HF Controls

HF CONTROLS CORPORATION

HFC-6000 Product Line
Nuclear Qualification Project ERD 111

EPRI TR 107330

REQUIREMENTS COMPLIANCE TRACEABILITY MATRIX

RR901-000-10

Rev C

Effective Date: 12/14/2009

Author: Ivan Chow

Reviewer: Jonathan Taylor

Approval: Allen Hsu

Revision History

Date	Revision	Author	Changes
2/3/05	A0	J Taylor	Draft
3/1/05	A	J Taylor	Incorporate review comments
11/19/09	B	I. Chow	Resolved the inconsistencies about undetectable errors and remedial implementations in RR901-000-01 Rev. B and PP901-000-01 Rev. C SCR 2612, CR 2009-0540
12/9/09	C	I. Chow	Revised and based on new documented information from the qualification summary report and reconstructed requirement documentations.

Table of Contents

List of Tables

1.0 INTRODUCTION

The following pages present a traceability matrix for compliance of the ERD111 project with EPRI TR-107330, Generic Requirements Specification for Qualifying a Commercially Available PLC for Safety-Related Applications in Nuclear Power Plants. The purpose of this project was to assemble an HFC-6000 control system and conduct the specified range of tests to demonstrate the functional capabilities and resiliency of the system design.

2.0 TRACEABILITY MATRIX

The traceability matrix consists of a multi column table. The purpose and content of the material in each column is as follows:

EPRI TR-107330 Reference	Contains the section and paragraph number reference for each line of text in the specification.
Summary of Requirement	Contains either the paragraph heading or the summary of the content in the indicated paragraph.
Compliance	Indicates level of compliance achieved. (Refer to paragraph 3.0.)
HFC Document Reference	Identifies the HFC document that either accomplishes the specific requirement or provides the evidence for compliance. Refer to PP901-000-01, HFC-6000 Product Line Document Map for a list of document references.
Comments	Provides explanatory information about the level of compliance or the way in which compliance is accomplished.

3.0 GLOSSARY

3.1 TRACEABILITY MATRIX COMPLIANCE

Comply	The intent of the stated requirement was met in full by the indicated document.
Exception	The intent of the stated requirement was not met in some respect. The entry in the comments column indicates the nature of the deviations.
N/A	Not Applicable. Either the EPRI reference did not include any requirement, or the stated requirement is not applicable to the test specimen covered by this report.

3.2 ABBREVIATIONS

ADC	Analog/Digital Converter
AI	Analog Input
AIC	Analog Input Conversion
AO	Analog Output
C	Centigrade
CD	Compact Disk
C-Link	Communication Link
CPC	Communication Protocol Controller
CPLD	Complex Programmable Logic device
CR	Condition Report
CRC	Cyclic Redundancy Check
CSM	Control Switch Module
DAC	Digital/Analog Converter
DB	deci Bell
DI	Digital (Discrete) Input
DIP	Dual In-Line Package
DO	Digital (Discrete) Output
EMI	Electromagnetic Interference
EWS	Engineering Workstation
FMEA	Failure Modes and Effects Analysis
FOT	Fiber-Optics Transmitter
FPC	Flat Panel Controller
FPD	Flat Panel Display
g	acceleration of gravity
HAS	Historical Archiving System
HFC	HF Controls
HIFR	Host Interface Remote (HFC software utility)
HMI	Human-Machine Interface
HPAT	HFC Plant Automated Tester
hr	hour
iaw	in accordance with
ICL	Intercommunications Link
I/O	Input/Output
JCRT	Java CRT (HFC software utility for operator workstations)
KHz	Kilo Hertz
LED	Light Emitting diode
M/A	Manual/Automatic
MA	milli Ampere
min	minute
ms	millisecond
NMI	Non-Maskable Interrupt
OBE	Operating Basis Event
PC	Personal Computer
PCB	Printed circuit Board
PLC	Programmable Logic Controller
PROM	Programmable Read-Only Memory

PVC	Poly Vinyl Chloride
QA	Quality Assurance
QAPM	QA Program Manual
RAM	Random Access Memory
RFI	Radio Frequency Interference
RH	Relative Humidity
RQ	Designation for a remote data routing table
RTD	Resistance Thermal Detector
ROM	Read Only Memory
sec	second
SLC	Single Loop Controller
SOE	Sequence of Events
SSE	Safety Shutdown Event
TSAP	Test Specimen Application (synthetic application program for test specimen)
TTL	Transistor-Transistor Logic
v	volt
V&V	Verification and Validation
vac	volt alternating current
vdc	volt direct current
w	watt

4.0 REFERENCES

Document Number	Description	Revision ERD111/Current
400409-01	HFC-BPC01-19, Hardware Design Spec.	A/D
400419-01	HFC SBC06, Hardware Design Spec	A/C
400434-01	HFC-AI16F, HW Design Spec.	A/B
400454-01	HFC-DI16I, HW Design Spec.	A/B
400459-01	HFC-DO8J, HW Design Specification	A/A
400464-01	HFC-DC33, HW Design Specification	A/C
400469-01	HFC-DC34, HW Design Spec.	A/C
400474-01	HFC-AO8F, HW Design Spec.	A/B
51378-1	Wyle Report	-
700709-00	HFC-6000 Chassis Assembly	A/A
700901-06	HFC-6000, IO Requirements Spec.	A/A
700901-09	ERD111 TSAP Requirement Spec.	A/A
700907-01	ERD111 TSAP Wiring Schematic	D/D
700907-02	Single Loop Controller	C/C
700908-01	HPAT Wiring	C/C
700909-01	FOT Wiring	D/D
700910-01	TSAP Test Rack	D/D
700912-01	TSAP System Assembly Drawing	G/G
700915-00	I/O Module Wiring	B/B
700916-01	Power Distribution, TSAP Configuration	C/C
700916-02	Power Distribution, Single Loop Configuration	D/D

Document Number	Description	Revision ERD111/Current
ADS0401	TSAP Design Description	A/A
ATP0402	Application Test Plan	A/D
DD0401	Test Specimen Design Description	A/B
DS001-000-01	Operating System Component Design Spec.	C/C
DS002-000-01	C-Link Protocol Design Spec.	C/C
DS002-000-02	ICL Protocol Design Spec.	E/E
DS004-000-03	MCRT Design	A/A
DS901-000-01	SBC06_DPM06, Module Detailed Design Spec.	B/D
DS901-000-02	IO Board Module Detailed Design Spec.	B/B
DS901-000-03	DO8J, Module Detailed Design Spec.	B/B
DS901-000-04	DI16I, Detail Design Spec.	B/B
DS901-000-05	DC33 Detailed Design Spec.	A/D
DS901-000-06	DC34 Detailed Design Spec.	A/D
DS901-000-07	AI16F Detailed Design Spec.	D1/D1
DS901-000-08	AO8F Detailed Design Spec	A/E
DS901-000-10	AI8L Detailed Design Spec.	B/E
DS901-000-11	AI8M Detailed Design Spec.	C/C
DS901-000-12	AI4K Detailed Design Spec.	C/C
MS901-000-01	SBC06 Module Design Spec.	F/F
MS901-000-02	IO Board Module Design Spec.	C/C
PP901-000-01	Topical Report	A/C
QAPM	Quality Assurance Program Manual	5/H
QPP 3.1	Design Control	D/I
QPP 3.2	Software Lifecycle and V&V Program	1/I
QPP 6.1	Control and Distribution of Documents	B/H
QPP 12.1	Control of Measurement and Test Equipment	C/G
QPP 13.1	Handling, Shipping, Storage and Preservation of Materials, Parts and Components	0/C
QPP 16.1	Corrective Action Program	D/M
QPP 16.2	Customer Feedback	0/E
QPP 16.3	10CFR Part 21 Report	0/B
RR901-000-01	Failure Modes and Effects Analysis	B/B
RR901-000-04	Reliability and Availability Analysis Report	A/A
RS901-000-01	HFC-6000 Product Line	C/F
RS901-000-02	HFC-PSR06 Requirements Spec.	D/E
TN0401	Master Test Plan	C/C
TP0401	Integration Test Plan	B/B
TP0402	Operability Test Procedure	C-E/F
TP0403	Prudency Test Procedure	C-E/F
TP0404	Environmental Stress Test Procedure	C/D
TP0405	Seismic Test Procedure	C-D/E
TP0406	Surge Withstand Test Procedure	C/D
TP0407	EMI-RFI Test Procedure	C/C
TP0408	TSAP Validation Test Procedure	A/B

Document Number	Description	Revision ERD111/Current
TP0408B	Test Specimens Validation Test Procedure	A/B
TP0409	ESD Test Procedure	C/C
TP0410	Burn-in Test Procedures	B/C
TP0411	Isolation Test Procedures	B/B
TR001-000-02	Application Object Test Plan	B/B
TS901-000-22	ERD111, Baseline Testing Summary Report	B/B
TS901-000-23	Environmental Test Report	B/C
TS901-000-25	EMI Test Report	B/C
TS901-000-28	Isolation Test Report	B/C
TS901-000-29	Post Qualification Report	B/B
TS901-000-30	Summary Report for Burn In Setup, TSAP Validation.	B/B
TS901-000-34	Seismic Retest In House Test Report	B/B
TS901-000-35	HFC6000 Seismic Retest Report	B/B
UG004-000-01	EWS User's Guide	E/E
UG004-000-02	OIS User's Guide	E/E
UG004-000-04	Onestep Software User's Guide	D/D
UG004-000-05	Software Installation Guide, Version 1.14 or 2.0	D/D
UG004-000-07	Site Planning and Installation Guide	H/H
UG004-000-08	Maintenance, Troubleshooting and Diagnostics	F/F
UG004-000-10	WCRT Setup User's Guide	A/A
VV0414	Master Configuration List	A/A
WI-DOC-001	Document Distribution	B/G
WI-ENG-003	Configuration Management	1/E
WI-ENG-006	PCB Assembly Order Requirement List	2/A
WI-ENG-008	Software V&V Procedures	0/VV-001
WI-ENG-020	Software Security	0/B
WI-ENG-100	Engineering Processes	0/D
WI-ENG-206	CMS Library SW Source Code Control	A/A

Table 1 – EPRI TR 107330 Requirement Compliance Traceability Matrix Table

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
1	**Scope.** Background information only.	N/A		No Requirements
2	**Definitions, Abbreviations, Acronyms.** Reference information only.	N/A		No Requirements
3	**Reference Documents** List of reference standards only.	N/A		No Requirements
4	**System Requirements.** Section Heading	N/A		No Requirements
4.1	**Overview of Performance Basis**. Descriptive Information	N/A		No Requirements
4.2.1	**Functional Requirements**. Section Heading	N/A		No Requirements
4.2.1.A	Response Time. Overall response time from input exceeding trip condition to the resulting output shall be 100 ms or less. This duration includes the effects of input filtering, internal processing and two processing cycles for an application having the equivalent of 2000 simple logic elements.	Exception	TP0402 TS901-000-22 RR901-000-37	See the performance envelop as defined in RR901-000-37.
4.2.1.B	**Discrete I/O**. Provide capability for a total of at least 400 discrete I/O	Comply	DD0401 700907-01 700907-02	I/O capacity exceeds this requirement.
4.2.1.C	**Analog I/O**. Provide capability for a total of at least 100 analog I/O	Comply	DD0401 700907-01, -02	I/O capacity exceeds this requirement.
4.2.1.D	**Combined I/O**. Provide capability for a combined total of at least 50 and 400 discrete I/O points.	Comply	DD0401 700907-01, 02	The final test specimen provides the capability of configuring total of 55 I/O modules, or up to 880 analog and digital I/O in any combination. Of these, approximately 370 digital points and 115 analog points were actually configured. The unused slots were filled with spare modules.
4.2.2	**Control Functional Requirements**. The PLC shall provide a high level language for implementing applications.	Comply	UG004-000-01 UG004-000-04 700907-01, -02 700908-01	Programming medium consists of logic diagrams using standard logic symbols. The diagrams are converted to program source code either by a software tool or manually using a workstation editor. The source code consists of sequential program statements that can be used as the basis for source code review..
4.2.3	**Availability/Reliability and FEMA**. Section Heading	N/A		
4.2.3.1	**Availability/Reliability Overview**. Descriptive	N/A		

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
	Information			
4.3.3.2	**Availability/Reliability and Basic Requirements**. Overall availability shall be 0.99. The analysis shall be based on the following combination of modules: A. 3 discrete input modules B. 2 analog input modules C. 1 analog output module D. 3 discrete output modules and 1 relay output module E. 1 high-level language module (N/A) F. Any other module required to support performance G. Any required ancillary devices H. Main processor I. Power supplies J. Chassis/backplane K. Interconnect devices L. Modules required to implement redundancy M. Ringback (N/A)	Comply	*RR901-000-04*	*The lowest calculated value for* availability was 99.9931%.
4.2.3.3	**Availability/Reliability Calculation Requirements**. Method of analysis shall comply with IEEE 352. A. Fault detection by online diagnostics instantaneous B. Analysis includes surveillance interval C. Module replacement requires 24 hours D. Fault detection by surveillance requires 24 hours E. Normal environmental conditions assumed F. Probability of normal operation for 2 wks under environmental stress G. Definition of module availability 4.2.3.3.1.A Single point failure rates 4.2.3.3.1.B Faults not detected by diagnostics 4.2.3.3.1.C Triple redundant systems (N/A) 4.2.3.3.1.D PLC failure definition	Comply	RR901-000-04	Redundancy was considered for power supplies, controllers, and critical communication links. Triple redundancy was not considered. Unique configurations that might be required for particular applications were not considered.
4.2.3.4	**PLC Fault Tolerance Requirements**. Fault tolerance shall be included as part of the reliability/availability analysis and included as part of the qualification envelope definition.	Comply	RR901-000-04 Topical Report	Redundancy was considered for power supplies, controllers, and critical communication links. Triple redundancy was not considered.
4.2.3.5	**Failure State/FMEA Requirements**. FMEA shall be conducted in accordance with IEEE 352.	Comply	RR901-000-01	FMEA to be done in accordance with IEEE 352-1987.
4.2.3.6	**Failure Detection Requirements**. PLC provides features to permit generating an alarm when fault detected during online operation. Redundant systems provide:	Comply	RR901-000-01	All faults detected generate alarms. Software failures such as run-time bit failure in memory are detected indirectly through sanity checking which will halt

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
	A. Significant level of coverage and status transfer B. Processor-processor communication (N/A) C. Processor firmware requirements of 4.4.5.2 and section 7.			the PLC and cause failover to the secondary PLC. No undetectable errors can occur in the system.
4.2.3.7	**Recovery Capability Requirements**. PLC shall include watchdog timer and power bus monitor. Output modules shall initialize to a known state following powerup.	Comply	RR901-000-01 MS901-000-01 DS901-000-02	Mailbox software watchdogs; hardware watchdog timers on each module; power monitor.
4.2.3.7.A	The PLC shall have a watchdog timer or equivalent capable of detecting failure to complete a scan. • On failure to complete a scan the PLC shall halt. • The mechanism shall not depend on the same clock source as the processor. • No communication feature of the executive shall defeat the operation of the mechanism. • No interrupt service routine shall defeat the mechanism.	Comply	DS001-000-08	The hardware watchdog on both the controller and the I/O modules is a single-shot controlled by an RC time constant. The watchdog on the I/O modules controls the NMI signal line. The watchdog on the controller drives the SANE signal. During normal operation, the FALSE state of the SANE signal on the primary controller triggers failover.
4.2.3.7.B	The PLC shall provide a power bus monitor.	Comply	DS901-000-01 400419-01	The controller contains both 3.5 and 5 vdc power buses and a separate low power monitor for both. Low voltage for either results in reset.
4.2.3.7.C	All output modules shall initialize to a known state.	Comply	DS001-000-08	Following powerup, relay output channels remain deenergized until after receiving the first valid message from the controller. AO modules include onboard jumpers to select one of three failure states. The module forces all channels to this state after completing powerup.
4.2.3.8	**Requirements for Use of Operating Experience**. A. Non-proprietary problem reporting and tracking B. Provide justification for claimed operating history C. System under configuration management	Comply	PP901-000-01	Operating history is being used as part of the basis for qualification of the legacy software modules.
4.2.4	**Setpoint Analysis Support Requirements**. Analysis report iaw ISA RP 67.04 shall include: A. Calibrated accuracy, hysteresis, and nonlinearity B. Repeatability C. Temperature sensitivity D. Drift with time E. Variations caused by power supply voltage levels F. Error contribution of arithmetic operations G. Components that could be affected by vibration	Exception	TS901-000-22 through TS901-000-29	This analysis is dependant on the application and will be implemented as part of each project. Items C through I are addressed by the qualification tests that were accomplished as part of this project.

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
	H. Components that could be affected by radiation I. Components that could be affected by humidity			
4.3	**Hardware Requirements**. Section Heading	N/A		No Requirements
4.3.1	**General**. Section Heading	N/A		No Requirements
4.3.1.1	**Background**. General Information	N/A		No Requirements
4.3.1.2	**Requirements Common to all Modules**. A. Shall meet or support requirements of section 4.2.1. B. A square root of the sum of squares may be used to combine independent random factors. C. Environmental requirements defined in section 4.3.6. Single assemblies with both inputs and outputs shall meet isolation and surge withstand requirements.	Comply	RS901-000-01 TP0406 TP0411 TS901-000-22 through TS901-000-29	Scope of testing is intended to comply with these requirements. See RR901-000-37 for environmental and other stress performance limits
4.3.1.3	**External Device Requirements**. External devices used to meet I/O requirements shall meet listed overall requirements.	N/A	RS901-000-01	No external devices were used to meet specific I/O requirements. Previously qualified switch modules and M/A stations were used as part of the Test Specimen.
4.3.1.4	**General Redundancy Requirements**. Test specimen may include redundant modules.	Comply	RS901-000-01 DD0401	The test specimen included redundant controllers, power supply modules, and major communication links.
4.3.2	**Input Requirements**. Section Heading	N/A		No Requirements
4.3.2.1	**Analog Input Requirements**. Test specimen shall include analog input modules.	Comply	RS901-000-01 700901-06	
4.3.2.1.A	Monotonic within ±1/2 LSB (equivalent to ±0.00122 v)	Comply	DS901-000-07 DS901-000-08 700901-06	Both the ADC and the DAC have guaranteed linearity within this tolerance.
4.3.2.1.B	Each module shall provide a minimum of 4 channels.	Comply	MS901-000-06 thru -08 700901-06	All modules except the pulse board have 8 or more channels; the pulse board has 4 channels..
4.3.2.1.C	The converted value shall remain at its maximum value for inputs up to twice the rated input.	Comply	DS901-000-07 DS901-000-08 UG004-000-01	When an AI module receives an input above its design range, it reports an over range condition. The AIC block holds the input count at the last valid input value, and marks that data as questionable.
4.3.2.1.D	The converted value shall remain at its minimum for up to twice the rated value for unipolar inputs.	Comply	DS901-000-07 DS901-000-08 UG004-000-01	When an AI module receives an input below its design range, it reports an under range condition. The AIC block holds the input count at the last valid input value, and marks that data as questionable.

ERD111 EPRI TR 107330 Requirement Compliance Traceability Matrix

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
4.3.2.1.E	Under range and over range conditions shall be indicated with a flag that is available to the application program.	Comply	700901-06 DS901-000-07 DS901-000-11	AI modules produce separate alarm codes for over range, under range, and cal error conditions. These alarm codes can be used to activate module alarms.
4.3.2.1.1	**Voltage Input Requirements**. Section Heading	Exception		Initial test specimen does not include any voltage-based AI or AO modules.
4.3.2.1.2	**Current Input Requirements**. Section Heading	N/A		No Requirements
4.3.2.1.2.A	Current input shall be 4 to 20 mA, 0 to 20 mA, 10 to 50 mA, or 0 to 50 mA	Comply	700901-06 MS901-000-02 DS901-000-07	Standard HFC AI modules are designed for 0 to 20 mA, the reported count values are based on 4 to 20 mA inputs.
4.3.2.1.2.B	Overall accuracy shall be ≤ ±0.35%, including drift and hystereses.	Comply	DS901-000-07	The module provides a 15-bit image and is calibrated to provide an accuracy of ±0.1% over full span.
4.3.2.1.2.C	Minimum resolution shall be 12 bits.	Comply	700901-06 DS901-000-07	AI boards all include a 16-bit ADC chip. The MSB is reserved for an error flag, and the remaining bits present the AI image data.
4.3.2.1.2.D	The common mode voltage capability shall be at least 10 volts.	Comply	DS901-000-07	Each channel can be configured with 24 vdc excitation voltage on a channel-by-channel basis. The resultant analog signal is scaled to a 0 to 10 v range at the ADC input.
4.3.2.1.2.E	Common mode rejection shall be at least 90 dB.	Exception	TS901-000-04	One of three channels tested failed to meet the 90 dB requirement; the remainder exceeded the requirement.
4.3.2.1.2.F	Overall response for AI modules shall support the response time requirement of Section 4.2.1.A.	Exception	TP0402 TS901-000-22 RR901-000-37	See RR901-000-37 for the operating envelop.
4.3.2.1.2.G	Group-to-group isolation shall be ±30 volts peak for 4- to 20 mA channels	Comply	TP0411 TS901-000-28	Each AI channel type was tested to this level or greater. Results presented in test report.
4.3.2.1.2.H	Module Isolation shall meet requirements of Section 4.6.4.	Comply	TP0411 TS901-000-28	Each AI channel type was tested to this level or to the limits of the test equipment. Detailed results presented in test report.
4.3.2.1.2.I	Surge withstand shall meet requirements of Section 4.6.2.	Comply	TP0406 TS901-000-25	Each AI channel type was tested to this level. Detailed results presented in test report.
4.3.2.1.2.J	Input impedance shall be at least 250 ohms maximum.	Comply	DS901-000-07 400434-01	The input signal for each channel is developed across a 249-ohm resistor.

ERD111 EPRI TR 107330 Requirement Compliance Traceability Matrix

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
4.3.2.1.3	**RTD Input Requirements**. Section Title	N/A		No Requirements
4.3.2.1.3.A	The input module shall be suitable for 2, 3, and 4 wire elements using both European and US standard 100 ohm RTDs.	Exception	DS901-000-11	Designed to accept 2 or 3 wire 100 ohm SAMA RTDs only.
4.3.2.1.3.B	The range shall be at least 0° to 800° C.	Exception	DS901-000-11	Calibration range is 0° to 700° C.
4.3.2.1.3.C	Overall accuracy shall be ±2° C or better.	Comply	DS901-000-11	Designed for overall accuracy of ±0.1% over full calibrated range, or ±0.7° C.
4.3.2.1.3.D	Minimum resolution shall be 0.1° or less for both be ° C and be ° F scales.	Comply	DS901-000-11	Module produces a 15-bit image over a 700° C span, so the minimum resolution is 0.02° C.
4.3.2.1.3.E	Common mode voltage capability shall be at least 10 vdc.	Comply	DS901-000-11 400443-01	ADC for this module designed to operate over an input range of 0 to 10 v.
4.3.2.1.3.F	Common mode rejection shall be at least 90 dB.	Exception		Not tested.
4.3.2.1.3.G	Overall response time shall support requirements of Section 4.2.1.	Exception	TP0402	RTD input board was not used as signal source for analog response time test.
4.3.2.1.3.H	Group to group isolation shall be at least ±30 volts peak.	Comply	TP0411 TS901-000-28	Tested to this level or greater. Result presented in test report.
4.3.2.1.3.I	Module isolation shall meet the requirements of Section 4.6.4.	Comply	TP0411 TS901-000-28	Tested to this level or to the limit of the test equipment. Results presented in test report.
4.3.2.1.3.J	Surge withstand shall meet requirements of Section 4.6.2.	Comply	TP0406 TS901-000-25	Tested to this level. Result presented in test result.
4.3.2.1.3.K	Input impedance shall be 1 megohm minimum.	Comply	400443-01	Each channel includes a 2.2 Megohm input resistor.
4.3.2.1.4	**Thermocouple Input Requirements**. Section Heading	N/A		No Requirements
4.3.2.1.4.A	TC input module shall be provided for types B, E, J, K, N, R, S, and T over specified input ranges.	Exception	DS901-000-10	Module withdrawn from consideration for qualification at the present time.
4.3.2.1.4.B	Overall accuracy shall be: B type ≤ ±2.5° C; E type ≤ ±3.0° C; J type ≤ ±3.5° C; K type ≤ ±4.0° C; N type ≤ ±2.0° C; R type ≤ ±2.5° C; S type ≤ ±2.5° C; T type ≤ ±2.5° C;			
4.3.2.1.4.C	Cold junction compensation shall support required accuracy			
4.3.2.1.4.D	Minimum resolution shall be 0.1° or less for both be ° C and be ° F scales.			
4.3.2.1.4.E	Common mode voltage capability shall be at least 10 vdc.			
4.3.2.1.4.F	Common mode rejection ratio shall be at least 90dB.			
4.3.2.1.4.G	The module shall provide open thermocouple detection.			

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
4.3.2.1.4.H	Overall response shall support requirements of Section 4.2.1.			
4.3.2.1.4.I	Group to group isolation shall be at least ±30 volts peak.			
4.3.2.1.4.J	Module isolation shall meet the requirements of Section 4.6.4.			
4.3.2.1.4.K	Surge withstand shall meet requirements of Section 4.6.2.			
4.3.2.1.4.L	Input impedance shall be 1 megohm minimum.			
4.3.2.2	**Discrete Input Requirements**. Each module shall provide a minimum of 8 channels with an ON/OFF status indicator for each.	Comply	700901-06 MS901-000-02	Current modules can process either 16 or 12 field input signals.
4.3.2.2.1	**Discrete AC Input Requirements**. Section Heading	Exception		Test Specimen does not include an ac input module at this time.
4.3.2.2.2	**Discrete DC Input Requirements**. Section Heading	N/A		No Requirements
4.3.2.2.2.A	Input module voltage levels shall be 1) 125 vdc, 2) 24 vdc, 3) 125 vdc, and 4) 12 vdc	Exception	700901-06 400454-01 MS901-000-02 RR901-000-37	Standard HFC-6000 DI modules are designed for a nominal excitation voltage of 48 vdc. They can respond to input voltages over a range of 20 to 52 vdc. Interface with signals outside this range can be accomplished with interposing relays. Refer to RR901-000-37 for the operating enveople.
4.3.2.2.2.B	Input transition to ON state shall occur at: 90 vdc max (125 vdc input); 20 vdc max (24 vdc input), 12 vdc max (15 vdc input); 10 vdc max (12 vdc input)	Comply	TP0402 TS901-000-22 and -29	Nominal excitation voltage is 48 vdc; guaranteed turn on voltage is 20 v at 25° C (42% of nominal excitation voltage).
4.3.2.2.2.C	Input transition to OFF state shall occur at: 65 to 25 vdc (125 vdc input); 15 to 6 vdc (24 vdc input), 9 to 4 vdc (15 vdc input); 7.5 to 3 vdc (12 vdc input)	Comply	TP0402 TS901-000-22 and -29	Operability test covered the range from 0 up to 53 vdc. Guaranteed turn off voltage is 12 v at 25° C (25% of nominal excitation voltage).
4.3.2.2.2.D	Must operate up to at least: 150 vdc min (125 vdc input); 40 vdc min (24 vdc input), 25 vdc min (15 vdc input); 10 vdc max (12 vdc input)	Comply	TP0402 TP0411 TS901-000-28	Calculated maximum voltage input is 53 vdc. Operability test covered the range from 0 up to 53 vdc. Isolation test applied 250 vdc to input channel for 30 sec.
4.3.2.2.2.E	Overall response time must support requirements of Section 4.2.1.	Comply	TP0402 TS901-000-22	Average input scan time is approximately 2 ms per module.
4.3.2.2.2.F	Group to group isolation shall be at least: 600 v peak (125 vdc input); 40 vdc peak (24, 15, 12 vdc input).	Comply	TP0411 TS901-000-28	Test to the required levels. Results recorded in test report.
4.3.2.2.2.G	Module isolation shall meet the requirements of Section 4.6.4.	Comply	TP0411 TS901-000-28	Tested at the specified level. Results covered in test report.

ERD111 EPRI TR 107330 Requirement Compliance Traceability Matrix

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
4.3.2.2.2.H	Surge withstand shall comply with Section 4.6.2.	Comply	TP0406 TS901-000-25	Tested at the specified level. Results covered in test report.
4.3.2.2.3	**TTL Input Requirements**. Section Heading	Exception		Test specimen does not include a TTL input module at this time.
4.3.2.3	**Pulse Input Requirements**. Section Heading	N/A		No Requirements
4.3.2.3.A	The module shall have at least two inputs	Comply	700901-06	Module provides four channels configured in groups of two.
4.3.2.3.B	The count frequency shall be at least 20 to 5000 Hz.	Comply	700901-06	Range is 50 Hz to 20 KHz for rate mode; accumulate mode range is 0 to 20 kHz. 10 kHz for 8 bit mode; 20 kHz for 12 bit mode
4.3.2.3.C	Input must operate for input pulse with a peak voltage of 3 to 28 vdc and a duty cycle of 20 µs to 90%.	Exception	TP0402 TS901-000-22 and –29 RR901-000-37	Actual input voltage limits never tested. Specified peak voltage range is 12 to 150 v; limit of signal generator during test was 32.2 vpp with duty cycle from 10% to 90%. Minimum pulse width tested was 5 µs. Refer to RR901-000-37 for the operating envelop.
4.3.2.3.D	Module shall have up and down count modes with a range of 9999. Accuracy shall be 0.1% over range of environmental conditions in Section 4.3.6 and over a time period of up to 30 months.	Exception	700901-06; TP0402 TS901-000-22 and –29	No count down mode. Maximum count is 24 bit binary number (16777215). Drift over time period not tested or measured.
4.3.2.3.E	Module shall have frequency range from at least 20 Hz to 5000 Hz. Accuracy shall be 0.1% over range of environmental conditions in Section 4.3.6 and over a time period of up to 30 months.	Comply	700901-06; TP0402 TS901-000-22 and –29	Pulse rate range for rate mode is 50 Hz to 20 KHz. Accuracy of the 8-bit rate mode is limited by its resolution at the low frequency end; the 12-bit mode is uniformly accurate within 0.1% based on full span.
4.3.2.3.F	Overall response time must support requirement of Section 4.2.1.	Exception		The pulse input board was not tested for response time characteristics.
4.3.2.3.G	Group to group isolation shall be at least 40 vdc.	Comply	TP0411 TS901-000-28	Tested to the required level. Results covered in test report.
4.3.2.3.H	Module isolation shall meet requirements of Section 4.6.4.	Comply	TP0411 TS901-000-28	Tested to the required level. Results covered in test report.
4.3.2.3.I	Surge withstand shall be as given in Section 4.6.2.	Comply	TP0406 TS901-000-25	Tested to the required level. Results covered in test report,
4.3.3	**Output Requirements**. Section Heading	N/A		No Requirements
4.3.3.1	**Analog Output Requirements**. AO channels shall be monotonic within ±1/2 LSB, and each AO module shall	Comply	400474-01	The selected DAC meets this requirement based on manufacturer's specifications.

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
	have at least four channels.			
4.3.3.1.1	**Voltage Output Requirements**.	Exception		Test specimen does not include a voltage-based AO module at this time.
4.3.3.1.2	**Current Output Requirements**. Section Heading	N/A		No Requirements
4.3.3.1.2.A	AO channel ranges shall be: 1) 4 to 20 mA or 4 to 20 mA; and 2) 10 to 50 mA or 0 to 50 mA.	Exception	700901-06	The test specimen AO channels are designed for 4 to 20 mA only.
4.3.3.1.2.B	AO channels shall provide an overall accuracy of ±0.32% accuracy.	Comply	700901-06	AO channels are designed for an overall accuracy of ±0.1%.
4.3.3.1.2.C	The minimum resolution shall be 12 bits.	Comply	700901-06 DS901-000-08	Resolution for AO channels is 12 bits.
4.3.3.1.2.D	The output signal will meet requirements for a load impedance of 1Kohm or less.	Exception		Not measured. Theoretical calculation indicates that the module should meet this requirement.
4.3.3.1.2.E	Overall response shall support requirements of Section 4.2.1.	Exception	TP0402 RR901-000-37	EPRI requirements for the analog response time test are based on performance of the AI module, not those of the AO module. No AO channel was included in this test. Refer to RR901-000-37 for the operating envelope.
4.3.3.1.2.F	Group to group, module to module, and module to backplane isolation shall meet requirements of Section 4.6.4.	Exception	TP0411 TS901-000-28	Tested to up to 250 vdc and 283 vac. Response covered in test results.
4.3.3.1.2.G	Surge withstand shall meet requirements of Section 4.6.2.	Comply	TP0406 TS901-000-25	Tested to this level. Response covered in test results.
4.3.3.2	**Discrete Output Requirements**. Section Heading	N/A		No requirements
4.3.3.2.A	Each module shall provide a minimum of 8 output channels.	Exception	700901-06 MS901-000-02	Relay modules have 8 DO channels; special function modules have 2 DO channel, 12 DI channels for field signals, and 4 DI channels for internal status..
4.3.3.2.B	Leakage in the off state shall be as specified in the following section or 80% of the minimum current needed to turn on any input module whose range includes the range of the output.	Comply	DS901-000-03 TP0402 TS901-000-22 and –29	Relay output channels are open; special function modules include circuitry to monitor continuity of the field relay. The magnitude of the leakage for these modules satisfies the second criterion.
4.3.3.2.C	Output channels must include circuit interrupter.	Comply	400459-01 400464-01 400469-01	DO channels do not include onboard line fuses. HFC control systems typically include fuse panels mounted inside the cabinet for this purpose.
4.3.3.2.D	Modules must provide onboard indicators to display	Comply	700901-06	Every DO channel and every DI channel

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
	ON/OFF status of each channel.		400459-01 400464-01 400469-01	to field equipment includes a status LED mounted on the front edge of the module and visible through the bezel.
4.3.3.2.1	**Solid State Discrete AC Output Requirements**. Section Heading	N/A		No Requirements
4.3.3.2.1.A	Output voltage ranges shall be 120 vac and 24 vac.	Comply	700901-06, 400464-01 TP0402	HFC-DC33 is designed to control two 120 vac ourput channels. The solid state relay is rated for 24 to 280 vac; the operability test measured characteristics over range of 90 to 130 vac.
4.3.3.2.1.B	Outputs must operate as specified with an output current between 50 mA and 0.5 A with an inrush capacity of at least 2 A.	Comply	700901-06 DS901-000-05 TP0402 TS901-000-22 and –29	Module exceeds requirements.
4.3.3.2.1.C	ON state voltage drop shall not exceed 2 vac at 0.5 A.	Comply	TP0402 TS901-000-22 and –29	Covered as part of operability test. Results covered in test report.
4.3.3.2.1.D	OFF state leakage shall not exceed 2 mA.	N/A	TP0402 TS901-000-22 and –29	The module is designed to use OFF state leakage for coil continuity monitoring. The magnitude of OFF state leakage meets limits of paragraph 4.3.3.2.B.
4.3.3.2.1.E	Outputs must operate with a 47 to 63 Hz source over a range of at least 90 to 130 vac (120 vac output) or 20 to 28 vac (24 vac output)	Comply	TP0402 TS901-000-22 and –29	Test for 120 vac output included as part of operability test. No 24 vac output channel included in test specimen.
4.3.3.2.1.F	Overall response must support requirements of Section 4.2.1.	Exception	TP0402	EPRI requirements for digital response time testing did not include this channel type.
4.3.3.2.1.G	Group to group isolation shall be at least 600 volts peak for 120 vac and 100 volts peak for 24 vac.	Exception	TP0411 TS901-000-28	120 vac DO channel tested to 250 vdc and 283 vac. Results covered in test report.
4.3.3.2.1.H	Module isolation shall meet requirements of Section 4.6.4.	Exception	TP0411 TS901-000-28	120 vac DO channel tested to 250 vdc and 283 vac. Results covered in test report.
4.3.3.2.1.I	Surge withstand requirements shall meet Section 4.6.2.	Comply	TP0406 TS901-000-25	120 vac DO channel tested to this level. Results covered in test report.
4.3.3.2.2	**Solid State Discrete DC Output Requirements**. Section Heading	N/A		No Requirements
4.3.3.2.2.A	Output voltage ranges shall be 125 vdc, 48 vdc, 24 vdc, 15 vdc, and 12 vdc.	Exception	DS901-000-06	HFC-DC34 is designed to control two 125 vdc (range of 90 to 140 vdc) output channels. The other voltage ranges are not included in the test specimen at the present time.

ERD111 EPRI TR 107330 Requirement Compliance Traceability Matrix

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
4.3.3.2.2.B	Outputs must operate as specified with an output current between 50 mA and 0.5 A with an inrush capacity of at least 2 A.	Comply	DS901-000-06 TP0402 TS901-000-22 and –29	Module exceeds requirements.
4.3.3.2.2.C	ON state voltage drop shall not exceed 2 vac at 0.5 A.	Comply	TP0402 TS901-000-22 and –29	Covered as part of operability test. Results covered in test report.
4.3.3.2.2.D	OFF state leakage shall not exceed 2 mA.	N/A	TP0402	The module is designed to use OFF state leakage to verify coil continuity. The magnitude of OFF state leakage satisfies limits of paragraph 4.3.3.2.B.
4.3.3.2.2.E	Outputs must operate with a power source over a range of at least 90 to 140 vdc (125 vac output); 35 to 60 vdc (48 vdc output); 20 to 28 vdc (24 vdc output); 12 to 18 vdc (15 cdc output); 10 to 14 vdc (12 vdc output)	Exception	TP0402 TS901-000-22 and –29	125 vdc DO channels meet requirement; other output voltage levels not included in test specimen at this time.
4.3.3.2.2.F	Overall response must support requirements of Section 4.2.1.	Exception	TP0402	EPRI requirements for digital response time testing did not include this channel type.
4.3.3.2.2.G	Group to group isolation shall be at least twice the nominal output.	Exception	TP0411 TS901-000-28	125 vdc DO channel tested to 250 vdc and 283 vac. Results covered in test report.
4.3.3.2.2.H	Module isolation shall meet requirements of Section 4.6.4.	Exception	TP0411 TS901-000-28	125 vdc DO channel subjected to maximum output voltage level that the test equipment could produce. The coil continuity circuit prevented the test equipment from reaching the specified voltage level before tripping.
4.3.3.2.2.I	Surge withstand requirements shall meet Section 4.6.2.	Comply	TP0406 TS901-000-25	125 vdc DO channel tested to this level. Results presented in test report.
4.3.3.2.3	**Relay Output Requirements**. Section Heading	N/A		No Requirements
4.3.3.2.3.A	Relay output channels shall provide both normally open and normally closed contacts.	Comply	700901-06	
4.3.3.2.3.B	Minimum contact rating shall be for 2 A continuous current with switching capacity of at least 750 VA (ac) or 150 watts (dc).	Comply	700901-06	Based on manufacturer specifications, module exceeds requirements. Tested up to 9 A.
4.3.3.2.3.C	Contact resistance shall not exceed 0.2 ohm.	Comply	TP0402 TS901-000-22 and –29	Relay rated for maximum contact rating of 0.1 ohm. Covered as part of Operability test. Results covered in test report. Result covered in test report.
4.3.3.2.3.D	Contact must operate from source up to 30 vdc or 150 vac.	Comply	TP0402 TS901-000-22 and –29	Relay rated for 48 vdc. Must operate at 75% of rated voltage.
4.3.3.2.3.E	Overall response must support requirements of Section	Comply	TP0402	Covered as part of operability response

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
	4.2.1.		TS901-000-22 and –29	time test. Result covered in test report.
4.3.3.2.3.F	Group to group isolation shall be at least 600 v peak.	Exception	TP0411 TS901-000-28	Module tested to 250 vdc and 283 vac. Result covered in test report.
4.3.3.2.3.G	Module isolation shall meet requirements of Section 4.6.4.	Exception	TP0411 TS901-000-28	Module tested to 250 vdc and 283 vac. Result covered in test report.
4.3.3.2.3.H	Surge withstand requirements shall meet Section 4.6.2.	Comply	TP0406 TS901-000-25	DO channel tested to this level. Result covered in test report.
4.3.3.2.4	**TTL Output Requirements**. Section Heading	Exception		Test specimen does not include a TTL input module at this time.
4.3.4	**Processor/Other System Component Requirements**. Section Heading	N/A		No Requirements
4.3.4.1	**Processor Loop Time Requirements**. Processor loop time shall support response time requirement of Section 4.2.1. Also the loop time shall be faster than the greater of the analog conversion time or of 2.5 times the analog input filter cutoff frequency.	Comply	RR901-000-37	For this system, this limitation applies to the scan cycle of the AI module, not the loop cycle of the main processor. The ADC conversion time is in the order of microseconds. The RC time constant for the input filter is on the order of 800 ms, so the microprocessor cycle time must be faster that 320 ms. The scan cycle time is on the order of 2 ms per scan.
4.3.4.2	**Memory Capacity and Data Retention Capacity Requirements**			
	Controller shall provide sufficient memory capacity to execute a single application with the indicated number of program elements.	Comply	400419-01 RS901-000-01, -02	8 Mbit flash memory provides ample capacity.
	Memory used for application program shall be capable of retaining information for a minimum of 6 months without power applied.	Comply	RS901-000-01, -02	Application program is contained in flash memory, which does not require power to retain information.
4.3.4.3	**Data Acquisition Requirements**. Controller shall be capable of transferring information between main processor and I/O modules in the same chassis or an extension chassis. Data transfer rates shall support requirements of Section 4.2.1.	Comply	DD0401 RS901-000-01 TP0402 RS901-000-01, -02	Controller can communicate with up to three expansion chassis.
4.3.4.3.A	Interfacing devices shall meet environmental requirements of Section 4.3.6. Failure of interconnecting devices shall not defeat ability to transfer information between main processor and expansion chassis.	Comply	TP0404 TS901-000-23	All such components included in environmental test. Refer to test report.
4.3.4.3.B	Failure of interconnect modules shall not defeat ability to transfer data between main processor and local I/O or	Comply	TP0403 TS901-000-22 and –29	Refer to report for serial communication failure tests.

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
	data capacity and data retention capability.			
4.3.4.3.C	Loss of power in interconnect modules shall not defeat capability to transfer power between main processor and local I/O.	N/A		ICL is connected directly from chassis to chassis unless fiber-optics is involved. The fiber-optics converter module is powered from the ICL cable, so it cannot loose power independently from the controller chassis.
4.3.4.3.D	Main chassis interconnect module shall meet requirements of Section 4.6.4 for Class 1E to Non Class 1E isolation.	Exception	TP0411	Class 1E isolation was restricted to electrical cables that extend outside of an equipment cabinet. Fiber optic cables connect the main processor to remote I/O in a different cabinet.
4.3.4.3.E	Surge withstand shall be as indicated in Section 4.6.2.	Comply	TP0406 TS901-000-25	Tested to the required level. Refer to test report.
4.3.4.3.F	Data acquisition time shall be deterministic or manufacturer shall provide information necessary to determine maximum possible acquisition time.	Comply	DS002-000-02 DS901-000-01, -02	Total data acquisition time is a combination of the acquisition time for an individual I/O module and the ICL scan rate of the main controller. Total transfer delay through the input filters vary, depending on module type. Refer to Topical Report Section 8.
4.3.4.3.G	Inter-processor data acquisition buses on backplane. Descriptive Information.	N/A		No Requirements
4.3.4.3.G.1	Buses shall be dual redundant at least.	N/A	RS901-000-01, -02	No buses used. All data transfer is accomplished by means of redundant serial communication links.
4.3.4.3.G.2	Loss of one buss shall not cause any processor to stall, result in an indeterminate state, or create conflicting fault indications.	Comply	TP0403 TS901-000-29 and –34	Test executed using the serial communication links.
4.3.4.3.G.3	Loss of all busses shall not result in indeterminate operation.	Comply	TP0403 TS901-000-29 and –34	Test executed using the serial communication links. Failure of ICL causes output modules to hold channels in last valid state.
4.3.4.3.G.4	Provide capability to generate alarm on loss of one or more buses.	Comply	TP0403 TS901-000-29 and –34	Link and station alarm status flags
4.3.4.3.G.5	Data acquisition time shall be deterministic.	Comply		Refer to Topical Report Section 8.
4.3.4.3.G.6	Operation of buses shall support response time requirement of Section 4.2.1.A.	Comply	TP0402 TS901-000-22, -29, -34	Refer to test report.
4.3.4.4	**Communication Port Requirements**. Main processor shall provide at least one communication port.	Comply	DD0401, RS901-000-01	Two serial ICL ports and two serial C-Link ports included on main controller.

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
			DS901-000-01	The HFC-FPC06 includes 6 serial ports.
4.3.4.4.A	Port shall support data rates up to at least 9600 baud.	Comply	DS002-000-01 DS002-000-02	C-Link operates at 10 MHz. ICL operates at 346 kb.
4.3.4.4.B	The ports shall support a widely used standard physical layer protocol.	Comply	DS002-000-01 DS002-000-02	C-Link based on IEEE 802.3. ICL based on RS-485.
4.3.4.4.C	The ports shall provide positive hold down connectors.	Comply	700709-00	Chassis assembly diagram. Each connector includes two jack screws.
4.3.4.4.D	Port to port isolation shall be at least ±300 volts peak for 30 seconds.	Comply	TP0411 TS91-000-28	Both the ICL and the C-Link are implemented with fiber optic cables for any segment that passes outside of the equipment cabinet. Fiber optics provide complete electrical isolation.
4.3.4.4.E	Port to processor isolation shall meet requirements of Section 4.6.4.	Exception	TP0411 TS91-000-28	ICL and C-Links have been eliminated from this test because they are implemented with fiber-optic cables outside of the equipment cabinet.
4.3.4.4.F	Surge withstand shall meet requirements of Section 4.6.2.	Exception	TP0406 TS91-000-25	ICL and C-Links have been eliminated from this test because they are implemented with fiber-optic cables outside of the equipment cabinet.
4.3.4.5	**Coprocessor Module Requirements**. Section Heading	N/A		Does not include any coprocessor.
4.3.4.6	**Chassis Requirements**. Section Heading	N/A		No Requirements
4.3.4.6.A	Suitable for installation in standard 19-in. equipment cabinets.	Comply	700709-00	Chassis assembly diagram
4.3.4.6.B	Provide positive hold down for modules.	Comply	700709-00	Every module is secured to the chassis by two thumbscrews through the bezel.
4.3.4.6.C	Provide adequate structural integrity to meet seismic requirements of Section 4.3.9.	Comply	TP0405	Verified by test. Refer to test report.
4.3.4.7	**Backup Devices/Redundancy Requirements**. Section Heading	N/A		No Requirements
4.3.4.7.A	Automatic transfer to a backup device shall occur within the greater of two main processor scan cycles or three conversion cycles of the main processor.	Exception	RS901-000-01 TS901-000-42 TR901-000-02	Failover of the main processor can take up to 2 seconds. A scheduled hardware modification will reduce this period to approximately 0.5 second.
4.3.4.7.B	Features or procedures shall be provided to assure that undetected failures are detected during periodic surveillance testing.	Comply	RR901-000-01	FMEA is designed to identify any failure condition that might not be detectable. Run time bit errors will cause the software stop working and cause the PLC to halt. Failover will then occur and such failure will be shown to operators to take

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
				remedial actions.
4.3.4.7.C	Diagnostics shall not result in repetitive failover between redundant modules.	Comply	DS001-000-08 RR901-000-01	As a minimum, failover following loss of sanity requires manual reset for the failed chassis to recover.
4.3.4.7.D	Mechanism for transferring between redundant modules:	N/A		No Requirements
4.3.4.7.D.1	Analog I/O modules	N/A		Redundant I/O modules not used.
4.3.4.7.D.2	Discrete I/O modules	N/A		Redundant I/O modules not used.
4.3.4.7.D.3	Pulse input modules	N/A		Redundant I/O modules not used.
4.3.4.7.D.4	Failover between redundant main processors shall be bumpless and result in an alarm.	Comply	DS001-000-08 TP0402 TS901-000-22, -29, -34	Failover responses included in operability test. Refer to test report.
4.3.4.7.D.5	Transfer between redundant power supplies	Comply	400409-01	Test specimen redundant power supplies are connected in parallel with diode auctioneering so both are on line.
4.3.5	**Programming Terminal Requirements**. If a special programming terminal is required, its software shall meet requirements of Section 4.4.4, 7.5.2, and 7.7.2.	Comply	UG004-000-01 UG004-000-04	All programming is accomplished on an offline PC. See entries for Sections 4.4.4, 7.5.2, and 7.7.2. Programs are transferred to the controller either by installation of a PROM or by transfer to flash memory via the HFC-FPC06.
4.3.6	**Environmental Requirements**. Section Heading	N/A		No Requirements
4.3.6.1	**Normal Environmental Basic Requirements**. Ranges for normal environmental conditions: Temperature: 16° to 40° C (60° to 104° F) Humidity: 40 to 95% noncondensing Power source range per Section 4.6.1.1 A and B Radiation Exposure: Up to 103 RADS	Comply	RS901-000-01 TP0404 TS901-000-23 RR901-000-36	HFC-6000 exceeds specified environmental requirements for temperature and humidity. Refer to Section 4.6.1.1 for power source compliance. Refer to RR901-000-36 for the justification of the 1k RADS compliance.
4.3.6.2	**Abnormal Environmental Basic Requirements**. Ranges for normal environmental conditions: Temperature: 4° to 50° C (40° to 120° F) Humidity: 10 to 95% noncondensing Power source range per Section 4.6.1.1 A and B Radiation Exposure: Up to 103 RADS	Comply	RS901-000-01 TP0404 TS901-000-23 RR901-000-36	HFC-6000 operation tested under the environmental extremes: 40° to 140° F, 5 to 90% RH, noncondensing, per Table 4-4 of the EPRI specification. Refer to Section 4.6.1.1 for power source compliance. Refer to RR901-000-36 for the justification of the 1k RADS compliance.
4.3.6.3	**Environmental Withstand Specific Requirements**. The test specimen shall be subjected to the temperature profile shown in Figure 4-4 and tested in accordance with	Comply	TP0404 TS901-000-23 RR901-000-36	The test was conducted in accordance with the specified temperature and humidity profile.

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
	Section 5.3. Evaluations for paragraphs 4.3.6.1 and 4.3.6.2 provide adequate confidence for radiation harness.			Refer to RR901-000-36 for the justification of the 1k RADS compliance.
4.3.7	**EMI/RFI Withstand Requirements**. The test specimen shall withstand EMI/RFI levels defined by specified sections of EPRI TR-102323.	Exception	TP0407 TS901-000-25 RR901-000-37	Test levels were conducted as specified. Two modules exhibited a considerable range of susceptibility and were dropped from the test specimen. Refer to Test Report. Refer to RR901-000-37 for the operating envelop.
4.3.8	**Electrostatic Discharge (ESD) withstand Requirements**. Test specimen shall withstand ESD levels as defined by EPRI TR-102323, Appendix B Section 3.5.	Comply	TP0409 TS901-000-25	Test levels were conducted as specified. No susceptibilities were exhibited. Refer to test report.
4.3.9	**Seismic Withstand Requirements**. Test specimen shall be subjected to the Required Response Spectrum shown in Figure 4-5. Relay output modules shall not chatter.	Exception	TP0405 TS901-000-35	Test range up to the limits of the seismic simulation table (10 g max). Some mechanical damage did occur during test, but that damage did not disrupt operation. Refer to test report.
4.4	**Software/Firmware**. Section Heading	N/A		No Requirements
4.4.1	**Executive**. Section Heading	N/A		No Requirements
4.4.1.1	**Background**. Descriptive Information	N/A		No Requirements
4.4.1.2	**Main Processor Executive Capability Requirements**. Main processor shall: A. Acquire inputs from modules. B. Implement the application in a continuous loop. C. Load outputs to modules. D. Perform powerup and runtime diagnostics per Section 4.4.6. E. Manage communications functions. F. Provide features to permit uploading application program while in program mode. G. Provide features to support online diagnostics per Section 4.4.6 and troubleshooting per Section 4.7. H. Provide at least the minimum set of application program functions per Section 4.4.3. I. Perform powerup initialization functions required for graceful startup. J. For systems with redundant I/O, the I/O section shall be transparent to the application program.	Comply	RS901-000-01	Controller functions divided between three different microprocessors mounted on a single assembly. Each microprocessor is dedicated for a specific range of functions. Redundant I/O is not an inherent feature of the HFC-6000 architecture, but it can be implemented as part of a particular application.
4.4.1.3	**Program Flow Control Requirements**. PLCs that	Comply	RS901-000-01	Separate microprocessors control I/O

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
	perform I/O scan and execute the application in parallel shall assure that both input scan and execution of the application are completed each cycle.			scan and execution of the application asynchronously. The maximum number of stations on the ICL is 53, and that determines the maximum amount of time required for each scan cycle. The size of the application determines the amount of time required for each execution cycle. Both are expected to run approximately 10 times per second as a minimum.
	Use of interrupts shall be restricted to prevent non deterministic operation of the application program.	Comply		Interrupts for the main processor are restricted to a 10 ms clock tick.
	Requirements for PLCs that use non deterministic operation of the application program.	N/A		Not used.
4.4.1.4	**Unintended/Unused Function Isolation Requirements**. Descriptive Information	N/A		No Requirements
4.4.1.5	**Coprocessor Executive Capability**.	N/A		HFC-6000 does not use any coprocessor. Subordinate processors on the controller and I/O boards are not user programmable.
4.4.2	**Media Requirements**. Software media used for shipping and storing software shall be high quality and new. CD ROMs or 3.3-in. floppy disks are acceptable. Packaging shall prevent damage in transit. The media shall be clearly labeled with the contents of the media, including revision level and serial numbers.	Comply	UG004-000-05	Workstation software is normally supplied to the customer on CD ROM. Control system software and application programs are normally installed in PROM at HFC prior to shipment.
4.4.3	**Ladder Requirements**. Descriptive Information	N/A		Application is not implemented with ladder logic. The source code is either a sequential text file that can be commented or a logic diagram that can be converted into object code by a software tool. (See Section 4.4.8.)
4.4.3.A	Normally open/normally closed elements	Comply	UG004-000-01	Implemented as logic states of simple Boolean data points.
4.4.3.B	Single-shot for transition on or transition off functions.	Comply	UG004-000-01	Implemented with set/reset memory logic points.
4.4.3.C	Ability to simulate make before break and break before make contact actions.	Comply	UG004-000-01	Implemented with Boolean logic functions and set/reset memory logic.
4.4.3.D	Simulate standard coil that causes paths associated with it to change from normal to alternate state when energized.	Comply	UG004-000-01	Implemented with Boolean logic functions.

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
4.4.3.E	Simulate latching coil that causes paths associated with it to change from normal to alternate state when coil is energized and to remain in that state until coil is de-energized and reset signal is applied.	Comply	UG004-000-01	Implemented with Boolean logic functions and set/reset memory logic.
4.4.3.F	Timers that can be adjusted from 0.1 second to 2 hours with a timing accuracy of 0.1% or better.	Exception	UG004-000-01	TI points provides minimum preset and exceeds the maximum preset value. The timer function can be configured with a time base of 1 sec, 1 min, or 1 hr. The maximum possible deviation for each time base is: • 0.1 sec – 1 sec time base • 6 sec – 1 min time base • 6 min – 1 hr time base Overall accuracy will depend on the selected time base and the timer preset value. Averaged timing accuracy meets ± 0.1 %
4.4.3.G	Count up and count down functions with a range from 1 up to at least 9999.	Comply	UG004-000-01	Up/down counter value is as a two-byte integer (0 to 65535).
4.4.3.H	Comparison function between two numeric values.	Comply	UG004-000-01 DS004-000-03	Implemented both for floating-point and integer comparisons. May be used to control conditional Boolean operations or alarm status.
4.4.3.I	Basic math functions (+, - , *, ÷) shall be provided for both floating-point and integer values.	Comply	UG004-000-01 DS004-000-03	Implemented with ADD, DIV, MUL, SUB, and CAL block algorithms; also may be implemented directly without using block algorithms.
4.4.3.J	Advanced math functions (exp, square root, log) shall be provided.	Comply	UG004-000-01 DS004-000-03	Implemented with CAL, CHP, DIV, PLY, or SQR block algorithm.
4.4.3.K	PID algorithm shall provide the following capabilities: • Proportional band in range of 5% to 500% with minimum 1% resolution. • Integral action in range of 0 to 100 repeats per minute with a minimum resolution of 1 repeat per second. • Anti-reset windup • Rate action in range of 0 to 100 minutes with minimum resolution of 1 second. • Output limiting • Out of range status indications • Internal exception monitoring	Comply	UG004-000-01 DS004-000-03 700907-01	Implemented with PID block algorithm. Capabilities of algorithm exceed stated requirements. Minimum resolution determined by block execution frequency parameter. Maximum execution frequency is once every execution cycle of the application (typically 10 times per second or more). Can be configured with either a hardware or a software M/A station for operator

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
	• Mechanism for external manual control with bumpless *transfer between manual and auto.* • PLC shall include the minimum number of analog loops indicated in Section 4.3.4.2.I.			control. Bumpless transfer between manual and auto modes supported.
4.4.3.L	Lead/lag algorithm with the following minimum characteristics: • Lead lag ratio range of 0 to 10 with minimum resolution of 0.05. • Lag time with minimum range of 0.01 to 100 minutes and minimum resolution of 1 second. • Lead action filter.	Comply	UG004-000-01 DS004-000-03	LLG algorithm provides an increment mode to limit the magnitude of change per processing cycle. The algorithm does not itself include any other kind of integral lead action filter, but additional filtering can be provided by other blocks external to the LLG.
4.4.3.M	The capability to limit values	Comply	UG004-000-01 DS004-000-03	Most block types include either real or virtual clamps, particularly AIC, ANO LLG, and PID.
4.4.3.N	Function generator with a minimum of five slopes.	Comply	UG004-000-01 DS004-000-03	Implemented with CHR (up to 7 coordinate pairs), CHP (parabolic), PLY (eighth-degree linear polynomial), or CAL (8 element calculation). More complex functions can be created by cascading blocks.
4.4.3.O	PLC shall include functions necessary to support communication requirements of Section 4.9.1.	Comply	DS002-000-01 DS002-000-02	Implemented by subordinate processors independent of the application program.
4.4.3.P	PLC shall include functions necessary for application to capture results of self-tests. (Refer to Section 4.4.6)	Comply	UG004-000-01	Self-tests and diagnostics are run by the operating system software, but specific status flag points are reserved for system status. These status points are accessible to the application for display and alarm generation.
4.4.3.Q	Functions necessary to implement sequence of events	Exception	DS901-000-01 DS901-000-04	Hardware support for SOE is built into HFC-DI161 and HFC-SBC06, but software support is not available at this time.
4.4.3.R	Bit manipulation functions of AND, OR, and XOR shall be provided.	Comply	UG004-000-01	Implemented directly as Boolean AND and OR functions. XOR can be implemented in logic.
4.4.3.S	Ability to store results of calculations of at least 10 instances of at least 50 values in a ring buffer for transfer over a serial port.	Comply	DS002-000-02	Not provided as a utility of the application program. The hardware interface for the C-Link includes a separate ring buffer for transmit and receive packets. Each packet contains 256 bytes, and the number of packets in

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
				the buffer is programmable within the CPC processor software. A separate ring buffer can also be implemented as part of an application program.
4.4.3.T	PLC shall include functions to implement database requirements per Section 4.4.7.2.	Comply	UG004-000-01	Refer to comments for Section 4.4.7.2.
4.4.3.U	PLC application software and programming utilities shall permit insertion of explanatory comments. (Refer to Section 4.4.4.)	Comply	UG004-000-01 UG004-000-04	Application code is generated directly from the logic diagrams by a software tool. The graphic representation of the logic serves the function of program comments. If the application is generated by manual editing, comments can be inserted into the source code and compiled into object code.
4.4.4	Software Tools Requirements. Tool shall be provided for programming, debugging, and documentation of application code.	Comply	UG004-000-01 UG004-000-04	The EWS workstation software and the One-Step software provide the standard tools for this purpose. However, these tools are used offline and are not part of the safety system envelope. Qualification of any safety system application program will be accomplished by comprehensive t code review and testing.
4.4.4.A	Ability to use host device to enter a program into the PLC.	Comply	UG004-000-01 UG004-000-04	In programming mode, the application can be transferred to the remote via the HFC-FPC06 module. The normal method for program installation is mounting a PROM or flash on the module.
4.4.4.A.1	Ability to attach explanatory comments to the program steps.	Comply	UG004-000-01 UG004-000-04	Functional representation of the application is provided directly by logic diagrams; comments may be inserted into the source code text file manually with the Equation Editor utility of the EWS.
4.4.4.A.2	Ability to store the program on removable magnetic media or some other type of offline storage device.	Comply	UG004-000-01 UG004-000-04	The primary source of the application is a logic diagram, which exists as an electronic file. The processed code also exists as a source code text file and as an object code (binary) file. All of these formats can be transferred to floppy disk or CD.
4.4.4.A.3	Ability to perform bit-by-bit comparison between	Comply	UG004-000-01	Equation editor can compare the CRC of

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
	program in the PLC and a program contained in the programming device.			the object file in the PLC with the CRC of the source file in the EWS PC. The controller also validates the PROM CRC as part of its powerup initialization.
4.4.4.A.4	Ability to print program that is contained in PLC and in programming device in a fashion similar to the appearance of the program steps in the programming device. Programming device shall provide the ability to print programming values that do not appear on the screen.	Comply	UG004-000-01	Equation editor displays application code text file whose statements are in the same sequence as the object code in the controller. When operating on line, the point values can be displayed in real time. Configuration values for blocks can be displayed in popup windows.
4.4.4.A.5	Features to aid in I/O mapping and memory management	Comply	UG004-000-01	Application program includes I/O configuration table, which provides the software I/O assignments for the system.
4.4.4.A.6	Provide a method to prevent modification of the application program or the operating system while the PLC is online performing its safety function.	Comply	UG004-000-01 UG004-000-05 DS901-000-01	The system software is not accessible to the user under any conditions. Normal installation is accomplished by mounting a PROM on the controller. Download to flash requires modification of FPC06 configuration, setting both a toggle switch and a DIP switch, and then cycling power to the controller. Unauthorized access to the download function can also be blocked by password protection.
4.4.4.B	Debugging aids	N/A		No Requirements
4.4.4.B.1	Ability to highlight all discrete elements that are not in their normal mode.	Comply	UG004-000-01	Equation editor provides monitor mode that highlights all TRUE logic points.
4.4.4.B.2	Ability to display values of all inputs, outputs, and intermediate points.	Comply	UG004-000-01	Equation editor monitor mode for analog blocks displays their numeric value.
4.4.4.B.3	Ability to set constants and variables	Comply	UG004-000-01	Database editor can be used to change the value of all data points. Numeric constants cannot be changed without modifying the application unless they are represented by a data point.
4.4.4.B.4	Ability to force outputs	Comply	UG004-000-01	Equation editor can stop execution of the application, and the database editor can then force outputs to any desired state. Blocks can be put into manual mode, and their value can then be controlled directly.

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
4.4.4.B.5	Ability to single step through the program.	Exception		Single-step execution of the application program is not supported.
4.4.4.B.6	Ability to view the status of any memory location where error codes and other status information is stored.	Comply	UG004-000-01	Memory editor enables read access to any memory address in the controller. Database editor enables user to read the status of any point defined for a controller. Block edit windows enable direct examination of the quality word for every analog block configured in an application.
4.4.4.C	Application configuration management requirements of Section 7.7.3 shall be applied to the software tools.	Comply		See table for Section 7.7.3.
4.4.4.D	The tools shall meet support requirements of Sections 4.4.5.2 and 4.4.7.2.	Comply		See table for Sections 4.4.5.2 and 4.4.7.2.
4.4.4.E	Software V&V shall be applied to the tools in accordance with requirements of Section 7.4.	Exception		All of the software tools except One-Step are legacy components, and none of them are being presented as safety related. The One-Step program was developed under a V&V program for a nuclear control system supplied to a plant in Korea, but it is used on a strictly offline basis and is not presented as a safety-related utility.
4.4.4.F	The tools shall provide features to aid in detecting any faults not detectable by the self-diagnostics.	Comply	UG004-000-01 UG004-000-04	Application compiler generates error messages to indicate programming errors.
4.4.5	**Configuration Identification**. Section Heading	N/A		No Requirements
4.4.5.1	**Configuration Identification Background**. Descriptive Information	N/A		No Requirements
4.4.5.2	**Configuration Management Aids Requirements**. Descriptive Information	N/A		No Requirements
4.4.5.2.A	An electronic revision level embedded in the PLC executive.	Comply	UG004-000-04	The header for both the system software and the application code provides the build/compilation date and revision information. This data can be read with the PROM programmer offline or the memory editor online.
4.4.5.2.B	Configuration data for configurable modules shall be retrievable in the field.	Comply	UG004-000-01	Configuration and PID tuning parameters can be displayed on the Equation editor. With proper access authorization, the values can be revised to support system tuning. Hardware M/A stations can also be used to modify tuning parameters.

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
				However, no permanent change can be made to any tuning parameter without changing the onboard PROM/flash code.
4.4.5.2.C	Any software tool capable of altering a configuration item shall have positive mechanisms to prevent unauthorized access.	Comply	UG004-000-01 UG004-000-05	1) Access authorization utility 2) FPC06 configuration 3) User login 4) Switch settings on the controller.
4.4.5.2.D	PLC or support tools shall provide capability to extract and record any database information contained in the application.	Comply	UG004-000-01	With proper access authority, EWS utilities provide the mechanism for updating both the application and the mass database.
4.4.5.2.E	Any device in a PLC assembly or any external device that contains firmware or other programmed information shall be marked with an identifier that includes the revision level of the information programmed into it.	Comply	Work instruction WI-ENG-006	HFC-6000 assemblies include PROMs, flash memory, and CPLDs. 1) PROMs are marked with part No. and checksum value. 2) The contents of the application flash can be verified from the EWS workstation. 3) Programmed CPLDs are labeled with part number. 4) CPLD configuration control maintained by HFC procedures
4.4.5.2.F	Tools provide the capability to confirm that the configuration of hardware, software, and firmware is consistent between redundant devices.	Comply	UG004-000-01 DS001-000-01	Memory editor permits reading program headers in the primary controller; failover permits access to second controller. Application equalization occurs automatically following powerup. Equalization can be initiated manually from EWS.
4.4.6	**Diagnostic Requirements**. Section Heading	N/A		No Requirements
4.4.6.1	**General Diagnostic Requirements**. The PLC must provide sufficient diagnostics and test capability to permit detection of any failure that could prevent the system from performing its safety function. Items 4.4.6.1.1 through 4.4.6.1.6 must be covered by online self tests. Item 4.4.6.1.7 must be covered by powerup or online self tests.	Comply Comply Comply		Refer to Sections 4.4.6.1.1 through 4.4.6.1.14.

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
	Item 4.4.6.1.8 must be covered by powerup self tests. The remaining items are covered by maintenance and operator surveillance (Section 4.7). If any diagnostics uses short term changes in outputs to detect failures, the change shall be 2 ms or less for dc outputs and ½ cycle or less for ac outputs	Exception Comply N/A		Hardware watchdog timers cannot be tested by powerup test; software watchdogs (mailboxes) require runtime *environment to operate.* Method not used.
4.4.6.1.1	**Processor Stall**. Watchdog function shall detect processor stall.	Comply	DS901-000-01 DS901-000-02	During initialization: Stall at this time prevents the processor from beginning its normal run time loop. Stall of the main processor or either subordinate processor on the controller during run time will result in failover. Processor stall for an I/O module will cause that module to stop operation. Either condition will set a status flag that can trigger an alarm at the operator station.
4.4.6.1.2	**Executive Program Error**. Check of executive program using checksum or equivalent test.	Comply.	DS901-000-01 DS901-000-02	Checksum validation for the system software is one of the initialization tests for each processor in the system. Failure prevents operation from beginning. Checksum validation of the system program is not repeated during run time.
4.4.6.1.3	**Application Program Error**. Check of application program using checksum or equivalent test.	Comply	DS001-000-02	Checksum validation for application program is one of the initialization tests for the main processor. Failure prevents operation from beginning. Checksum validation is repeated during each execution cycle of equation interpreter.
4.4.6.1.4	**Variable Memory Error**. Read/write test of specific bit patterns to test both states of each bit or equivalent test.	Comply	DS901-000-01 DS901-000-02	RAM read/write test is one of the initialization tests for all processors in the system. Failure prevents operation from beginning. I/O modules perform a limited RAM read/write test during run time. Failure sets a fault flag in memory, and that fault will be reported during the next I/O scan.
4.4.6.1.5	**Module Communication Error**. Processor monitors	Comply	DS002-000-01	All serial data communications are

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
	communication data integrity.		DS002-000-02	validated by CRC. On detection of a CRC error, the processor rejects the data and increments an error counter. Error *counters are accessible so that the* operator can monitor communication quality.
4.4.6.1.6	**Memory Battery Low**.	N/A		Controller has flash memory rather than battery-backed RAM.
4.4.6.1.7	**Module Loss of Configuration**. Validate configuration of module with software set configuration, and set indication if not valid.	Comply	DS001-000-01	Main processor configures the mailbox for each subordinate processor during powerup initialization and verifies their operation before enabling runtime operation to begin.
4.4.6.1.8	**Failure of Watchdog Mechanism**. Surveillance of watchdog and failover function.	Comply	DS001-000-01 DS901-000-01	Maintenance failover is available as a mechanism as a surveillance procedure to verify normal operation of the secondary controller and the watchdog circuits. (Refer to Section 4.2.3.7.)
4.4.6.1.9	**Application Not Executing**. Application program fails to complete a processing cycle.	Comply	DS901-000-01 DS001-000-02 UG004-000-01 UG004-000-08	Equation cycle counter stops incrementing, and all point values remain static. Watchdog timer triggers failover and alarm following processor stall.
4.4.6.1.10	**Analog Output not Following**. AO signal fails to follow commanded output signal.	Comply	UG004-000-08	Regular surveillance program to monitor calibration of AO channels. Closed loop configuration can detect loss of process control and trigger alarm (application specific).
4.4.6.1.11	**Analog Input not Responding**. AI channel fails to respond to input signal.	Comply	DS901-000-07, -11 UG004-000-08	Run time auto cal routine monitors analog circuit for loss of calibration. (See Section 4.4.6.1.13.) Module generates alarm for calibration error during runtime. Regular surveillance program to monitor calibration of each AI channel.
4.4.6.1.12	**Discrete I/O not Responding**. Discrete I/O channel fails to respond to operate correctly.	Comply	UG004-000-08	Regular surveillance program to monitor operation of each discrete I/O channel. Closed loop configuration can detect failure of process to respond within

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
				predetermined interval and trigger alarm (application specific).
4.4.6.1.13	**Analog I/O Out of Calibration**. Analog I/O channel out of calibration.	Comply	UG004-000-08 DS901-000-07, -11	Each AI module performs a calibration check at powerup and at regular intervals during runtime. Loss of calibration sets a failure flag and disables further operation. Regular surveillance program to monitor calibration of each AO channel. Closed loop configuration can detect loss of effective process control and trigger alarm (application specific).
4.4.6.1.14	**Power Supply Out of Tolerance**. Power supply fails or produces an incorrect output voltage.	Comply	UG004-000-08	Regular surveillance program to verify and adjust power supply output voltage levels. Redundant power rails are diode auctioneered and regulated on each module (standard configuration). Failure of power module triggers alarm (part of typical application)
4.4.6.2	**OnLine Self Test Requirements**. As a minimum, online self test for the main processor shall cover Sections 4.4.6.1.1 through 4.4.6.1.6. The results of the self test shall be made available to the application unless the fault causes the processor to halt.	Comply	DS901-000-01 DS901-000-02 DS001-000-01 DS001-000-02 DS002-000-01 DS002-000-02	Complete RAM read/write test is run during initialization. Controllers and I/O modules use a limited area of RAM to validate memory integrity during run time operation. Safeguard against processor stall is provided by watchdog and sanity monitoring. Communication integrity is indicated by error counter status.
4.4.6.3	**Powerup Diagnostics Requirements**. As a minimum, powerup diagnostics shall include: A. All of the online self tests B. Configuration verification for modules with software set configurations. C. Test of failure to complete scan detection feature.	Exception	DS901-000-02 DS001-000-01 DS001-000-02	Test of CRC validation function for serial data communication is not possible at powerup. Test of hardware and software watchdogs is not possible at powerup.

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
	(Refer to Section 4.2.3.7.)			Failure to complete scan is covered by mailbox monitoring function, and this requires the run-time environment.
4.4.7	**Data and Database**. Section Heading	N/A		No Requirements
4.4.7.1	**Data and Database Overflow**. Descriptive Information	N/A		No Requirements
4.4.7.2	**Data and Database Requirements**. Refer to Sections 4.4.4 and 4.4.5.2.	N/A		Refer to Sections 4.4.4 and 4.4.5.2.
4.4.7.2.A	Support user-defined program constants that are contained in non-volatile memory. Redundant systems shall provide a mechanism to confirm that the constants are the same for both processors.	Comply	DS901-000-01 UG004-000-01	Controller software is installed in PROM and runs from flash memory. The memory editor utility of the EWS enables user to read the program headers. The equation editor enables user to verify program constants. Application equalization occurs automatically at powerup, and the equation editor can be used to initiate equalization from primary to secondary following software update.
4.4.7.2.B	PLC shall provide function to read and modify constants in the application program.	Comply	DS901-000-01 UG004-000-01	Equation editor permits user to read configuration parameters for the application. User can modify the configuration parameters and download these values without altering the application code, but such changes do not become permanent without revising the PROM code.
4.4.7.2.C	PLC shall provide features to prevent modifications to configuration constants over peer-to-peer communication paths.	Comply	DS901-000-01 UG004-000-01 UG004-000-05	The application and all configuration constants are contained in flash memory. This segment of memory cannot be altered by peer-to-peer communication. The contents of this flash memory can be altered only if the flash memory write function is enabled. Memory equalization is required following download to ensure that both controllers contain the same data. Permanent changes can be implemented only by changing the PROM code.

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
				The HFC-FPC06 will provide the interface for making such modifications, and password protection can be used to prevent unauthorized changes.
4.4.7.2.D	PLC shall provide features to enable transmitting inputs, outputs, and calculated values to other devices via serial port.	Comply	DS901-000-01 UG004-000-01 DS002-000-01	C-Link provides redundant hardware media for transmitting data between different controllers in a system. RQ table determines specific mapping of data from an external controller to the data points in local memory.
4.4.8	**Other Non-Ladder Logic Programming Language**. Section Heading	N/A		No Requirements
4.4.8.1	**Requirements for Sequential Logic Languages**. Sequential language may be used for the application program instead of ladder logic. Sequential language shall provide the minimum capabilities of Section 4.4.3 and be supported by tools as described in Section 4.4.4.	Comply	UG004-000-01 UG004-000-04	HFC uses logic diagrams as source for applications, and a software tool converts the logic diagrams into both a text file and object code. The text file consists of sequential program statements that can be edited manually. Refer to Sections 4.4.3 and 4.4.4.
4.4.8.2	**Standard High Level Languages**. Section Heading	N/A		No Requirements
4.4.8.2.1	**Overview of Standard High Level Languages**. Descriptive Information	N/A		No Requirements
4.4.8.2.2	**Requirements for Standard High Level Languages**	N/A		HFC-6000 does not use a standard high-level language for its application.
4.4.9	**Sequence of Events Processing Requirements**	N/A		SOE is not implemented at this time.
4.4.10	**System Integration Requirements**. An appropriate level of integration and integration testing shall be applied to the test speciment and TSAP.	Comply	TN0401, ATP0402, TP0401, TP0408B, TP0410 TS901-000-30 TS901-000-22 TS901-000-34	Integration and pretest program was conducted in accordance with Section 5.2.
4.5	**Human/Machine Interface (HMI)**. Section Heading	N/A		No Requirements
4.5.1	**HMI Background**. Descriptive Information	N/A		No Requirements
4.5.2	**Requirements for HMI Functions**. Section Heading	N/A		No Requirements
4.5.2.A	Provides method for switching control mode between manual and auto modes. (Refer to Section 4.4.3.K.)	Comply	UG004-000-02 700907-01	CSM provides from 1 to 4 switch inputs to application program, which determines the function controlled by that switch.

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
				M/A station provides HMI for analog control functions. Interactive graphic controls on the HFC-FPD06 can be configured, but these soft controls are not currently expected to be used as the HMI for safety-related functions.
4.5.2.B	Methods and features will be provided to permit adjustment of setpoint values via HMI.	Comply	UG004-000-01 UG004-000-08	M/A station and equation editor of the EWS provide a mechanism for adjusting setpoints and other configuration parameters.
4.5.2.C	PLC shall permit manual initiation and detection of manual initiation of equipment that is normally automatically initiated.	Comply	UG004-000-01 UG004-000-02 700907-01	Application logic can sense manual override status; PC workstation can be configured to display override status and generate appropriate alarms. (Application specific)
4.5.2.D	PLC must provide features for displaying status of discrete elements and analog values via any of the specified output modules specified in Sections 4.3.3.1 and 4.3.3.2.	Comply	700907-01 UG004-000-10 UG004-000-02 UG004-000-08	DO channels can be used to drive both individual indicators and CSM displays. AO channels can be used to drive analog meters. Analog values and digital status for analog processes can also be displayed by the M/A stations. The status of both digital and analog points can be displayed on the workstation.
4.5.2.E	The PLC shall support transfer of data via a serial port iaw Sections 4.3.4.4 and 4.9.1.1. Available information shall be inputs, outputs, calculated values, SOE data, and data from ring buffer. (Refer to Sections 4.4.9 and 4.4.3.S.)	Comply	DS901-000-04 DS002-000-01	C-Link and RQ table provide the mechanism for data transfer between separate controllers. HFC-6000 does not support SOE at this time. The ring buffer is part of the CPC processor section of the controller. Hardware support for the SOE function is part of an I/O module, not the controller.
4.5.3	**Requirements for Interactive Features**. The PLC shall provide interactive features to support programming and maintenance. The PLC shall provide mechanism to prevent unauthorized access to interactive features and to prevent inadvertent change of internal parameters.	Comply Comply	UG004-000-01 UG004-000-02 UG004-000-05 UG004-000-04 UG004-000-08	EWS workstation provides primary utilities for programming, maintenance and troubleshooting. Workstation log-in utilities provide mechanism to prevent unauthorized access to maintenance and programming utilities.

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
				Security configuration utility provides mechanism for limiting access for changing system configuration parameters. Onboard switches on the controller prevent inadvertent alteration of either application program code or configuration parameters.
4.5.4	**Requirements for Operator Action System Response Times**. If an operator action requires confirmation from the PLC, the PLC shall supply that confirmation within 0.5 second.	N/A	UG004-000-02	Handshaking between the operator console and the remote is not required. Activation of displays to indicate selection of a target is handled by the workstation PC, not the controller.
4.5.5	**Display Requirements**. Any status displays included with PLC shall be easily readable in normal to low room lighting within a ±30° angle.	Comply		Status LEDs are visible through cutouts in the front edge bezel. The flat panel display is designed for mounting on the control panel or operator console and provides ample luminous flux. Detailed display characteristics are application specific.
4.5.6	**Alarm Processing Requirements**. Descriptive Information	N/A		No Requirements
4.5.6.A	Ability to compare input or derived value to setpoints (equivalent to Section 4.4.3.H).	Comply	UG004-000-01 700907-01	Implemented by DLA, DHA, and other blocks that support alarm processing. Current value of inputs and alarm status can be monitored with the equation editor.
4.5.6.B	Ability to latch alarm condition and reset it based on an alarm reset condition (equivalent to Section 4.4.3.E).	Comply	UG004-000-01 UG004-000-02 700907-01	System-level alarms are built in to the operating system. Functional alarms are implemented with Boolean logic on an application specific basis. Alarm process utility latches configured alarms until acknowledged.
4.5.6.C	Ability to produce a flashing display indication (equivalent to 4.4.3.B and F).	Comply	UG004-000-01 700907-01	Inherent capability built into logic point quality words; can also be implemented with individual logic points and timers.
4.5.6.D	Capability to acknowledge an alarm (equivalent to Section 4.4.3.A, D, and E).	Comply	UG004-000-02 700907-01	Capability built in to the alarm process utility. This utility deletes acknowledged

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
				alarms from the alarm display when the alarm state ceases to exist.
4.5.6.E	Capability for the application program to access the results of self diagnostics.	Comply	UG004-000-01 UG004-000-02	Specific logic points are reserved for system status. The logic state of these points can be used to control system alarms and status displays.
4.5.6.F	Capability of the application program to store the results of alarm processing in a ring buffer for transmission over via a serial port (equivalent to Section 4.4.3.S).	Comply	DS002-000-01	The ring buffer is part of the CPC processor section, not part of the application program. Alarm status is processed and transmitted over the C-Link like any other status data generated by the controller.
4.5.7	**Hard Manual Backup**. Descriptive Information	N/A		No Requirements
4.6	**Electrical**. Section Heading	N/A		No Requirements
4.6.1	**Power Supply Requirements**. Section Heading	N/A		No Requirements
4.6.1.1	**PLC Power Sources and Power Supply Requirements**. Section Heading	N/A		No Requirements
4.6.1.A	Power supplies for an ac power source shall operate over the following ranges of supply characteristics: • 90 to 150 vac • 57 to 63 Hz • Environmental conditions specified by Section 4.3.6.	Comply	RS901-000-01, -02 TP0402, TP0403 TS901-000-22, -29, -34	Tested for these ranges. See RR901-000-37 for performance envelope.
4.6.1.B	Power supplies for a dc power source	N/A		Test specimen does not include provision for a dc power source at the present time.
4.6.1.C	Power supplies for a dc power source	N/A		Test specimen does not include provision for a dc power source at the present time.
4.6.1.D	Power supplies shall be capable of supplying 1.2 times bus loading for controller chassis.	Comply	700916-01	The main controller had redundant power modules for +24 and +48 vdc, and each was designed for 600 w. With all slots of the main controller filled, the total load was 324 w for the 24 vdc power supply and 81.6 w for the 48 vdc power supply. Each individual module provided well over the 20% excess capacity. The power supply for the SLC was rated for 400 w, and the unit drew approximately 84 w. Power supply requirements are applica-

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
				tion specific.
4.6.1.E	Power supplies shall be capable of supplying 1.2 times bus loading for expansion chassis.	Comply	700916-01	Same as 4.6.1.D for the main remote.
4.6.1.F	Holdup time shall be 40 ms on loss of ac power source when chassis loading is as described above.	Exception	TP0402 TS901-000-22, -29, -34	Tested to this requirement. The power supplies used did not consistently meet this requirement, so a replacement module is being procured.
4.6.1.G	The power supply shall meet EMI/RFI, surge withstand, and ESD requirements of sections 4.3.7, 4.6.2, and 4.3.8.	Exception	TP0406, TP0407, TP0409 TS901-000-25	Tested to these levels. Refer to test reports.
4.6.1.H	For power supplies with fan cooling, a fan failure detection or over temperature status alarm shall be provided.	Exception		Power modules did not include such an alarm. However, no temperature related power fault occurred during environmental stress testing.
4.6.1.I	If redundant power supplies are provided, power faults for one supply shall not affect the other.	Comply	TP0402 TS901-000-22, -29, -34	Redundant power rails are diode auctioneered on each module to enable completely independent operation of the two supplies.
4.6.1.2	**Loop Power Supply Requirements**. The PLC manufacturer shall provide power supply modules for external transmitters and other devices. These power supplies shall provide at least 500 mA at 24 vdc and meet items A, B, C, G, and H above.	Exception	TP0406, TP0407, TP0409 TS901-000-25	The HFC-6000 system includes redundant 48-vdc power supplies for excitation power. Each module is rated for 600 w and tested to the required level.
4.6.2	**Surge Withstand Capability Requirements**. The PLC shall withstand surges of both ring wave and combination wave with 3000-v peak voltage. The waveform shall be applied to power sources, I/O interfaces, and communication port interfaces per IEEE C62.41.	Comply	TP0406 TS901-000-25	Tested to the indicated level. Several hardware failures were experienced during surge testing, but no component failure affected overall operation of controller.
4.6.3	**Separation**. Descriptive Information	N/A		No Requirements
4.6.4	**1E/non-1E Isolation Requirement**. PLC modules shall provide isolation of at least 600 vac and 250 vac applied for 30 seconds.	Exception	TP0411 TS901-000-28	Each channel type was subjected to 250 vdc and 283 vac. Several of the channel types experienced destructive failure, and several module types exhibited temporary disruption of channels within the same group. However, in no case was the entire module affected, or was the overall operation of the controller disrupted.
4.6.5	**Cabling/Wiring Requirements**. Manufacturer shall supply cabling and wiring used for connecting to terminations. Cable shall be suitable for UL class 2	Comply	700915-00	Cabling/interconnect diagram. All wire insulation is tefzel; no PVC is

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
	service, withstand levels shall be for 3 times the signal levels of 150 v, and temperature rating shall be 60° C or greater. The manufacturer shall identify quantity of PVC used.			included.
4.6.6	**Termination Requirements**. Method of connection to field terminations shall permit swapping of PLC modules without disturbing field cables. Field terminations and communication modules shall be qualified with generic PLC.	Comply	700915-00 700907-01, -02	For the test specimen, the I/O cables extend to terminal connections of the HPAT or a terminal panel.
4.6.7	**Backup Power**.	N/A		Not included in test specimen
4.6.8	**Grounding/Shielding Requirements**. Grounding and shielding shall conform with guidelines of IEEE 1050 and EPRI TR-102323. PLC chassis and power supply shall have grounding connection points.	Comply	700715-00 700716-01 700716-02	
4.7	**Maintenance**. Section Heading	N/A		No Requirements
4.7.1	**Maintenance Background**. Descriptive Information			No Requirements
4.7.2	**Diagnosis/Built-in Testability Requirements**. Descriptive Information	N/A		No Requirements
4.7.3	**Module Replacement Requirements**. PLC shall provide features to aid in module replacement. Maintenance manual shall describe any module configuration required. Method for securing module to assembly shall be easily accessible and permit easy removal and reinstallation.	Comply	 UG004-000-08	Most modules are directly accessible from the front of the chassis. C-Link and ICL fiber-optic modules mount on standoffs. Maintenance manual describes jumper/switch functions. Switch configurations required for ICL communication defined on logic and wiring diagrams. Most modules secured to chassis by thumb screws through front bezel.
4.7.4	**Preventive Maintenance Requirements**. Manuals shall provide information required for preventive maintenance.	Comply	UG004-000-08	Preventive maintenance schedule provided.
4.7.5	**Surveillance Testing Requirements**. PLC shall support IEEE 338 surveillance testing through: • Ability to read inputs, intermediate, and output values. • Ability to force output values. • Ability to make connections to all I/O signals. • Ability to program I/O operations.	Comply	UG004-000-01 UG004-000-08 RR901-000-01	EWS provides utilities for reading/forcing values of internal variables within the application. All I/O channels are accessible at the field connection point (terminals or patch panel). LEDs provide visual indication of operation for redundant modules.

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
	For PLCs that include redundancy, features and procedures shall be provided to detect failures that could be masked by redundancy.			Scheduled surveillance procedures verify operation.
4.7.6	**Output Bypass/Control Devices**.	N/A		No Requirements
4.7.7	**"Hot" Repair Capability**. PLC shall support removal and replacement of modules except for main controller with power applied to the backplane. When output module is removed from backplane, the state of the output channels should be known and repeatable.	Comply N/A	 DS001-000-02 DS002-000-02	All modules have shortened connector pins for the +24 and +48 power lines, so any module can be removed and replaced with power on the backplane. Secondary controller module can be powered down and replaced without affecting operation of the primary controller. The image of all output channels resides in the controller. When an output module is removed, all of its channels are opened. When the output module is replaced, the controller supplies the current image for all channels after the output module completes its internal initialization.
4.7.8	**Manufacturer System Life Cycle Maintenance**. Section Heading	N/A		No Requirements
4.7.8.1	**Parts Replacement Life Cycle Requirements**. Manufacturer shall establish baseline configuration of the qualified PLC hardware and software. Maintain records of revision history, failures, and changes. Identify and accomplish any testing needed to maintain a qualified PLC due to revision or replacement of modules.	Comply	VV0414 WI-ENG-100 WI-ENG-003 QPP 16.1	Internal procedures mandate an NQA-1 program for all product development.
4.7.8.2	**Component Aging Analysis**. Perform an aging analysis based on normal and abnormal environmental conditions per Section 4.3.6. An acceptable alternative is based on in-service surveillance and type testing in accordance with IEEE 323-1983.	Exception	RR901-000-04	Final aging analysis to be conducted for each specific application and its configuration.
4.7.9	**Maintenance Human Factors**. Section Heading	N/A		No Requirements
4.7.9.A	The manufacturer shall provide unambiguous documentation and job aids for any equipment supplied	Comply	UG004-000-01 UG004-000-02	The EWS, JCRT, and HIFR are standard software packages typically used with

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
	to support the PLC platform.		UG004-000-07	HFC control systems. The JCRT and HIFR will be replaced for the HFC-6000 with comparable utilities.
4.7.9.B	Test equipment connections to the PLC shall be supported by appropriate equipment, manuals, and special test leads.	Comply	UG004-000-08	Maintenance manual provides all required precautions and instructions. No special test leads or equipment are needed for normal maintenance.
4.7.9.C	Job aids, keyed connectors, warning signs shall be provided.	Comply	UG004-000-08	Warning labels on the equipment and keyed connectors are included in the system design. Maintenance manual provides warning summary page to present all major precautions in a single location.
4.7.9.D	Help screens shall be provided for software used to support maintenance.	Exception	UG004-000-01 UG004-000-02 UG004-000-05	At the present time no help screens are available. However, the manual set can be supplied on CD ROM and therefore can be accessible at the maintenance workstation.
4.8	Requirements for Third Party/Sub-Vendor Items. All third party items used with the PLC shall be subjected to all of the requirements and tests that are applicable to that item's function and design. The hardware and software compatibility of these items shall be subjected to suitable tests and analysis.	Comply	TP0401 through TP0411	All vendor items were subjected to the same tests as the remainder of the control system. The FPC assembly had the Windows NT control system installed, but this software will not be used for the final system. The M/A stations were qualified for a previous nuclear project.
4.9	**Other**. Section Heading	N./A		No Requirements
4.9.1	**Data Handling and Communication Interfacing Overview**. Descriptive Information	N/A		No Requirements
4.9.1.1	**Peripheral Communication Requirements**. The PLC executive shall prevent loss of serial communication from degrading the application program.	Comply	RS901-000-01	ICL is controlled by a subordinate processor that has no access to the application program.
	The communication protocol shall assure deterministic overhead time or permit easy determination of the upper bound on the scan time interval.	Comply	DS002-000-02	ICL has a fixed response period for each station and no retry. If any station fails to respond, the processor continues with the next station in sequence.
	Peripheral communication shall support a buffer of the size specified in Section 4.3.4.2.K.	Comply	DS002-000-02	ICL processor has direct access to the entire public memory, which encom-

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
				passes the complete database for the remote.
	All serial communication shall include data quality checks at least as robust as checksum.	Comply	DS002-000-02	ICL uses CRC-16 validation.
	For redundant PLCs, the peripheral communication shall use data that is validated between redundant processor. The redundancy shall be transparent to the communication path, the PLC, and peripheral communication program	N/A	MS901-000-01 DS901-000-01 DS002-000-02	The architecture uses primary and secondary controllers. The secondary ICL is used only if the primary communication to a particular station fails.
4.9.1.1.1	**Software Isolation Requirements**. Descriptive Information	N/A		No Requirements
4.9.1.1.1.A	Serial communication shall require no hardware or software handshaking.	Comply	DS002-000-01 DS002-000-02	C-Link communication is based on broadcast transmissions only. ICL communication is based on POLL-RESPONSE exchanges with no hand-shaking.
4.9.1.1.1.B	Features shall permit application to ignore any incoming data on the port.	Comply	DS901-000-01 DS002-000-01 DS002-000-02	Application software is run by the main processor; the serial links are run by subordinate processors. The subordinate processors have no access to the application, and the application has no interaction with the serial data streams.
4.9.1.1.1.C	Application object shall permit use of the send data function with the receive data function effectively disabled.	N/A	DS901-000-01 DS001-000-02	Operation of the application program is completely independent of the serial communication function.
4.9.1.1.1.D	The application program shall be capable of disable interrupts based on receive buffer full status.	N/A	DS901-000-01 DS001-000-02	Operation of the application program is completely independent of the serial communication function.
4.9.1.2	**PLC Peer-to-Peer Communication Requirements**. Peer-to-peer communication shall be accomplished over a dedicated link. If the PLC includes redundancy, this link shall also be redundant.	Comply	DD0401 RS901-000-01 DS901-000-01 DS002-000-01	Peer-to-peer communication is provided by redundant C-link
	Communication on this link shall be deterministic.	Comply	DS002-000-01	C-Link control is based on a state machine with 5 defined states. Each state has a programmed period and a fixed number of possible transitions.
	No communication error on this link shall stop the application program from functioning or inhibit the PLC scan cycle.	Comply	DS002-000-01 DS901-000-01	C-Link is controlled by a subordinate processor whose operation is completely independent from the ICL and the

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
				operation of the application program. However, timeout of this subordinate processor will trigger failover.
	The response time requirement shall be met with any latency time needed to provide synchronization.	N/A	700907-01, -02	The peer-to-peer link is not used for safety-critical data transfer.
	Data quality check shall be at least as robust as checksum.		DS002-000-01	C-Link uses CRC-32.
	Program shall detect loss of peer-to-peer communication and make that status available to the application.		UG004-000-01	Online status of external remotes is available to the application program by means of the RR point type. Loss of C-Link is indicated by link error counters and alarm flags.
4.9.2	**Overall System Security Requirements**. Switching the main controller from RUN mode to any other mode shall be by keylock switch.	Exception	UG004-000-08	Mode selection is controlled by a DIP switch on the front edge of the controller. If operating mode is changed, the controller must be reset before that change takes effect. Normally, the equipment cabinets include a key lock to prevent unauthorized access to the interior.
	PLCs having redundancy shall include features to aid in assuring that the mode of the processors is the same.	Comply	UG004-000-08	Visual inspection of the DIP switches on the front edge of the controller permits immediate verification of mode selection.
	System security should include provide to prevent modification of either the application or the operating system while online performing its safety function.	Comply	UG004-000-01 UG004-000-08	Normal provisions are key lock on the equipment cabinet, switch selection to enable programming mode, and password access to the EWS workstation.
	Redundant systems shall include features to ensure that program changes are loaded into all redundant processors.	Comply	UG004-000-01	Equalize utility enables transfer of program code from primary to secondary.
4.9.3	**Heartbeat Requirement**. PLC shall include capability to activate a heartbeat indication that is external to the controller. This requirement does not apply to redundant PLCs.	Comply	700907-01 UG004-000-01	Implemented as 1-sec flasher signal that can be connected to an LED or displayed on the JCRT graphic.
4.9.4	**Hazardous Materials Requirements**. Material Safety Datasheets shall be provided for any hazardous materials included with the PLC.	N/A		No hazardous materials are included in the system design.
4.10	**Shipping and Handling Requirements**. Packaging and	Comply	UG004-000-07	

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
	shipping shall conform with requirements of ANSI N45.2.2.		QPP13.1	
4.10.1	**Packaging Requirements**. Section Heading	N/A		No Requirements
4.10.2	**Shipping Requirements**. Section Heading	N/A		No Requirements
4.10.2.A	Shall be shipped in a sealed container designed to prevent deterioration of PLC components during shipment.	Comply	QPP13.1	
4.10.2.B	Packaging shall include desiccant material when required iaw ANSI N45.2.2.	Comply	QPP13.1	
4.10.2.C	Items shall be inspected for cleanness prior to packaging and cleaned as required.	Comply	QPP13.1	
4.10.2.D	Appropriate cushioning material shall be used as required.	Comply	QPP13.1	
4.10.3	Storage Requirements. Manufacturer shall provide storage requirements and shelf life limits for all devices required for qualification.	Comply	UG004-000-07 UG004-000-08	Parts list manual for individual projects typically lists the replacement schedule for nuclear projects.
5	**Acceptance Operability Testing**. Descriptive Information	N/A		No Requirements
5.1	**Acceptance Operability Testing Overview**. The development design, and performance of the acceptance test program shall use the documentation defined by Section 8.14.	Comply		Refer to entries for Section 8.14.
5.2	**Pre-Qualification Acceptance Test Requirements**. Descriptive Information	N/A		No Requirements
5.2.A	**Application Objects Testing**. Testing of the software objects in the PLC library. This testing shall be in addition to any testing conducted by the manufacturer.	Comply	ATP0402	Testing covered block algorithms and Boolean primitive functions.
5.2.B	**Initial PLC Calibration**. Test specimen modules shall be calibrated to NIST traceable sources.	Comply	VV0414 Project quality records	Calibration records for the initial configuration of the test specimen were incomplete. All of the analog cards were recalibrated prior to repetition of the seismic test.
5.2.C	**System Integration**. System setup and checkout and TSAP validation should be accomplished in conjunction with acceptance testing.	Comply	TP0401 TP0408 TP901-000-30 TP901-000-34	Hardware validation, power distribution, functional validation, and TSAP verification accomplished at this time.
5.2.D	**Operability Tests**. Initial execution of operability tests accomplished as part of acceptance testing.	Comply	TP0402 TP901-000-22	
5.2.E	Prudency Tests. Initial execution of produency tests accomplished as part of acceptance testing.	Comply	TP0403 TP901-000-22	
5.2.F	**Burn-in Test**. Minimum 352-hour burnin test to be	Comply	TP0410	Burnin test was accomplished prior to

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
	performed to eliminate any early life failures. Acceptance criteria are that test specimen pass operability after completion of burnin.		TP901-000-30	system integration.
5.3	**Operability Test Requirement**. Descriptive Information	N/A		No Requirements
5.3.A	**Accuracy**. This test will verify that analog I/O modules meet the accuracy and linearity requirements.	Comply	TP0402 TP901-000-22, -29, -34	
5.3.B	**Response Time**. This test will measure the response time for discrete and analog inputs from the leading edge of the input to the leading edge of the resulting output.	Comply	TP0402 TP901-000-22, -29, -34	
5.3.C	**Discrete Input Operability**. This test will verify the capability of discrete input channels to respond to simulated input signals.	Comply	TP0402 TP901-000-22, -29, -34	
5.3.D	**Discrete Output Operability**. This test will verify the capability of discrete output channels to produce output signals having specified voltages and currents.	Comply	TP0402 TP901-000-22, -29, -34	
5.3.E	**Communication Operability**. This test will verify reliable data transfer over the ICL, C-Link, and serial interfaces with CSMs and M/A stations. An acceptance criterion is that the bit rates, signal levels, and pulse shapes be within the specifications for the protocol used.	Exception	TP0402 TP901-000-22, -29, -34	Bit rates, signal levels, and pulse shape cannot be monitored directly in the HFC-6000. In order to meet the intent of the standard, the test will monitor communication error counters. An acceptance criterion is that communication continues in the presence of line noise without error.
5.3.F	**Coprocessor Operability**.	N/A		No coprocessor in the HFC-6000.
5.3.G	**Timer Tests**. This test will verify the accuracy of the timer function accessible to the TSAP.	Comply	TP0402 TP901-000-22	Timer performance was in accordance with theoretical accuracy limits.
5.3.H	**Test of Failure to Complete Scan**. Not applicable.	N/A		For HFC-6000 this test duplicates function of the failover operability test.
5.3.I	**Failover Operability**. This test will demonstrate correct operation of the failover function.	Comply	TP0402 TP901-000-22	
5.3.J	**Loss of Power Test**. This test will demonstrate correct response of all I/O channels to loss of source power followed by reapplication of power to the system.	Comply	TP0402 TP901-000-22	
5.3.K	**Power Interruption Test**. This test will demonstrate the capability of the power modules to sustain system operation during a temporary (transient) power interruption.	Exception	TP0402 TP901-000-22, -29, -34	The test procedure required shutdown of one power supply. When the test was run under this condition, the remaining power supply could not consistently hold up the voltage level for 40 ms. HFC is planning to replace the power supply modules with

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
				units that will provide the 40-ms holdup time.
5.4	**Prudency Test Requirements**. Descriptive information	N/A		No Requirements
5.4.A	**Burst of Events Test**. This test will consist of the simultaneous activation of a significant proportion of input and output channels.	Exception	TP0403	The specific combination of channels specified in Section 5.4.A was not available in the test specimen. An equivalent level of activity was established to meet the intent of the test.
5.4.B	**Failure of Serial Port Receiver Test**. The Test Specimen has two redundant serial communication links. For each redundant link, this test will impose three simulated failures on one cable at a time: link open, transmit line shorted to ground, and transmit line shorted to receive line.	Comply	TP0403 TP901-000-22, -29, -34	
5.4.C	**Serial Port Noise Test**. This test will introduce a white noise signal on each of the serial links one port at a time.	Exception	TP0403 TP901-000-29, -34	The test was run with a 100 kHz modulated sawtooth waveform, because a white noise generator having the specified range could not be located.
5.4.D	**Fault Simulation Test**. This test covers introduction of a simulated failure condition to trigger failover from the primary to the secondary controller.	Exception	TP0403	The intent of this test was covered by the failover operability test, so this test was not performed.
5.5	**Operability/Prudency Testing Applicability Requirements**. Specified portions of the operability and prudency tests are to be repeated before, during and after specific qualification tests.	Comply	TN0401, TP0402, TP0403, TP0404, TP0405, TP0407, TP0409	
5.6	**Application Software Objects Acceptance Testing**. Descriptive Information	N/A		No Requirements
5.6.1	**Failure Detection**. Refer to Sections 4.2.3.6.B items 2 and 3.	N/A		Functions external to the application program.
5.6.2	**Ladder Logic**. Refer to Section 4.4.3.	Comply	ATP0402	Refer to Section 4.4.3 for specific implementations.
5.6.3	**Software Tools**. Refer to Section 4.4.4	N/A		Functions external to the application program.
5.6.4	**Configuration Management Aids**. Section 4.4.5.2	N/A		Functions external to the application program.
5.6.5	**Sequence of Events Processing**	N/a		Function not implemented in the present version of the system.
5.6.7	**Alarm Processing**. Refer to Section 4.5.6.	Comply	ATP0402	Refer to Section 4.4.5.2 for specific implementations.
5.6.8	**Software Isolation**. Refer to Section 4.9.1.1.1.	N/A		Functions external to the application

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
				program.
5.6.9	**Peer-to-Peer Communications**. Refer to Section 4.9.1.2.	N/A		Functions external to the application program.
6.0	**Qualification Testing and Analysis**. Section Heading	N/A		No Requirements
6.1	**Qualification Process Overview**. Descriptive Information	N/A		No Requirements
6.1.1	**PLC System Qualification Overview**. Descriptive Information	N/A		No Requirements
6.2	**PLC System Test Configuration**. Requirements. Descriptive Information	N/A		No Requirements
6.2.1.	**Test Specimen Hardware Configuration Requirements**. Descriptive Information	N/A		No Requirements
6.2.1.A	Includes at least one of each module of each type to be qualified. (Refer to Sections 4.3, 4.4, 4.5, 4.9.)	Comply	700907-01,-02	HFC-AC36 and –AI8L dropped from consideration due to excessive number of failures during test.
6.2.1.B	Includes any additional modules that are needed to support operability testing.	Comply	700910-01 700912-01	Includes fiber-optic interface, power supplies, and interconnect cables. Automated tester and workstations are external to the test specimen.
6.2.1.C	At least one of each ancillary device needed to meet requirements of Section 4.3.	N/A		No external ancillary devices used as part of the qualification test specimen.
6.2.1.D	At least one of each chassis needed to meet requirements of 4.2.1.	Comply	700910-01 700912-01	Controller chassis, expansion chassis, single loop chassis, power supply rack, FPD.
6.2.1.E	Power supplies to meet requirements of Section 4.6.1 loaded to their power rating.	Comply	700715-01 700716-01	Test specimen was configured with every spare slot loaded throughout the qualification tests.
6.2.1.F	If necessary, dummy modules shall be used so that at least one chassis is fully loaded.	N/A		Test specimen was configured with every spare slot loaded throughout the qualification tests.
6.2.1.G	At least one of each type of termination device used to meet requirements of Section 4.6.6.	N/A		No external termination devices other than simple terminal strips were used. The terminals were not included as part of the qualification test specimen.
6.2.1.H	Any modules required to implement redundancy to be included in the qualification envelope.	Comply	700909-01 700910-01 700912-01	Redundant controllers, communication links, and power supplies
6.2.1.I	Any additional modules required to support operability and prudency testing or to support module variations.	Comply	700907-02	No additional modules were required for operability and prudency; the single loop configuration of the controller was an

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
				alternate implementation.
6.2.1.1	**Test Specimen Hardware Arrangement Requirements**. Section Heading	N/A		No Requirements
6.2.1.1.A	For seismic testing, modules and their cables shall be arranged to maximize stress on chassis and its mounting hardware.	Comply	700912-01	All spare slots were filled, so no dummy weights were required.
6.2.1.1.B	For environmental testing, modules shall be arranged to maximize temperature rise across chassis.	Comply	700912-01	Four controller racks configured in stack arrangement above power rack; single loop rack configured in a closed box.
6.2.2	**TSAP Configuration Requirements**. TSAP shall be developed iaw applicable sections of 7 and 8.6.	Comply	700901-09 ADS0401 700907-01,-02	
6.2.2.A	If providing serial output data is to be included in the qualification envelop, then a serial output sequence shall be included.	Comply	700915-00	The C-Link and ICL functions are both external to the application program. The I/O configuration and RQ tables are generated as part of the TSAP.
6.2.2.B	Suggested programming sequence for operability and prudency support.	N/A		No Requirements
6.2.2.B.1	The lead/lag function may be used to simulate a simple analog process.	Comply	700908-01	Implemented for three simulated closed loop processes.
6.2.2.B.2	Mapping of a set of discrete inputs to aid in linearity testing.	Comply	700907-01 700908-01 TP0402	Analog linearity testing implemented with step algorithm and soft control.
6.2.2.B.3	Initiating a timer on a discrete input and loading a discrete output on time out.	N/A	700907-01 TP0402	Timer test implemented as a standing square wave to display both timeon and timeoff delay periods. One second and five second timers were used to accommodate brief duration of seismic test runs.
6.2.2.B.4	If serial output is required to support requirements of Section 5.3.E, the TSAP shall include bit pattern.	N/A		C-Link and ICL functions are external to the application program.
6.2.2.B.5	Discrete round-robin sequence of DI and DO channels to facilitate response time testing.	Comply	700907-01 TP0402	Implemented with seven DI-DO channel pairs with soft enable/disable control.
6.2.2.B.6	Include a serial output message triggered by discrete input to facilitate analog output linearity testing.	Comply	700907-01 700908-01 TP0402	Analog linearity testing implemented with step algorithm and soft control rather than with a bit pattern.
6.2.2.B.7	One-second timer that triggers a discrete output on each time out.	Comply	700907-01 TP0402	Used for timer accuracy test as well as heartbeat.
6.2.2.B.8	Function that drives four analog output channels from 10% to 90% of full scale on 1 second period.	Exception	700907-01 700908-01	Algorithm implemented in the automated tester as part of the burst of events

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
			TP0403	algorithm. The dwell time was increased to 10 seconds at the two levels to accommodate the response characteristics of the AI module.
6.2.2.C	A program sequence to change state of an output once each processing cycle.	Comply	700907-01 TP0402	Round-robin sequence of discrete response time test produces a change of state every 7 processing cycles. Cycle counter increments during each processing cycle. Heartbeat signal changes state once per second.
6.2.2.D	Any application functions required to support redundancy and failover functions	N/A		Redundancy and failover functions are external and transparent to the application program.
6.2.2.1	**Coprocessor TSAP Requirements**	N/A		No Coprocessor
6.2.3	**Test Support Equipment Requirements**. Descriptive Information	N/A		No Requirements
6.2.3.A	Panel or other device for connecting inputs and outputs, for stimulating inputs, and for monitoring outputs/	Comply	700907-01,-02 700908-01 700915-00	HPAT provides terminals on front edge bezels. Test specimen includes terminal strips for local connections.
6.2.3.B	Test and measuring equipment with accuracy needed to support acceptance criteria.	Comply	TP0401 thru TP0410	See lists of required M&TE in test procedures.
6.2.3.C	Any special tools and devices needed to support testing	Comply	700909-01	HPAT, SOE, HAS, JCRT, EWS software
6.2.3.D	All test equipment shall be controlled per IEEE 498	Exception	QAPM QPP 12.1	Under the HFC QA program, all test equipment is controlled in accordance with requirements of NQA-1. HFC uses qualified vendors for all calibration activities.
6.3	**Qualification Test and Analysis Requirements**. Descriptive Information	N/A		No Requirements
6.3.1	Aging Requirements. The test specimen shall be exposed to five different aging factors with the environmental stress test performed first. No specific order is imposed for the other tests.	Comply	TN0401, TP0404 thru TP0411	Planned test program
6.3.2	**EMI/RFI Test Requirements**. Testing shall be conducted iaw Section 4.3.7. Testing shall be conducted at 25%, 50%, 75%, and 100% of the specified levels. For redundant components, only the selected value from among the selected redundant signals must meet acceptance criteria.	Comply	TP0407 TS901-000-25	The thermocouple module and FOT exhibited susceptibility at certain frequencies. The thermocouple module will be withdrawn from consideration for approval, and the FOT will require installation inside of a cabinet to prevent

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
				direct exposure to an EMI source.
6.3.3	**Environmental Test Requirements**. Test will be conducted iaw Section 4.3.6. Tolerance margins for the environmental test shall be ±2.8° C and ±5% RH. Power sources shall be set to values to maximize heat dissipation in test specimen; ½ of relay outputs shall be energized and loaded to their rated value; analog outputs shall be set between ½ and 2/3 of full scale.	Exception	TP0404 TS901-000-23 RR901-000-37	Planned environmental profile followed requirements. The facility power source tripped when set to low voltage/frequency configuration. Hardware configuration and available power supplies were not adequate to load ½ of all relay outputs to 5 A throughout the environmental test period. Refer to RR901-000-37 for the information.
6.3.3.1	**Environmental Test Mounting Requirements**. The test specimen shall be mounted in the environmental chamber on a simple structure that does not enclose the chassis. The environmental air shall be monitored at the power supply fan inlet.	Comply	TP0404	The test specimen was mounted in an equipment rack with front door, rear door, and one side panel removed. The single loop rack was mounted in a standard wall-mounted equipment box with door closed to maximize heat buildup. The mounting framework supplied by Wyle was not available at the time this test was performed. The temperature monitor was positioned as stipulated on the main cabinet.
6.3.4	**Seismic Test Requirements**. The test specimen shall be subjected to 5 OBEs and one SSE iaw the spectrum shown in Figure 4-5.	Exception	TP0405 TS901-000-35	All requirements were followed, except the SSE spectrum exceeded the maximum capability of the seismic simulation table. The SSE was run up to the limit of the test equipment.
6.3.4.1	**Seismic Test Mounting Requirements**. Test specimen shall be mounted iaw with mounting requirements on a structure having no resonances below 100 Hz.	Comply	TP0405 700912-01	Mounting frame fabricated by Wyle personnel; other mounting requirements were as stipulated on HFC installation drawings.
6.3.4.2	**Seismic Test Measurement Requirements**. Relay contact monitor shall be used to detect contact chatter. Half of the relays shall be energized and half deenergized on a given module. The test specimen shall be energized with TASP running and ½ of solid state outputs energized. Power source shall be at lower end of specified range.	Comply	TP0405 TS901-000-35 51378-1Wyle report Chatter box chart	Wyle chatter box used to monitor relay contact chatter during seismic retest. A combination of static and dynamic relays were modnitored by the Wyle chatter box to detect contact bounce.

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
	In addition to control acceleromenter, additional accelerometers shall be mounted on each chassis.			A total of 20 accelerometers mounted on equipment. Refer to test log for placement.
6.3.4.3	Seismic Test Performance Requirements. The following test sequence shall be conducted: • Resonance search iaw IEEE 3.4.4. • Five tri-axial OBEs • One tri-axial SSE • Complete operability test	Comply	TP0405	
6.3.4.4	**Seismic Test Spectrum Analysis Requirements**. Test spectrum shall be reported for ½, 1, 2, 3, and 5% damping.	Comply	TP0405 51378-1 Wyle report	Seismic spectrum analyses covered in Wyle test report.
6.3.5	**Surge Withstand Capability Testing**. Surge withstand testing shall be conducted iaw Section 4.6.2. The test only needs to be applied to a representative of points.	Comply	TP0406 TS901-000-25	Test procedure specifies the specific circuits to be subjected to surge testing.
6.3.5.1	**Surge Withstand Test Mounting Requirements**. Test specimen shall be mounted on non-metalic vertical surface at a vertical height of 6 feet.	Exception	TP0406 TS901-000-25	Test specimen was installed in same equipment cabinet used for environmental test. The size of the test chamber and physical configuration of the test specimen did not permit the specified arrangement.
6.3.6	**Class 1E to Non-Class 1E Isolation Testing**. Isolation shall be conducted iaw Sections 4.3.2, 4.3.3, 4.3.4.3, 4.3.4.4, and 4.6.4. Failure of one of a redundant component will be considered acceptable if the other component continues normal operation.	Comply	TP0411 TS901-000-28	Selected channels subjected to Class 1-E isolation waveform. If the channel survived that test, no further test was done. If the channel failed, the group isolation test was done.
6.4	**Other Tests and Analyses**. Section Heading	N/A		No Requirements
6.4.1	**FMEA**. Analysis shall be conducted iaw requirements of Sections 4.2.3.3 through 4.2.3.6 and IEEE 352 Sections 4.1, 4.5, and 4.6.	Comply	RR901-000-01	Completed to cover legacy hardware configured in the configuration to be presented for qualification.
6.4.2	Electrostatic Discharge (ESD) Testing Requirements. Testing shall be accomplished iaw Section 4.3.8 and EPRI TR-102323.	Comply	TP0409 TS901-000-25	No failure or deficiency detected.
6.4.3	Power Quality Tolerance Requirements. Testing shall be accomplished to the voltage range of Section 4.6.1.1 items A and B. Testing shall be done during aceptance testing, at the end of the high temperature phase of the environmental test, and after completion of seismic testing.	Comply	TP0402 TS901-000-22, -29, -34	Test was performed at the following times to satisfy the intent of this requirement: • At the end of the high temp. period of the environmental test • After completion of the first seismic test

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
				• After return from Wyle • Prior to the second seismic test at Wyle • After completion of the second seismic test.
6.4.4	**Requirements for Compliance to Specifications**. Descriptive Information	N/A		No Requirements
6.4.4.A	Performance of operability and prudency tests during qualification tests shall be compared with performance during acceptance.	Comply	TS901-000-23, -25, -35	Magnitude of disruption under stress remained within the acceptable limits except as noted in the test reports.
6.4.4.B	Applied seismic spectrum where test specimen meets requirements shall be compared with required response spectrum. If the test spectrum is less than the required response spectrum, then this will level determine the seismic withstand level for the system.	Comply	TS901-000-35	The test spectrum for the OBE was in accordance with the required response spectrum. The test spectrum for the SSE was run up to the limit of the Wyle seismic simulator table.
6.4.4.C	Isolation level shall be compared with requirements of Section 4.6.4. Actual level met shall be recorded in application guide iaw Section 8.6.3.	Comply	TS901-000-28 Channels tested to limits of the power source 250 vdc 283 vac	Some of the individual modules met these limits and some did not. However, none of the individual channel failures propagated beyond the individual module exposed to the test signal. The serial channels of the HFC-PCC06 were not tested because these channels are intended to operate only with CSM and M/A stations.
6.4.4.D	Surge withstand levels shall compared with requirements of Section 4.3.7. Actual level met shall be recorded in application guide iaw Section 8.6.3.	Comply	TS901-000-25	One I/O module and one ICL channel was partially damaged by the test pulses, but overall operation of the main controller was not disrupted. The SLC power supply reset but was not permanently damaged. This power supply will be replaced with a different module.
6.4.4.E	Performance of EMI/RFI testing shall be compared with requirements of Section 4.3.7. Actual level met shall be recorded in application guide iaw Section 8.6.3.	Exception	TS901-000-25 RR901-000-37	The HFC-AI8L and –AC38 modules exhibited considerable susceptibility and have been dropped from consideration. The FOT modules exhibited susceptibility for certain frequency ranges and will require shielding. Refer to RR901-00037 for the disturbance envelop.

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
6.4.4.F	Results of power quality testing shall be compared with requirements of Section 4.6.1 and 4.2.3.7.B.	Comply	TS901-000-29 TS901-000-35	This test was finally executed a total of four times. The prototype HFC-PSR01 power supply used in the SLC chassis exhibited some fluctuation in the output voltage level, but this caused no disruption in controller performance due to the onboard power regulation included on every HFC-6000 module.
6.4.4.G	Results of application object testing shall be compared with requirements of Section 5.6.	Comply	TR001-000-02	Refer to TR001-000-02 for the information.
6.4.4.H	Results of surveys and audits shall be compared with requirements of Section 7.			Refer to entries for Section 7.
6.4.5	**Human Factors**	N/A		No Requirements
6.5	**QA Measures Applied to Qualification Testing**. Activities for qualification testing shall meet requirements of 10CFR50 Appendix B.	Comply	HFC QA Manual	HFC QA program has been developed based on 10CFR50 Appendix B and NQA-1.
6.5.A	QA program shall apply to development of TSAP.	Comply	HFC QA records 700901-09 700907-01, -02 WI-ENG-008	
6.5.B	QA program shall apply to procurement of all items included in the test specimen.	Comply	QA records	
6.5.C	Chain of custody shall be maintained from initial receipt until all test reports and all other documentation is complete.	Comply	QA records	
6.5.D	The QA program shall apply to all tests and analyses that are conducted under Section 6 of EPRI TR-107330.	Comply	QA records TN0401, TP0401 thru TP0411 TS901-000-22 thru –35	
7	**Quality Assurance**. Section Heading	N/A		No Requirements
7.1	**QA Overview**. Descriptive Information	N/A		No Requirements
7.2	**10CFR50 Appendix B Requirements for Safety-Related Equipment**: Section Heading	N/A		No Requirements
7.2.A	All activities to provide generic qualification for the HFC-6000 platform.	Comply	QAPM	QA program based on NQA1 and 10CFR50 Appendix B for nuclear applications.
7.2.B	Application specific design and development, including integration.	Comply	700901-01 thru –13 DS901-000-01 thru –21 700907-01, -02	
7.2C	Any supplementary application specific activities for		QAPM	Software dedication procedure

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
	dedication of the product line.			Software V&V procedure
7.2.D	If processes other than those specified by 10CFR50 Appendix B, the manufacturer shall demonstrate that those processes provide equivalent confidence.	N/A	QAPM	HFC QA program and related procedures for nuclear applications are based on NQA1 and 10CFR50 Appendix B.
7.2.E	The qualifier shall perform audits to confirm their quality program.	N/A		HFC QA program and procedures for nuclear applications are based on NQA1 and 10CFR50 Appendix B.
7.2.F	If the audits are performed against ISO 9001 or other standards, qualifier shall provide supplementary activities to meet 10CFR50, App B requirements.	N/A		HFC QA program and procedures for nuclear applications are based on NQA-1 for all nuclear safety-related programs.
7.2.G	Qualifier shall evaluate manufacturer's V&V program according to criteria of Section 7.4.	Comply	QAPM	Outside consultant audits and reviews of internal procedures and programs over the past three years.
7.2.H	The qualifier shall have the right to witness some or all of the qualification tests being performed.	N/A		All qualification tests were conducted by HFC personnel in conjunction with a qualified vendor of laboratory services. No third party qualifier was involved.
7.3	**10CFR21 Compliance Requirements**. Descriptive Information	N/A		No Requirements
7.3.A	Identify, document, and communicate problems and errors with the PLC and PLC manufacturer.	N/A	QAPM	HFC designed the platform. External vendors were use for manufacture of components, but their operation was performed under the scrutiny of the HFC QA program.
7.3.B	Evaluate problem reports received from PLC manufacturer and other users of the PLC and the NRC.	N/A	QAPM QPP 16.3	10CFR21 program is in place, but no problem report has yet been issued or received.
7.3.C	Screen relevance of all problem reports regardless of origin with respect to the application and environment.	N/A	QAPM QPP 16.3	10CFR21 program is in place, but no problem report has yet been issued or received.
7.3.D	Submit reportable items to the NRC as per requirements of the Part 21 program.	N/A	QAPM QPP 16.3	10CFR21 program is in place, but no problem report has yet been issued or received.
7.4	**Verification and Validation Requirements**. V&V program shall conform with requirements of IEEE 1012 and 7-4.3.2	Comply	QPP 3.2 WI-ENG-008	All of the basic operating system software is legacy design that was developed as commercial grade software. Basic qualification will be based on requirements for commercial grade dedication. New design will follow requirements of IEEE 1012 and the

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
				relevant NRC reg guides. The current procedure for V&V activities is WI-VV-001.
7.4.a	Shall have a V&V plan	Comply	QPP 3.2 WI-ENG-008	
7.4.b	Shall take a life cycle approach	Comply	QPP 3.2 WI-ENG-008	
7.4.c	Software requirements document shall be reviewed for completeness, correctness, and consistency	Comply	QPP 3.2 WI-ENG-008 700901-01 thru -11	Separate requirements specifications were produced for the control system and application. Only the application was new development.
7.4.d	Provide traceability of requirements through lifecycle.	Comply	QPP 03.2 WI-ENG-022 RR901-000-10	The EPRI specification provides the primary source of requirements for the ERD111 project.
7.4.e	Shall be both structural and functional testing of software.	Comply	ATP0402 TP0408 TP0408B	Review of logic versus requirements. Review of program text file versus both logic and requirements. TSAP validation test of operational functions.
7.5	**Manufacturer Qualification Maintenance Throughout Product Life Cycle. Section Heading**	N/A		No Requirements
7.5.1	**Overview of Manufacturer Qualification Maintenance Throughout Product Life Cycle**. Descriptive Information	N/A		No Requirements
7.5.2	Requirements for Manufacturer Qualification Maintenance Throughout Product Life Cycle. Provide documentation that manufacturer will ensure upward compatibility for revisions, maintain or enhance rigor of process, commit to supporting the qualified platform for a minimum of 5 years, and provide a minimum of 6 months notice before withdrawing product support.	Comply	QAPM	Past performance with customers who are still using HFC (Forney) control systems that were installed more than 30 years ago.
7.5.3	**Life Cycle Support Tools Requirements**. Ensure either continued access to the same version of the engineering tools and environment used to generate the software for the qualified PLC or the capability of reconstructing the functionality with revised tools and environment.	Comply	QAPM WI-ENG-003 WI-ENG-020	Configuration management tools ensure that the system software for a particular controller can be reconstructed.
7.6	**Compensatory Quality Activities for Legacy Software**. Section Heading	N/A		Section Heading
7.6.1	**Overview of Compensatory Quality Activities for Legacy Software**. Descriptive Information.	N/A		No Requirements

ERD111 EPRI TR 107330 Requirement Compliance Traceability Matrix

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
7.6.2	**Requirements for Compensatory Quality Activities for Legacy Software**. Guidance of EPRI TR-106439 shall be used to compensate for short comings in the development of legacy software based on documented operating history and black bock testing. Configuration control shall be imposed as soon as a baseline is established.	Comply	PP901-000-01	Topical report PP901-000-01 describes the commercial grade dedication for the pre-defined software (PDS).
7.7	**Configuration Management**. Section Heading	N/A		No Requirements
7.7.1	**Configuration Management Overview**. Descriptive Information	N/A		No Requirements
7.7.2	**Hardware Configuration Management**. Scope shall include revisions to module design, hardware configuration of the modules, compatibility of revised modules with existing architecture, and manufacturer documentation.	Comply	QAPM WI-ENG-003	
7.7.2.A	Utility shall use Section 5 of Supplement 3S-1 (Supplementary Requirements for Design Control) to evaluate the configuration management process.	N/A	QPP3.1, QPP3.2 WI-ENG-100	Descriptive information
7.7.2.B.	The manufacturer's configuration management plan shall include a method for identification of each component of the PLC modules so that changes to configuration can be tracked iaw Supplement S8-1 (Supplementary Requirements for Identification and Control of Items).	Comply	WI-ENG-003 VV0414	Every PCB assembly has a unique serial number attached to it, and it is tracked in the master configuration list by this serial number. Subcomponents on an assembly are tracked by part number only.
7.7.2.C	The manufacturer's method of document control shall be evaluated against Supplementary Requirements for Document Control.	Comply	QPP6.1 WI-DOC-001	
7.7.3	**Software Configuration Management**. Scope shall include PLC firmware, run-time software libraries and modules, software tools, documentation.	Comply	WI-ENG-003 WI-ENG-020 WI-ENG-206	
7.7.3.A	Define the organization and responsibilities for performing software configuration management.	Comply	WI-ENG-003	
7.7.3.B.	Provide four basic functions: • Configuration ID • Configuration Control • Configuration Status Accounting & Reporting • Configuration Audits and Reviews	Comply	WI-ENG-003 WI-ENG-020 WI-ENG-206	
7.7.3.C	Ensure that sub-tier suppliers to the PLC manufacturer.	N/A		No sub-tier suppliers are used for software.
7.8	**Problem Reporting/Tracking Requirements**. Qualifier shall maintain problem reporting and tracking	Comply	QAPM QPP 16.1	Problems may be reported either by HFC personnel or by customers. Either may

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
	information needed by the utility to evaluate potential PLC problem impacts on safety. Essential information includes: • Classification of problem or error • Description of problem or error • Affected OLC model, part, and revision Nos. • Type of application • Description of application configuration • Name of reporting site • Type of site • Cumulative operating time of PLC when error detected. An effective mechanism shall be provided to report problems, and a timely mechanism shall exist for making this information available to all nuclear utility customers.		QPP 16.2 QPP 16.3	trigger generation of a CR, which is tracked to final resolution. If a problem results in a significant safety hazard, it will trigger a report under 10 CFR Part 21.
8	**Documentation**. Descriptive Information	N/A		No Requirements
8.1	**Equipment General Overview Document Requirements**. Descriptive Information	N/A		No Requirements
8.1.A	Description of generic platform structure	Comply	DD0401 RS901-000-01	
8.1.B	Description of types of interconnections between main and expansion I/O or other chassis	Comply	RS901-000-01 DD0401	
8.1.C	Overview and selection guide of the modules available	Comply	RS901-000-01 RR901-000-37	This top-level document provides an overview with preliminary product line brochures to serve as a selection guide.
8.1.D	Overall capacity in terms of I/O and processing speeds	Comply	RS901-000-01 RR901-000-37	Refer to RR901-000-37 for the operating performance envelopes of the modules.
8.1.E	Installation information: • Any variation in mounting available • Torque requirement for mounting screws • Requirements or limitations on structure it can be mounted on • Limitation on separation between main and expansion chassis • Requirements for user-supplied hardware required for mounting and connection to the PLC • Any special handling requirements • Grounding and shielding requirements	Comply	UG004-000-07 700909-01 700910-01 700912-01 700915-00 700916-01 700916-02	Generic site planning and installation manual provides requirements and instructions that are applicable to all HFC control systems. The assembly and wiring diagrams for a particular application provide the parameters and guidance that are unique to a particular installation, including fastener torquing requirements, wiring, cable routing, etc.

ERD111 EPRI TR 107330 Requirement Compliance Traceability Matrix

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
8.1.F	Handing and storage requirements	Comply	UG004-000-07	Handling and storage requirements are generic instructions that apply equally to all HFC control systems and their sub components.
8.1.G	Description of the self-diagnostic and redundancy features in the PLC platform	Comply	UG004-000-008	Generic maintenance manual provides separate coverage for each HFC product line.
8.2	**Equipment General Specifications Requirements**. Manufacturer documentation shall include: • General specifications for the PLC and its modules • Establish overall speed, accuracy and I/O capacity • Environmental, EMI/RFI, surge, isolation, and shock withstand capabilities.	Comply	RR901-000-37	Refer to RR901-000-37 Qualification Summary Report for the performance operating envelop.
8.3	**Operator Manual Requirements**. Manufacturer's documentation shall describe operation: • Purpose of status indicators • Special operating procedures • Purpose and use of any switches or controls that are part of the PLC • Description of operation and any redundancy features.	Comply	UG004-000-02 UG004-000-03 UG004-000-05 UG004-000-08	The documents reflect the operator documentation set for standard HFC control systems. Complete user-level documentation specifically for the HFC-6000 product line is under development.
8.4	**Programmer's Manual Requirements**. Descriptive Information	N/A		No Requirements
8.4.A	Summary of available functions with brief description for each	Comply	UG004-000-01	All primitive Boolean functions and block algorithms available for use within an application are covered by the EWS User's Guide.
8.4.B	Detailed description of the usage for each function	Comply	UG004-000-01	
8.4.C	Examples of the use for complex blocks	Comply	UG004-000-01	Each block algorithm is defined in mathematical terms, and the valid range for each configuration parameter is described.
8.4.D	Limitations on any of the functions	Comply	UG004-000-01	The only limitation on the use of defined functions or algorithms is the number of points of a particular type defined in the mass database.
8.4.E	Methods for managing resource utilization	Comply	UG004-000-01	RQ table controls the volume of data broadcast to the C-Link.
8.4.F	User manual for programming and debugging tools	Comply	UG004-000-01	Application programs can be generated

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
			UG004-000-04	using AutoCAD and primis•e, or they can be generated manually using the EWS utilities.
8.4.G	Detailed information for the creation and testing of user-defined functions, if applicable.	N/A	UG004-000-01	Users can create complex application algorithms from simple Boolean functions and the block algorithms supplied with the control system. Users cannot create their own Boolean functions or block algorithms.
8.4.H	Detailed description for the use of conditional branching statements	Comply	UG004-000-01	Conditional branches can be used within the application program, but they are not recommended. The use of Jump statements is covered in the EWS User's Guide.
8.4.I	Detailed description of limitations on application of dynamic functions and the relation of their operation to scan time	Comply	UG004-000-01	Functional limits for timers, counters, blocks and their associated parameters are described. Use of these functions has no impact on scan time. However, the size of the application program can impact equation cycle time, which does affect response time for both digital and analog applications.
8.4.J	Detailed description of interaction between main processor and coprocessor modules.	N/A		HFC-6000 controller has two subordinate processors, but their operation does not correspond to that of coprocessors. Operation of the subordinate processors is not accessible to the application.
8.4.K	Detailed description of interaction between application program and any redundancy features.	N/A		Redundancy features inherent in the architecture of the control system are transparent to the application program.
8.4.L	Any software build procedures and software tools that are needed to apply the PLC to a safety system configuration.	N/A	UG004-000-01 UG004-000-04	The application program requires compilation but no build or linking functions. If the One Step software tool is used to generate the application source code file, the tool starts the compiler automatically after the source code file has been created.
8.4.M	Description of the executive, including flow control information.	N/A		Operation of the operating system program is transparent to the application.
8.4.N	Description of data, database management, data handling, data definition, and configuration management.	Comply	UG004-000-01 UG004-000-05	The user has no access to the operating system code, but the user can change the

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
			UG004-000-08	system mass database and application. Major aspects of configuration management for HFC control systems consist of access control, maintaining a single master database, and keeping a backup archive of the system data.
8.4.O	Description of self-diagnostic features, including the interface between the self-diagnostics and the application program.	Comply	UG004-000-01 UG004-000-02	Operation of the diagnostic utilities is independent of the application. However, a set of status flags, counters and timers have been reserved for system use. These data points can be used to control alarms within the application and on the operator console display
8.4.P	Programming manual for any coprocessor	N/A		No coprocessor is included in the system.
8.5	**Equipment Maintenance Manual General Requirements**. Manufacturer's manuals shall contain information needed for calibration, troubleshooting, and maintenance, including preventive maintenance procedures. Documentation shall include results of aging analysis..	Comply	UG004-000-08	
8.6	**Qualification Documentation Requirements**. Qualifier shall submit all documentation supporting qualification of PLC to customer utility for review and approval.	N/A		Descriptive information
8.6.1	**Programmatic Documentation Requirements**.	N/A		Section heading
8.6.1.A	Test plan shall be prepared covering environmental, seismic, surge and isolation, EMI/RFI. application objects tests, and FMEA and availability/reliability analyses.	Comply	TN0401 RR901-000-01 RR901-000-04	
8.6.1.B	Test specification that includes equipment identification, interfaces, and service conditions.	Comply	TN0401, ATP0402, TP0401 through TP04011	
8.6.1.C	Procedure shall include test procedures and data recording requirements. Procedure shall include requirements for identifying, handling, and documenting any test deviations and equipment modifications during tests.	Comply	TN0401, ATP0402, TP0401 thru TP0411	
8.6.1.D	Test reports shall be prepared for each of the test plans listed above.	Comply	TS901-000-22 thru –35	
8.6.1.E	Reports on all audits performed on the manufacturer or the manufacturer's suppliers and subcontractors.	Comply	QA records	

ERD111 EPRI TR 107330 Requirement Compliance Traceability Matrix

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
8.6.1.F	Reports on all design evaluations performed to address requirements that cannot reasonably be addressed by testing.	Comply		All portions of the HFC-6000 were based on legacy hardware and software designs that were repackaged. Such reports take the form of reviews and memos written during the repackaging process.
8.6.2	**Technical Items and Acceptance Criteria Documentation Requirements**. Descriptive Information	N/A		No Requirements
8.6.2.A	Provides requirements and specifications to be covered by the qualification for a specific PLC.	Comply	RS901-000-01 RS901-000-02	
8.6.2.B	Test specimen purchasing records	Comply	QA records	Not assembled into a separate document at the present time
8.6.2.C	TSAP development documentation	Comply	ADS0401 700907-01 700907-02	
8.6.2.D	Test specimen documentation per Sections 8.8, 8.9, 8.10, 8.12, and 8.13.			Refer to entries for relevant sections.
8.6.2.E	Test documentation per Section 8.14.			Refer to entries for section 8.14.
8.6.3	**Application Guide Documentation Requirements**.	N/A		Section heading
8.6.3.A	Results of the environmental operability test shall be evaluated to establish the qualification envelope. Performance characteristics shall be described in sufficient detail to permit comparison with system requirements.	Comply	TS901-000-23 RR901-000-37	Refer to RR901-000-37 Qualification Summary Report for the information.
8.6.3.B	The applied levels of the seismic test and the test response spectrum where test specimen met acceptance criteria shall be reported as the seismic withstand capability. Withstand capability shall be reported for all clamping values used.	Comply	TR901-000-35 RR901-000-37	Refer to RR901-000-37 Qualification Summary Report for the information.
8.6.3.C	The 1E to non-1E isolation level used in testing shall be reported as the qualification value for this parameter.	Comply	TR901-000-28 RR901-000-37	Refer to RR901-000-37 Qualification Summary Report for the information..
8.6.3.D	The surge withstand level used in testing shall be reported as the qualification value for this parameter/	Comply	TR901-000-25 RR901-000-37	Refer to RR901-000-37 Qualification Summary Report for the information.
8.6.3.E	Performance during EMI/RFI testing shall reported for all test levels, including the performance of each individual module type.	Comply	TR901-000-25 RR901-000-37	Refer to RR901-000-37 Qualification Summary Report for the information..
8.6.3.F	Actual variation of PLC performance during power quality testing shall be reported.	Comply	TR901-000-23, -29, -34, -35 RR901-000-37	Refer to RR901-000-37 Qualification Summary Report for the information.
8.6.3.G	Any combinations of software objects or special purpose objects created to implement requirements shall be	N/A		No new software objects were used.

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
	described completely.			
8.6.3.H	Complete description of the as tested PLC configuration shall be included.	Comply	TR901-000-22	Refer to RR901-000-37 Qualification Summary Report for the information.
8.6.3.I	A complete description of the executive software and software tools revision levels and any optional features that were included.	Comply	UG001-000-01 RR901-000-37	Refer to RR901-000-37 Qualification Summary Report for the information.
8.6.3.J	A complete as tested configuration shall be included for each module, including mounting, grounding, and shielding methods used during test.	Comply	TS901-000-23 RR901-000-37	Refer to RR901-000-37 Qualification Summary Report for the information.
8.6.3.K	A summary of the FMEA and availability analyses shall be included.	Comply	RR901-000-01 RR901-000-04	The reports show the summary of FMEA and availability.
8.6.3.L	The document shall include the setpoint analysis support iaw Section 4.2.4.	Exception		This analysis is dependant on the application and will be implemented as part of each project.
8.6.3.M	Any information from surveys and audits of the manufacturer's processes that are applicable to future purchasing shall be included.	N/A		None applicable
8.6.3.N	Description of the redundancy features included in the qualification	Comply	PP901-000-01 DS001-000-08	
8.6.3.O	Description of external devices covered by qualification	N/A		None included
8.6.3.P	Description of the configuration management methods and features needed to support application of the platform	Comply	PP901-000-01 WI-ENG-003	Configuration Management described in WI-ENG-003 provides the necessary methods and features to support application of the platform.
8.6.3.Q	Summary of the aging analysis performed iaw Section 4.7.8.2.	Comply	RR901-000-04	An aging analysis was conducted for the predecessor systems that used a large number of the same parts, but the environmental requirements were not as stringent.
8.6.3.R	Any special mounting methods or practices used to meet seismic requirements	Comply	TR901-000-35	Final application guide to be developed based on requirements of each application.
8.6.3.S	A definition of the qualification envelope for any module that is different for that from the whole PLC.	N/A		
8.6.3.T	Description of any application-level hardware or software features that are assumed in order to meet any of the requirements covered by the qualification.	N/A		No special requirements of this type were assumed or included.
8.6.4	**Supporting Analyses Documentation Requirements**. Descriptive Information	N/A		No Requirements
8.6.4.A	FMEA Report that is specific to the PLC platform being	Comply	RR901-000-01	

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
	qualified.			
8.6.4.B	Availability/reliability analysis report that is specific to the PLC platform being qualified. The analysis shall include the basis for the values used in the analysis, including the use of operating experience. The impact of any self-diagnostics and recovery capability features assumed in the analysis shall be described.	Comply	RR901-000-04	
8.6.5	**Class 1E to non-1E Isolation Test Plan**. The Isolation test plan and reports shall conform with requirements of IEEE 384 and Reg. Guide 1.75.	Comply	TP0411 TS901-000-28	Several modules met isolation limits up to 250 vdc and 283 vdc for Class 1E isolation, and others experienced either temporary disruption or permanent damage to the channel under test. In no case was the control system as a whole disrupted.
8.7	**V&V documentation Requirements**. Descriptive Information	N/A		No Requirements
8.7.A	Software QA plan	Comply	QAPM QPP 3.2	
8.7.B	Software Requirements Specification	Comply	RS901-000-01 700901-09	PDS requirements are not included here.
8.7.C	Software Design Description	Comply	ADS0401 700907-01 700907-02	PDS design specifications are not included here.
8.7.D	Software V&V plan	Comply	QPP3.2 WI-ENG-008	WI-ENG-008 was the V&V procedure used for the qualification project WI-VV-001 is the current V&V procedure.
8.7.E	Software V&V Report	Comply	VV0415	For the qualification, the focus of the V&V activities was not the pre-developed software (PDS), i.e. the platform. The V&V activities covered the TSAP development activities in according with WI-ENG-008 at that time.
8.7.F	User documentation	Comply	UG004-000-02 UG004-000-03 UG004-000-05	These documents represent material for standard HFC control systems. Corresponding documentation for the HFC-6000 is not yet available.
8.7.G	Software Configuration Management Plan	Comply	WI-ENG-003	
8.8	**System Description Requirements**. Design description covering the hardware and software, including the TSAP,	Comply	ADS0401 DD0401	

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
	configuration covered by the qualification.		RR901-000-01	
8.9	**Critical Characteristics Listing Requirements**. Definition of the critical characteristics covered by the qualification	Comply	QA records	Refer to the commercial dedication reports for both hardware and legacy software.
8.10	**System Drawing Requirements**. Descriptive Information	N/A		No Requirements
8.10.A	Functional description of the test specimen	Comply	DD0401	
8.10.B	Schematic of the test specimen, including devices external to the PLC used to create inputs and capture outputs.	Comply	700907-01 700907-02 700908-01 700915-00	
8.10.C	Ladder diagram or equivalent for the TSAP.	Comply	700907-01 700907-02	
8.10.D	Diagram that shows power distribution, wiring, and grounding	Comply	700915-00	
8.10.E	Layout drawing of chassis, modules, and any ancillary devices	Comply	700909-01 700912-01	System Arrangement Diagram, Controller-FOT Configuration Test System Arrangement Seismic System Drawings
8.10.F	Documents to describe test specimen mounting and any test fixtures used during qualification.	Comply	700911-01	Provided as notes on the assembly drawings.
8.11	**System Software/Hardware Configuration Document Requirements**. Descriptive Information	N/A		No Requirements
8.11.A	The identification and revision level of the executive software in the PLC main processor and any coprocessors.	Comply	VV0414	The controller contains three independent microprocessors but no coprocessor.
8.11.B	The revision level of firmware used in tested modules.	Comply	VV0414	Each I/O module contains a separate microprocessor.
8.11.C	Identification and revision of tools used to create the TSAP.	Comply	UG004-000-04	Created with standard commercial tools and HFC tool called One Step.
8.11.D	Identification and revision of any downloadable PLC executive packages.	N/A		None used.
8.11.E	Identification and revision of the TSAP. A printout of the TSAP shall be included.	Comply	700907-01 700907-02	A source code text file can be generated, but the real source is an AutoCAD logic diagram and its associated database.
8.11.F	Identification, revision level, and serial number of any hardware module shall be documented.	Comply	VV0414	VV0414 records the information.
8.12	**System Database Documentation Requirements**. The TSAP database, including range of values, shall be documented.	Comply	VV0414	VV0414 records changes that were made to parameters and program code. The mass database itself is a set of Excel files.

ERD111 EPRI TR 107330 Requirement Compliance Traceability Matrix

EPRI TR-107330 Reference	Summary of Requirement	Compliance	HFC Document Reference	Comments
8.13	**System Setup/Calibration/Checkout Procedure Requirements**. Setup, calibration, and checkout procedures used for the test specimens shall be documented.	Comply	TN0401, TP0401, TP0408, TP0408B TS901-000-30	Summary Report, TS901-000-30, summarizes and reports the setup, calibration, checkout procedures and the TSAP validation.
8.14	**System Test Documentation Requirements**. Descriptive Information	N/A	RR901-000-37	Refer to Qualification Summary Report, RR901-000-37 for the information.
8.14.A	Test requirements	Comply	TN0401	Master Test plan describes the test requirements.
8.14.B	Acceptance criteria for all tests	Comply	ATP0402, TP0401 through TP0411	Acceptance criteria are listed in the test procedures.
8.14.C	Sequence of testing	Comply	TN0401	Master Test Plan describes the test sequences.
8.14.D	Vehicles for recording the results of tests	Comply	TN0401 UG004-000-03	Test reports from each test procedure; SOE and HAS test data logs
8.14.E	Requirements for test equipment	Comply	ATP0402, TP0401 through TP0411	Requirements are listed in the test procedures.
8.14.F	Test report summarizing results of tests	Comply	TS901-000-22 thru –35	
8.15	**Manufacturer's Quality Documentation Requirements**. Provide a QA Plan	Comply	QA documentation	HFC QA Manual
8.16	Manufacturer's Certifications Requirements. Provide certifications of conformance to specifications and requirements for all items used in the test specimen.	Comply	QA documentation	Documentations are completed.