Mark* VIe Control Family

Quality Control Process and Validation Tests

fact sheet

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The Mark VIe control family consists of Mark VIe turbine and plant distributed control systems, Mark VIeS safety controllers, EX2100e generator excitation controls, LS2100e static starters, and Mark VIe Wind controls. The quality control process for these systems consists of a validation process for the core hardware and software, and additional validation processes for site-specific equipment with its unique packaging, networks, and application software.

This fact sheet describes the initial phase of validating the core hardware and software independent of its site-specific application. In addition, it is specific to the General Electric plant in Salem, Virginia whose processes comply with GE's overall quality policy. Compliance is verified by on-site independent audits and certified to ISO 9001:2008 via FM 590980 for *The design, manufacture, supply and service of programmable control, input/output, operator interface, software, and embedded computing products.*

Vendor Quality

Today's sophisticated control systems leverage a world-wide network of suppliers with best-in-class technology for printed circuit boards, terminal blocks, power supplies, network switches, and software packages. Therefore, quality control of the sourcing process is a major part of the overall quality program. The primary activities for implementing supplier quality include:

- **Approval Process**: assessment of the commodity and supplier with their EHS and labor practices
- **Qualification Process**: approval of purchased components
- **Surveillance**: audits of quality system, products, process, capacity, and EHS with varying frequency based on hardware complexity, impact of failure, and so forth
- **Issue Resolution**: analysis and prevention of supplier caused issues with root-cause-analysis
- **Deviation Review**: management and tracking of a supplier deviation request
- **Improvement**: Six Sigma projects, standardization, and quality process improvements

Two standards used by GE in the qualification and surveillance processes are IPC J-STD-001 Requirements for Soldered Electrical and Electronic Assemblies and IPC A-610 Acceptability of Electronic Assemblies, Class 2 Dedicated Service Electronic Products. For further assistance in qualification and surveillance, GE is a subscriber and active user of the Process Capability, Quality and Relative Reliability (PCQR2) Benchmark Database, which was developed by IPC and CAT (Conductor Analysis Technologies, Inc.), to quantify the performance and quality of printed circuit board manufacturers.

Cabinet Assembly Test

Mark VIe control cabinets are available in a variety of application-specific configurations for front/rear entrance, top/bottom cable accesses, I/O quantity, and IP classifications. Each cabinet is assembled and connected to automated test equipment, which performs a power-on test of the I/O independent of its application. I/O points of mission-critical functions are tested over their full range regardless of whether they are intended to be used or reserved for spare points in an application.

The test equipment verifies the functionality of I/O network switches, main processors, and cabinet infrastructure such as power distribution. Archives are maintained of the pass / fail results and reviewed for completeness at the end of the test.

Compliance with specific technical regulations and standards is a separate qualification process such as UL / CSA certification, EU directives, IEC 61508 capability, and NFPA 70, NEC, Articles 500 - 504 - Hazardous Locations, Class I, Division 2.

Printed Circuit Board and Module Test

Printed circuit boards and modules that are supplied by vendors are verified to contain the appropriate quality control markings. Non-vendor boards and modules that are manufactured by the GE global supply chain undergo the same rigorous test procedures and pass / fail criteria as vendor boards.

- **Component Test** – Components are screened for approved vendors and selectively tested according to the type of component and historical failure rates. Automated component insertion test equipment verifies component ratings on axial lead devices such as resistors, capacitors, diodes, zener diodes, and the orientation of polarized components.
- **Printed Circuit Board Test** – The *bare board* is typically tested by the board vendor prior to inserting components on the circuit board, this validates point-to-point continuity of solder runs and separation between solder runs. A comprehensive *in-circuit* test is used on populated circuit boards to verify the identification of chips on the board and test for open / short circuits, component values, D/A and A/D converters, and so forth.
- **I/O Module Test** – Mark VIe I/O modules contain an I/O pack mounted on a printed circuit board, and a local processor board and data acquisition board within the I/O pack. The printed circuit board also contains a terminal block for field wiring terminations and passive circuits that connect the terminal block to the I/O pack. I/O modules are tested for the proper identification of mounted boards, electrical continuity between points, and power-on functionality of the complete device including communication ports.

Temperature and vibration stress tests are not part of the factory qualification process. Customized stressing of selected boards and modules is sometimes performed in the development cycle with stress test methodology such as Highly Accelerated Life Test (HALT) to improve design margins.

Core Software Validation

Software can be segmented into site-specific software and core software, which may also be known as product code, firmware… The core software is based on the ControlST* Software Suite including WorkstationST* HMI and Historian Management software, ToolboxST* Configuration and Diagnostic tools, CIMPLICITY* Human-machine Interface, and other packages.

ControlST software releases occur at regular intervals and all elements of the release including firmware, configuration tools, operation and maintenance tools… are tested as a matched set. The core software is downloaded into a typical Mark VIe hardware configuration including I/O modules and evaluated in a closed-loop dynamic simulation of a typical application. This hardware / software integration test in a realistic environment reduces the risk of quality defects in the delivered product and enhances on-going life cycle support.

Power Conversion

Power conversion controls for EX2100e generator exciters, LS2100e static starters, and Wind turbines are designed and manufactured in the same GE factory as the other parts of the Mark VIe control family. Therefore, they share controllers, networks, and the ControlST software suite to simplify operation and maintenance, and they share quality control methodology. Although power converters differ in their design and ratings, they share many of the basic validation tests, including:

- Device identification
- Torque / hardware check
- Point-to-point wire check and inspection for proper wire routing
- Hi-Pot test
- Corona Test (LS2100e bridge and Wind attenuation module)
- Coolant System Test
- Power-on Test
  - Power Distribution
  - Functional Test (product-specific)
  - Load Test for bridges

Conclusion

The quality control process and validation tests of core Mark VIe hardware and software provide a reliable foundation for the subsequent testing of application-specific hardware and software.

Benefits

- Less project risk
- Less installation time
- Reduced commissioning cost
- Improved system reliability
- Better life-cycle support capability

For further assistance or technical information, contact the nearest GE Sales or Service Office, or an authorized GE Sales Representative.

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