Developer's Workshop: Session C
CIP Safety™ Conformance Testing 2017

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Session Overview

- Functional Safety
- CIP Safety Protocol
- Conformance Testing Process
- CIP Safety Conformance Test
- Test Guidance
- Available CIP Safety CCTs and TSP locations
Functional Safety

• IEC\textsuperscript{1} defines “safety” as
  – Freedom from unacceptable risk of physical injury or of damage to the health of people, either directly, or indirectly as a result of damage to property or to the environment.

• IEC further defines “functional safety” as
  – The part of the overall safety that depends on a system or equipment operating correctly in response to its inputs.

• IEC 61508
  – Functional safety of E/E/PE safety-related systems
  – Probability of dangerous failure (PFD\textsubscript{AV}, PFH)
  – SIL – Safety integrity level – e.g., SIL 3 $\Rightarrow$ $10^{-8} \leq PFH < 10^{-7}$

\textsuperscript{1}International Electrotechnical Commission; http://www.iec.ch/functionalsafety/
Functional Safety

• IEC 61508 is the basis for many other international standards that target application and product sectors; for example:
  – IEC 62061 Safety-Related Electrical Control System (SRECS)
  – IEC 61511 Safety Instrumented Systems (SIS)
  – ISO 13849 Safety of machinery (SRP/CS)
    • PLe vs. SIL 3

• IEC 61784-3 “Functional safety fieldbuses”
  – Defines Functional Safety Communication Profiles (FSCP)
  – Uses the “black channel” approach (61508-2 subclause 7.4.11.2)
  – CIP Safety is defined as FSCP 2/1 (61784-3-2)
• Provides a stated probability of failure for the network layer
  – PFH is average frequency of dangerous failures per hour
  – Network PFH (1%) part of overall PFH
  – $10^{-10} < PFH < 10^{-9}$ required for a SIL 3 data communications channel
• CIP Transport Class 0 Messaging
• Real time format (Vol 1 3-6, 7-3.6.10)
• Certified by TÜV Rheinland
Conformance Testing Overview

• Purpose of Conformance Testing
  – Satisfy ODVA Terms of Usage (TOU)
  – Obtain ODVA Declaration of Conformity (DOC)

• Prerequisites to CT
  – Current specification and software subscriptions

• Prepare for the lab test by running CT during development

• Procure test by placing an order on the ODVA website

• Provide required info and materials

• Participate by attending the lab test
  – Highly recommended for first-time and originator DUTs

• Pass the test to receive final test report and DOC
  – CIP Safety requires additional coordination between Vendor and ODVA
CIP Safety Conformance Testing Process

1 – Vendor works with Functional Safety Partner

2 – Functional Safety Partner requires ODVA certification

3 – Vendor orders CIP Safety conformance test

4 – ODVA provides test report

5 – Vendor provides ODVA test report

6 – Safety Partner provides Functional Safety certificate

7 – Vendor provides Functional Safety certificate

8 – ODVA issues Declaration of Conformity

9 – Vendor ships product to end users
CIP Safety Conformance Test

- Includes all relevant sections of Standard Conformance Test
  - A standard test order is not needed for safety products
  - A standard test order IS needed for non-safety product variants
- Establishes conformance to the Safety Test Plan
  - Does not establish *functional safety* of the device
- Software installation provides CIP Safety test guidance
  - Readme
  - Sample Test Report
  - User’s Guide – Appendix E
CIP Safety Conformance Test

• Implements automated safety protocol tests
  – Vol 5 Appendix F-3

• Includes CIP object test adaptations for safety
  – Vol 5 chapters 5 & 6
  – Safety-specific profiles and objects
  – Changes to standard objects (e.g., SNN attribute)

• Accommodation required for manual tests
  – QoS, ACD, DLR, TimeSync

• Dynamic Interoperability Test
  – Required for originators
  – Run if time permits for targets
CIP Safety Test Plan

• Volume 5 – Appendix F
  – Links to traceable requirements (FRSxxx, SRSxxx)
  – Includes “Black Box” and “White Box” tests
  – **Black Box** – tests that can be externally verified
    • Volume 5 Appendix F-3
    • Automated test scripts
    • e.g., TST101 SafetyClose Processing by Targets
  – **White Box** - tests that require visibility into the implementation
    • Verified by the product developer
      – e.g., code inspection, design review, etc.
    • Volume 5 Appendix F-4
    • e.g., TST93 – Safety Device Hardware Validation Tests
Test Guidance – CIP Safety Protocol Test Software

“Standard” Protocol Test

- CIP Network specific tests
- CIP Object tests
  - Safety-specific profiles and objects
  - Impact to existing objects
  - CIP object extensions for safety
  - (Vol 5 chapters 5 & 6, Pub 170)

- CIP Safety object tests
  - e.g., Safety Supervisor

Safety Protocol Test

- “Black Box” tests are automated
- “White Box” tests must be performed by Vendor
Test Guidance – CIP Safety Test Selection
• Two changes to the STC for safety
  • Safety results directory
    – This should be constant thru all test runs
    – Vary file name to manage multiple STCs
• Safety Characteristics
  – Device configurations and
  – Connection endpoints and sizes
Test Guidance – Safety STC

- Device Behavior
  - Input/Output
  - Controller
- Connection Info
  - Target/Originator
  - Consumer/Producer
  - Single/Multi-cast
  - Connection Endpoints
  - Provide one STC per required test configuration (small & large connection sizes)
- SafetyOpen Types
- TUNID/NodeID/SNN
- (optional) Config file
- Originator target config file

Safety Characteristics

- Device Behavior
  - Input
  - Output
  - Controller
  - Bridge

- Connection Info
  - Target/Originator
  - Consumer/Producer
  - Single/Multi-cast
  - Connection Endpoints
- Provide one STC per required test configuration (small & large connection sizes)

- Safety Open Application Path(s)
  - Class: 4
  - Instance: 064
  - Null Instance: 199
  - Attribute: 199
  - Connection Point: 199

- Safety Open Type(s)
  - Type 1 (Config)
  - Type 2 (SCID)
  - Type 2 (SCID=0)

- Safety I/O Data
  - Size: 6
  - Produced Size: 15
  - Max Consumers: 1
  - RPI Min: 1000
  - RPI Max: 1
  - RPI Tick: 1

- System Unique Identifiers
  - DUT UNID
    - SNN Date: 2017-01-01
    - SNN Time: 100:00
    - NodeID: 0x00000000
  - Test UNID
    - SNN Date: 2017-01-01
    - SNN Time: 100:00
    - NodeID: 0x00000000

- Target Configuration Data File
  - Config File

- Safety Protocol Version
  - 2.0
Test Guidance – Safety Configurations

• Clarification of the meaning of Produce/Consume
  • Input/Output
    – TSCP = Target Single-cast Producer (i.e., INPUT)
    – TSCC = Target Single-cast Consumer (i.e., OUTPUT)
    – TMCP = Target Multicast Producer

• Meaning “reversed” for Originator DUTs
  – OSCP is a CIP consuming connection (i.e., OUTPUT)
  – OSCC is a CIP producing connection (i.e., INPUT)
Test Guidance – Safety Log Files

Test script console output

SPTE Rollup html
Test Guidance – Pass/Fail

---

**Test Result status = Fail**
crc = X1F71876E

---

**Test Result status = Pass**
crc = X2F26088E

---

**Extended Format Producer Time Orientation Response Failure Test**
Testware Revision: 1.01 08/24/04

- Test number: 1162
- Receive skipped: no Response Expected
- Log messages suppressed: 13 in 0.1009

---

**Extended Format Producer Time Orientation Response Failure Test**
Testware Revision: 1.01 08/24/04

- Test number: 1162
- Receive skipped: no Response Expected
- Log messages suppressed: 13 in 0.1009

---

**Extended Format Producer Single-Cast Test**
Testware Revision: 1.01 08/24/04

- Test number: 1212
- Receive skipped: no Response Expected
- Log messages suppressed: 13 in 0.1009

---

**Extended Format Producer Single-Cast Test**
Testware Revision: 1.01 08/24/04

- Test number: 1212
- Receive skipped: no Response Expected
- Log messages suppressed: 13 in 0.1009

---

**Test Result status = Fail**
crc = X1F71876E

---

**Test Result status = Pass**
crc = X2F26088E

---
Test Guidance – Installed Documentation

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Create a .CFG File .................................................................... 87
Test Guidance – Installed Documentation

ODVA CIP Safety on EtherNet/IP Conformance (CT6)

- Composite Test Specifications
- Test Specifications (PCTS)
- CIP Safety on EtherNet/IP Protocol Conformance Testware
- CIP Safety Release Notes
- EtherNet/IP Release Notes
- Sample Conformance Test Result Report
- Supplemental Release for Third Party Communication
- Uninstall
- User Guide

- CIP PCTS (Protocol Conformance Test Specification)
- CIP Safety Conformance Specification
- EtherNet/IP Conformance Specification
2. CIP Safety Object Tests

This chapter specifies the conformance tests for CIP objects defined in the CIP Safety Specification, CIP Networks Library Volume 5 (ODVA PUB00085).

A template for use in developing CIP Conformance test specifications is provided in PUB00166 Appendix A.

Some testing specifications related to CIP Safety are contained in the common and network-specific test specification documents. For more information, please see the referenced document:

CIP Conformance Test Specification (ODVA PUB00160)
CIP Conformance Test Specification: DeviceNet Adaptation (ODVA PUB00167)
CIP Conformance Test Specification: EtherCAT Adaptation (ODVA PUB00168)

<table>
<thead>
<tr>
<th>Object Code</th>
<th>For Information about this Object Test:</th>
<th>Go to this page</th>
</tr>
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<td>Identity</td>
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<td>x03</td>
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<td>x2d</td>
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<td>x4f</td>
<td>TCP/IP Interface</td>
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Test Guidance – Safety Results Audit Tool

- Analyzes all safety logs
- Multiple test passes required
  - Target Configurations
    - I/O size ≤ 2 bytes
    - I/O size ≥ 3 bytes
  - Originator Configurations
    - Connection size variation
    - Single/Multi-Cast
  - Vendor-specific configuration
Test Guidance – Safety Results Audit Tool

- Safety Results Audit Summary
  - Errors detected by safety results audit.
  - Review Validation Log for more information.
  - Total number of test configurations:
    - Required: 187
    - Passing: 206
    - Failing: 2
    - Not Found: 4

- Requiring review of safety and standard logs:
  - Tests with mixed passing/failing results: 5
  - Results included with CIP object tests: 30

- Failing Tests:
  - TST116: ExtendedFormat_TCP, ExtendedFormat_TCPCL

- Missing Tests:
  - TST45: BaseFormat_OSSC, BaseFormat_OMCC, ExtendedFormat_OSSC, ExtendedFormat_OMCC
### Test Guidance – Safety Results Audit Tool

- **Sample SafetyResults.csv**
- **Sample SafetyResults.xml**

<table>
<thead>
<tr>
<th>STATUS</th>
<th>TEST</th>
<th>FORMAT</th>
<th>CONFIG</th>
<th>SPEI</th>
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    - <ResultCRC>0x5ED14E4F3</ResultCRC>
  </test>
  - <test>
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    </CRCs>
    - <Result>Pass</Result>
    - <ResultCRC>0x5ED14E4F3</ResultCRC>
  </test>
</testresults>
```
Available CIP Safety CCTs

- **DeviceNet**
  - CT7 DS (CT26 DN)
- **EtherNet/IP**
  - CT8 ES (CT12 EN)
- **Sercos III**
  - CT1 SS

- **Planned updates in 2017 – Release candidates available**
  - CT8 DS (CT28 DN)
  - CT9 ES (CT14 EN)
  - CT2 SS
Planned updates in 2017

• Release of new safety software subscriptions in first half of 2017
  – Improvements related to Originator testing
  – Improved support for non-SNCT devices
  – Fixes for unexpected stack behaviors

• Next software subscription
  – Improve safety results audit to cover all tests and eliminate manual checking
  – Add coverage for Safety Motion objects
  – Support ongoing specification changes
Available CIP Safety TSPs

• Ann Arbor (ODVA Technology and Training Center)
  – CIP Safety on EtherNet/IP, DeviceNet, Sercos III
  – Target and Originator

• Magdeburg TSP (University of Magdeburg)
  – CIP Safety on EtherNet/IP
  – Target

• Stuttgart TSP (University of Stuttgart ISW)
  – CIP Safety on Sercos III
  – Target

• Yokohama TSP and Shanghai TSP (TRJ, TRS)
  – No CIP Safety testing at the present time
Opportunities For Additional Training

- ODVA Quickstart Seminars
- CIP Safety One Day Training
  - in conjunction with TÜV Rheinland HW/SW FS Engineer Training and Exam
THANK YOU