

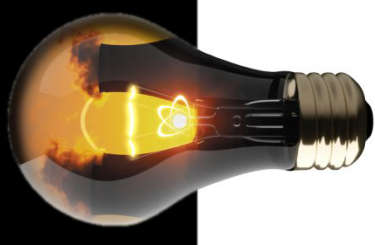


Dedication of Component with Imbedded Firmware



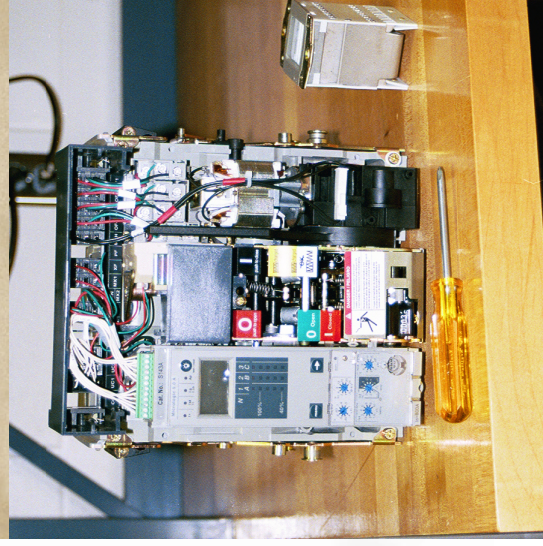
Craig S. Irish – V.P., Sales & Marketing

Equipment Types

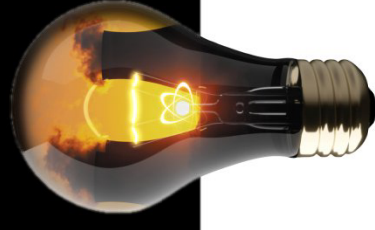


- This presentation is applicable to the supply of equipment with embedded software/firmware.
- Digital equipment is being used in a wide range of applications in nuclear power plants. Typical applications include the following:
 - Safety Related Applications
 - Instrumentation.
 - Trip units for low voltage switchgear breakers.
 - Electrical system protective relays.
 - HVAC controls.
 - Loop controllers.
 - Generator exciters.
 - Gas analyzers.
 - Critical Non-Safety Related Applications
 - Feedwater control system.
 - Variable frequency drives to replace MG sets.

Equipment Types

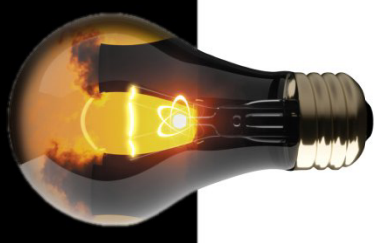


Requirements



- NRC R. G. 1.152, revision 2, “Criteria for use of Computers in Safety Systems of Nuclear Power Plants.”
 - Endorses the use of EPRI TR-106439.
- EPRI TR-106439, “Guidelines on Evaluation and Acceptance of Commercial Grade Digital Equipment for Nuclear Safety Applications” .

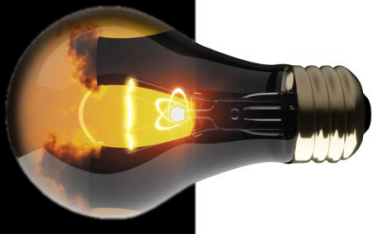
Dedication Process



- Identify the safety function of the equipment, including the computer system.
- Identify the critical characteristics that must be verified.
 - NLI's standard dedication plan for digital devices has approximately 55 CC's.
- Method for verification of the critical characteristics. All NLI dedication of components with imbedded firmware consist of both:
 - Software commercial grade survey (CGS) at the manufacturer's facility.
 - Testing at NLI.

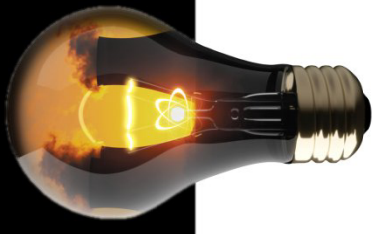
In our experience, both a CGS and in-house testing is required.

Identify the Safety Function



- Safety function is based on the plant requirements/specification.

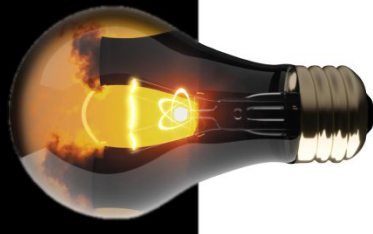
Identify the Critical Characteristics



Types of Critical characteristics (CC's)

- Lifecycle.
- Hardware/software.
- Functional.
- Abnormal conditions and events (ACE's).
- Configuration control.
- Cyber security.
- Human Machine Interface (HMI).
- Reliability and operating experience.

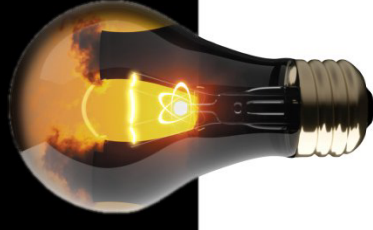
Lifecycle CC's



- Most are related to the vendor QA controls. A CGS is required.
- Examples:

Critical Characteristic	Acceptance Criteria	Acceptance Method
Software specification /software requirements	Software specification, or equivalent, documents the software requirements.	Software CGS.
Error/problem handling by the manufacturer.	<ol style="list-style-type: none">1. Software errors are identified, documented, evaluated, and reported in a controlled manner.2. Manufacturer has a mechanism for identifying and evaluating user reported errors.3. Identified problems are reported to the end user.	Software CGS.

Hardware/Software CC's



- Examples:

Critical Characteristic	Acceptance Criteria	Acceptance Method
Watchdog timer or equivalent.	The product contains a method to detect a failure to complete a cycle and resets.	Software CGS.
Processor restart and initialization	Following power removal and restoration, the item restarts and maintains the initial configuration.	NLI dedication/ FAT testing

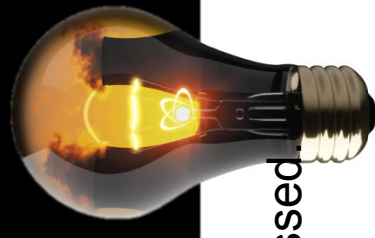
Functional CC's



- Based on the specific operating requirements from the client spec and vendor literature. Normally verified by NLI testing.
- Examples for HVAC chiller controls

Critical Characteristic	Acceptance Criteria	Acceptance Method
Leaving water setpoint.	Maintains the leaving water at 43 +/-1F.	NLI dedication/ FAT testing
Condenser high pressure trip.	Chiller shuts down when condenser pressure exceeds 200psig.	NLI dedication/ FAT testing

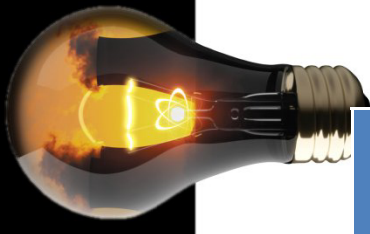
ACE CC's



- External and internal ACE's (also referred to as Hazards) are addressed
- Examples:

Critical Characteristic	Acceptance Criteria	Acceptance Method
EMI/RFI qualification	Item operates properly before, during, and after the EMI/RFI event (specific acceptance criteria are identified in the qualification plan).	NLI testing
Unused function isolation	<ul style="list-style-type: none">• No unused resident functions.• Development aids removed.• Portions of the code that are not used for the end user specific application will not impact operation.	Software CGS. NLI testing.

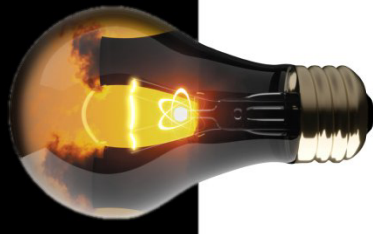
Configuration Control CC's



Examples:

Critical Characteristic	Acceptance Criteria	Acceptance Method
Revision control	Revision control is used by the vendor on hardware and software.	Software CGS.
User setpoints configuration control	NLI dedication/FAT testing is performed at the plant specific user setpoints and the setpoints are documented (specific acceptance criteria are in the dedication/FAT plan).	NLI dedication/ FAT testing

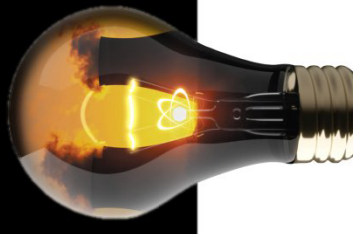
Cyber Security CC's



Examples:

Critical Characteristic	Acceptance Criteria	Acceptance Method
Cyber security during product development and manufacturing.	Vendor maintains an effective cyber security program that prevents malicious code from being installed.	Software CGS.
Product security.	The equipment contains the product security (passwords, physical security) per the plant requirements and vendor specifications.	NLI dedication/ FAT testing

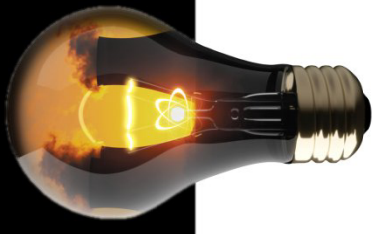
HMI CC's



Examples:

Critical Characteristic	Acceptance Criteria	Acceptance Method
Product HMI	Touch-screens are straightforward and in accordance with the vendors operating manual.	NLI dedication/ FAT testing
Laptop computer with supporting software.	Proper operation and interface with the digital device.	NLI dedication/ FAT testing

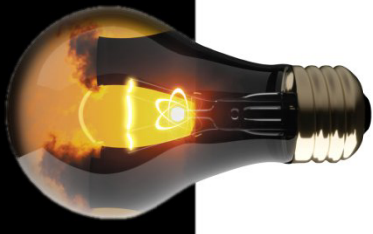
Reliability and Operating Experience CC's



Examples:

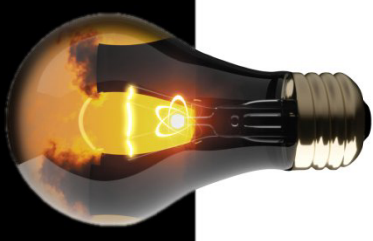
Critical Characteristic	Acceptance Criteria	Acceptance Method
Product operating experience.	Installed units have good operating history. Document the following and evaluate: <ol style="list-style-type: none">1. # operating units by revision level.2. Time in service.3. Number and types of identified problems (hardware , software).	Software CGS.
Software revisions due to problems.	Software revisions that were made due to identified problems fully resolves the problem.	Software CGS.

Sample Project-Chiller Controls



- Equipment Identification: Digital chiller controls for existing water chiller.
- Safety function: Maintain leaving water temperature at $42 \pm 2^{\circ}\text{F}$ for control room cooling coils.

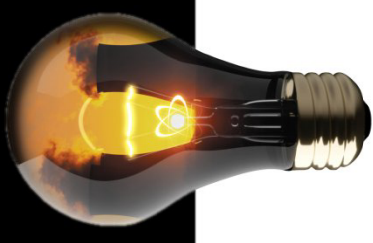
Sample Project-Chiller Controls



Dedication activities consisted of:

- Software CGS at Trane.
- NLI FAT/dedication testing.
- NLI qualification testing.

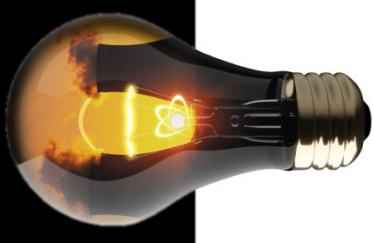
Sample Project-Chiller Controls



NLI FAT/dedication testing:

- Bench testing.
- Installation on a chiller in a flow system.
- Most of the client specification requirements were tested.

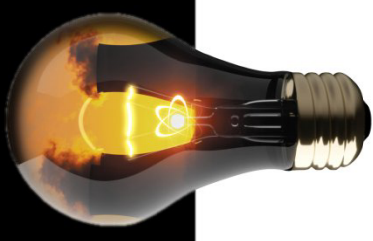
Sample Project-Chiller Controls



Software CGS at Trane:

- Lifecycle controls.
- Configurational control.
- Functional/performance requirements.
- Operating experience.

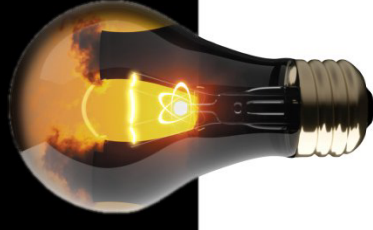
Sample Project-Chiller Controls



Equipment Qualification Testing

- Seismic.
- EMI/RFI.
- Mild Environment.

Key Issues/Lessons Learned



- There are regulatory and implementation differences between dedication of commercial grade software and development of digital equipment under a 10CFR50 Appendix B quality assurance program.
- Both a software CGS and FAT/dedication testing are required for proper dedication.



Questions?

