repeatable logic it shall be possible to place such logic in a subroutine section. Instructions which call the subroutine and return to the main program shall be included within the system. It shall be possible to program several subroutines and define each subroutine by a unique program file designator. The controller will support nesting of subroutines up to available stack at the moment of the call. It shall be possible to pass selected values (parameters) to a subroutine before its execution. The number of these parameters is limited only by available memory. This allows the subroutine to perform mathematical or logical operations on the data and return the results to the main program upon completion. These subroutines will be accessed by jump-to-subroutine instructions.
- 10.47 The program format shall display all instructions on a programming panel with appropriate mnemonics to define all data entered by the programmer. The system shall be capable of providing a "HELP" utility which when invoked by the programmer will display on the programming panel a list of instructions and all data and keystrokes required to enter an instruction into the system memory.
- 10.48 At the request of the programmer, tags contained in system memory shall be displayed on the programming panel. This monitoring feature shall be provided for all tags regardless of format or scope.
- 10.49 The system shall have the capability to enter rung comments above ladder diagram rungs. These comments may be entered at the same time the ladder logic is entered.
- 10.48 The capability shall exist for adding, removing, or modifying logic during program execution in routines of LD, FBD, SFC, and ST languages. When changes to logic are made or new logic is added it shall be possible to test the edits of such logic before removal of the prior logic occurs.
- 10.49 It shall be possible to manually set (force) either on or off all hardwired discrete input or output points from the programming panel. It shall also be possible to manually set (force) an analog input or output to a user specified value. Removal of these forced I/O points shall be achieved either individually or totally through selected keystrokes. The programming terminal shall be able to display forced I/O points.
- 10.50 A means to program a fault recovery routine shall exist. When a major system fault (Controller Fault) occurs in the system, the controller fault recovery routine shall be executed and then the system shall determine if the fault has been

eliminated. If the fault is eliminated, program execution resumes. If the fault still exists, the system will shut down.

- 10.51 The capability shall exist for each program to have its own fault routine for program fault recovery. Each having the same features as the controller based fault routine.
- 10.52 An instruction shall be available to give the control program diagnostic information, state control, and sequencing of a process simultaneously, while allowing the capability of user-friendly state programming techniques.
- 10.53 An instruction shall be supported to incorporate closed loop control systems. The "proportional", "integral", and "derivative" elements shall be accessible to the user in order to tune a closed loop system. This instruction must fully support floating-point math.
- 10.54 The system shall support both bit and word level diagnostic instructions.
- 10.55 To facilitate conditional event detection programming, output instructions shall include "one shot" instructions, which may be triggered on either low-to-high (rising) or high-to-low (falling) rung conditions.
- 10.56 To facilitate debugging, an "always false" instruction shall exist which may be utilized to temporarily inhibit the execution of control logic.
- 10.57 The controller shall support Master Control Reset (Relay) type functionality to selectively disable sections of logic.
- 10.58 The controller shall include direct support of FOR-NEXT loop constructions.
- 10.59 The controller shall include the ability to create user defined instructions that are re-usable in one or multiple projects/applications. These instructions will allow for the encapsulation of code developed by the user using the standard instruction set and other add-on instructions. The user defined instructions can be instantiated multiple times, each instance of the instruction having its own backing data and the ability to create custom online help for each user defined instruction.
- 10.60 The controller shall have the ability to create alarm instructions allowing for a single point of configuration for all alarms within the controller. The alarm data can then be read by a management system such as Factory Talk Alarms & Events and presented across the enterprise to HMI and other systems.

## **11. STATE CONTROL AND DIAGNOSTICS**

11.1 The Human Machine Interface (HMI) interface shall provide:

- A. A fault log for all stations on the network
- B. Operator guidance facilities
- C. A maintenance diary
- D. Message queue
- E. System menu

- F. Machine/process-specific graphics
- G. Production information such as cycle times
- H. The ability to "zoom" in on a specific station

11.2 It shall be possible to network multiple Programmable Automation Controllers, each of which shall report diagnostic information to a common terminal. The HMI shall maintain a fault log. The fault log shall time and date stamp each fault as it is received and/or cleared. This information shall have the ability to be sorted either by fault type or by initiator type. The fault log data shall rotate on a weekly basis. A fault log report may be scheduled to include fault message type, controller name, fault time, clear time, calendar date, fault date, active time, control file, etc.

11.3 A typical operator interface graphic screen generated by the standard diagnostic software shall display screen name, machine status, production counts, mimic panel (pilot lights), and I/O points. The graphic screens shall be easily accessible using user-friendly function keys either via keyboard or operator interface terminal.

11.4 The system shall provide the following types of diagnostic messages:

- A. Status messages
- B. Error messages
- C. Time-out messages
- D. One valid exit message
- E. Mismatch message

## 12. QUALITY REQUIREMENTS

The PLC shall be able to withstand conducted tests as outlined in the following:

Environmental Test	Industry Standard
Temperature	IEC 60068-2-1 IEC 60068-2-2 IEC 60068-2-14
Humidity	IEC 60068-2-30
Vibration	IEC 60068-2-6
Shock	IEC 60068-2-27
Emissions	CISPR 11: Group 1, Class A
ESD Immunity	IEC 61000-4-2
Radiated RF Immunity	IEC 61000-4-3
EFT/B Immunity	IEC 61000-4-4
Surge Transient Immunity	IEC 61000-4-5
Conducted RF Immunity	IEC 61000-4-6

## 13. SYSTEM REDUNDANCY

- 13.1 The Redundancy System shall provide higher system availability. This shall be realized by switching control to a secondary controller chassis if anything in the primary controller chassis fails.
- 13.2 The Redundancy System shall be realized using standard versions of hardware, including chassis, power supplies, controllers (L6x), and communication adapters.
- 13.3 In order to provide higher system availability, it shall be possible, but not solely required, to configure the Redundancy System with redundant power supplies.
- 13.4 The Redundancy System shall allow connecting to other (remotely located) networks using the bridging functionality of other communication modules.
- 13.5 The Redundancy System shall be able to operate without any local I/O, and having all I/O configured as remote I/O.
- 13.6 The Redundancy System shall use fiber optic media to connect the primary and the secondary control system.
- 13.7 It shall be possible to implement the Redundancy System without additional programming.
- 13.8 The switch over between primary and secondary controller shall happen transparent to the user and to the application. It shall allow switchover of any certified ControlNet devices.
- 13.9 In event of a switch over, the Redundancy System shall automatically swop ControlNet addresses between primary and secondary chassis. Any external device shall continue to communicate with the new primary controller.

- 13.10 The Redundancy System shall guarantee a bumpless switchover for any outputs in the highest priority task. Outputs referenced by the logic in this task shall never revert to a previous state because of a switchover event.
- 13.11 The Redundancy System shall provide an automatic program cross-load and synchronization. The program shall be downloaded only to the primary controller. Using this design, it shall eliminate the need for maintaining separate programs for the primary and the secondary controllers. A controller, configured as a secondary controller, shall automatically receive and buffer data changes from the primary controller.
- 13.12 The Redundancy System shall be able to support up to 5 1756-CNB(R)s ControlNet Bridge modules in the primary/secondary chassis. Supporting several ControlNet networks is an essential feature.
- 13.13 The Redundancy System shall be able to support two (if using up to three 1756-CNB(R) modules) 1756-ENBT Ethernet module in the primary/secondary chassis.