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August 11, 2010

Document Control Desk
U.S, Nuclear Regulatory Commission
Washington, DC 20555
Attn: Mr. Duane Hardesty

Dear Mr. Hardesty,

Subject: License Amendment Request (LAR) for Digital Control System Upgrade (2nd batch of documents) - University of Florida Training Reactor (UFTR), DOCKET NO. 50-83

Please find enclosed the 4th batch of documents for the UFTR LAR for Digital Control System Upgrade. This batch contains only Functional Requirements Specifications (FRS) (#UFTR-QA1-100) document, which includes the List of I/O (UFTR-QA1-101.1) document as attachment #2.

If you need further information, please do not hesitate to contact me at dhinten@ufl.edu or (352) 392-1401.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on August 11, 2010.

Sincerely,

David Hintenlang, PhD
Director of UFTR
Interim Chair of NRE

Alachua County Florida
August 11, 2010

Lisa L. Purvis
Commission # DD608673
Expires November 3, 2010
Bonded Troy Fain - Insurance, Inc. 800-385-7019

Cc
- Jack Donohue, NRC
- Gabriel Ghita, UF
- Alireza Haghighat, Project Director
- Glenn Sjoden, RSRS Chair
- Eric Wallace, AREVA
- UFTR – NRC file

A020
NRR

Project Title: ***UFTR DIGITAL CONTROL SYSTEM UPGRADE***

UFTR-QA1-100, Functional Requirements Specifications (FRS)

Prepared by,

Dr. Gabriel Ghita

.... (Signature)

Date: 08/10/2010

Reviewed by,

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.... (Signature)

Date: 8/10/10

Approved by,

Prof. Glenn Sjoden

.... (Signature)

Date: 08/10/2010

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Revision no.	*Reviewed by*	*Approved by*	*The Modified Pages*	*Date*

Table of Contents

1. Introduction

1.1 Purpose

The purpose of this Functional Requirements Specifications (FRS) is to define the technical requirements for the design and supply of the new digital Reactor Protection System (RPS) at the University of Florida Training Reactor (UFTR). This Specification contains the requirements for the hardware, software, design, development, performance, testing, training, configuration management, documentation, delivery, and technical support required to supply the new digital UFTR RPS.

Any deviations from the specified technical requirements will be considered as long as the differences are clearly justified and do not impact the reliability or required functionality of the design.

No deviation or non-conformance from this Specification or applicable federal, state, and local codes and standards invoked by this Specification shall be allowed unless approved in writing. Deviations are considered departures from any requirement of this Specification. Uncorrectable non-conformances are considered to be conditions that cannot be corrected within the Specification requirements by rework or replacement.

1.2 Scope

The FRS provides the functional requirements applicable to the design, manufacturing, and implementation of the new digital RPS for the UFTR. The scope includes only the new UFTR RPS, which is used for reactor monitoring and operation of the Reactor Trip System (RTS).

The UFTR RPS receives plant inputs and operator inputs, and performs the desired RPS functions.

A general arrangement of the UFTR RPS is shown in Attachment #1, 'UFTR RPS General Arrangement Diagram.'

1.2.1 Equipment Included

The UFTR RPS scope of supply includes one digital protection system, the TELEPERM TX (TXS), /7/. This RPS includes various equipments, software and supporting documentations as follows:

1) I/O hardware sufficient to meet demands defined by the I/O List attached to this document (Attachment #2).
2) Terminal blocks, power distribution, and wiring.
3) Power supplies appropriate to the load of I/O hardware.
4) Profibus converters and fiber optic cabling (glass) between the UFTR RPS and the T3000 control system.
5) DIN rail or similar hardware to mount the I/O in the cabinets.
6) Field terminal blocks as necessary to connect I/O input.

7) Software packages required for the UFTR RPS operation, maintenance, communication and controller programming.
8) Licenses as required for the software.
9) The UFTR RPS Manuals for operation, maintenance, repair, instruction, and training for both hardware and software.
10) The TXS internal breakers and fuses required for circuit protection and interruption for the 24 VDC power feed to the UFTR RPS components.

1.2.2 Services Required

The following services per the requirements of this Specification are needed:

1) Quality Assurance at least equivalent to the UFTR Quality Assurance Program (QAP)", /1/, which conforms to ANSI/ANS-15.8-1995; R2005 (R=Reaffirmed), "Quality Assurance Program Requirements for Research Reactors" standard, /12/, for all supplier design, software and equipment.
2) Design and analysis activities as described herein.
3) Site services to support installation, testing, programming, and commissioning including emergency site services.
4) Training for the UFTR Staff as defined in this Specification.

1.3 Other Deliverable Equipment and Tasks

1.3.1 Equipment

At this time, there is no other equipment beyond the TXS system shown in Attachment #3, "TXS Base Configuration."

1.3.2 Services Required

1) Support of equipment installation of all materials supplied.
2) The structural design and hardware required to mount the UFTR RPS I/O in the cabinets.
3) Routing of circuits between plant field components or systems and I/O, between I/O and other control room panels, and between the UFTR RPS cabinets and the T3000 control system cabinets.
4) Labor for installation, wiring connection, and post modification acceptance testing (other than as specified herein) of equipment.
5) Site Acceptance Test (SAT) shall be performed by the UFTR staff; this may require support from AREVA NP to include engineering staff and test equipment.

2. Codes and Standards

Unless otherwise specified, the RPS supplier shall comply with all codes and standards applicable to the services and equipment provided. The UFTR RPS upgrade shall meet all requirements for design, fabrication, assembly, testing, packaging and shipping of the latest revision of the codes and standards applicable to the UFTR RPS that have been issued as of the date of contract award. These include the codes and standards given in the UFTR QAPP, /3/. Later editions and addenda of the codes and standards may be invoked by the UFTR. This shall be done with concurrence of the RPS Supplier.

No provision of this Specification, including invocation of certain specific codes, standards or regulations will relieve the RPS supplier of responsibility for compliance with any code, standard, regulation or legislation applicable to the work specified. Certain provisions provided by this Specification may exceed the minimum requirements of the codes and standards, in which case this Specification shall govern.

All materials, equipment, and system components furnished shall be new. All equipment shall be designed and installed in accordance with the applicable codes and standards, the manufacturer's recommendations, and within the limitations of its ratings.

Any conflict between this Specification and the codes, standards, regulations or legislation applicable to the work performed shall be immediately brought to the attention of the UFTR in writing for resolution.

3. References

3.1 UF Documents

/1/ UFTR-QAP, "Quality Assurance Program (QAP)"

/2/ UFTR-QAP-01-P, "Conduct of Quality Assurance"

/3/ UFTR-QA1-QAPP, "Quality Assurance Project Plan (QAPP)"

/4/ UFTR-QA1-01, "Software Quality Assurance Plan (SQAP)"

/5/ University of Florida Training Reactor SAR, 2009

/6/ Technical Specifications

3.2 AREVA NP Inc. Documents

/7/ AREVA NP Inc. Document No., 38-1288541-00, Topical Report EMF-2110(NP) (A) Revision 1, "TELEPERM XS: A Digital Reactor Protection System"

3.3 Industry Standards

/8/ IEEE Std 730-1998, "Software Quality Assurance Plans"

/9/ IEEE Std 1012-1998, "Standard for Software Verification and Validation"

/10/ IEEE Std 1050-2004, "Guide for Instrumentation and Control Equipment Grounding in Generating Stations"

/11/ IEC 1131-1993, "Programmable Controllers Programming Languages"

3.4 NRC Documents

/12/ ANSI/ANS-15.8-1995; R2005 (R=Reaffirmed), "Quality Assurance Program Requirements for Research Reactors"

4. Abbreviations

4.1 Abbreviations

AC	Alternating Current
BF3	Boron Fluoride Detector
DC	Direct Current
°F	Degrees Fahrenheit
FRS	Functional Requirement Specification
Hz	Hertz
IC	Ion Chamber
ID	Identification
I/O	Input/Output
QA	Quality Assurance
RPS	Reactor Protection System
RTP	Reactor Thermal Power
SAR	Safety Analysis Report
UFTR	University of Florida Training Reactor
V	Volts
V&V	Verification and Validation
VAC	Volts Alternating Current
VDC	Volts Direct Current

4.2 Definitions

Accuracy: The degree of freedom from error of sensor and operator input, the degree of exactness exhibited by an approximation or measurement, and the degree of freedom from error of actuator output.

Completeness: Those attributes of the planning documents, implementation process documents and design outputs that provide full implementation of the functions required of the software. The functions that the software is required to perform are derived from the general functional requirements of the protection system and the assignment of functional requirements to the software in the overall system design.

Correctness: The degree to, which a design output is free from faults in its Specification, design, and implementation. There is considerable overlap between correctness properties and properties of other characteristics such as accuracy and completeness.

Fault Tolerance:	The quality of fault tolerance is achieved when a system has the ability to complete critical functions within its required performance characteristics in spite of power or equipment failures and software faults.
Functionality:	The operations, which must be carried out by the software. Functions generally transform input information into output information. Inputs may be obtained from sensors, operators, other equipment, or other software. Outputs may be directed to actuators, operators, other equipment, or other software.
Reliability:	The degree to, which a software system or component operates without failure. This definition does not consider the consequences of failure, only the existence of failure.
Security:	The ability to prevent unauthorized, undesired, and unsafe intrusions. Security is a safety concern insofar as such intrusions can affect the safety-related functions of the software.
Shall:	"Shall" denotes a requirement or action that must be performed.
Should:	"Should" denotes a requirement or action that would be beneficial, but is not mandatory within the UFTR RPS scope of work.
Timing:	The ability of the software system to achieve its timing objectives within the hardware constraints imposed by the computing system being used.
Traceability:	The degree to, which each element of one life cycle product can be traced forward to one or more elements of a successor life cycle product, and can be traced backwards to one or more elements of a predecessor life cycle product. Traceability is central to the production of complex systems to ensure all requirements are implemented, checked and tested.
Verifiability:	The degree to, which a software planning document, implementation process document or design output is stated or provided in such a way as to facilitate the establishment of verification criteria and the performance of analyses, reviews, or tests to determine whether those criteria have been met.
Will:	The word "will" means that an action or activity can be assumed to be completed by the subject of the sentence.

5. Quality Assurance Program (QAP) Requirements

5.1 General QA Requirements

The QA/Quality Control requirements for equipment supplied and work performed for the digital UFTR RPS upgrade project shall be in accordance with the criteria described in UFTR QAP, /1/, and UFTR "Conduct of Quality Assurance," /2/, and included in the UFTR "Quality Assurance Project Plan (QAPP)," /3/.

5.2 Software Quality Assurance Plans (SQAP) and Procedures

A UFTR Software Quality Assurance Plan (SQAP), /4/, and implementing procedures shall be prepared and made effective prior to development of application software for the project. All project related software plans and procedures shall be developed and issued prior to performing activities and tasks associated with each stage of the software life cycle as defined by the UFTR SQAP, /4/.

The SQAP and associated plans and procedures shall comply with the standards listed in the UFTR QAPP, /3/. Exceptions or deviation from the specified standards is acceptable provided adequate justification is documented and approved by the UFTR project management prior to commencement of work governed by the standard.

The Software Quality Assurance Plan (SQAP), /4/, shall be in accordance with IEEE Std 730, /8/, and shall define the requirements for the following plans and development of associated procedures in accordance with the standards listed in the UFTR QAPP, /3/.

- Software Safety Plan (SSP)
- Software Verification and Validation Plan (SVVP)
- Software Configuration Management Plan (SCMP)
- Software Test Plan SIVAT Plan
- Software Integration Plan
- Software Installation Plan
- Software Operation and Maintenance Plan
- Software Training Plan
- Software Audit Plan

6. Technical Requirements

6.1 System Description

The proposed protection system is comprised of three blocks. System blocks are shown in Figure 6-1 below, where arrows depict intended functional interface.

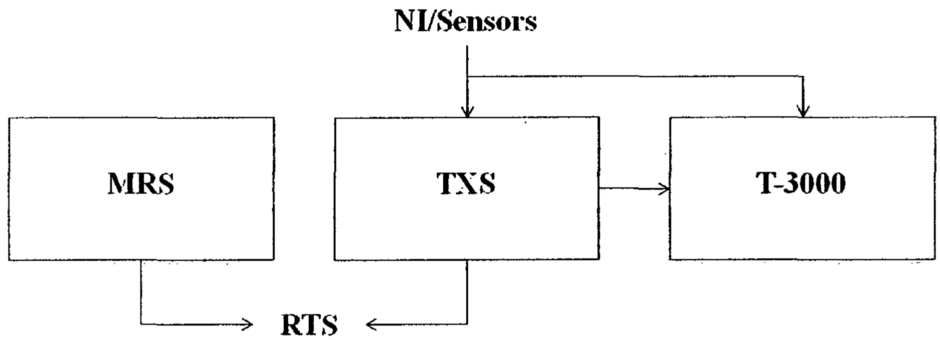


Figure 6-1: The proposed UFTR Protection System

The above system includes the TXS as the primary protection system, providing Monitoring and Indicator System (MIS) and Reactor Trip System (RTS), the T-3000 (with a diverse hardware and software) providing reactor control and a diverse MIS, and a hardwired Manual Reactor Scram (MRS) providing a diverse RTS as compared to TXS. Further, because of unidirectional communication between the TXS and T-3000, and no communication between the TXS and MRS. The failure of the MRS or T3000 blocks will not impact the operation of the TXS. In summary, as shown in Table 6-1, the above proposed system effectively addresses the functions of the RPS.

Table 6-1: Functionality and Diversity of the Proposed UFTR RPS

RPS Diverse Components	RTS	MIS
MRS	✓	
TXS	✓	✓
T-3000		✓

As above table indicates, each function of the proposed RPS system (i.e., MIS, MRS, and RTS) includes two diverse systems.

6.1.1 Monitoring and Indication System

The TXS system shall process various indication signals, which are monitoring various segments of the UFTR including: i) Reactor Core; ii) Primary cooling loop; iii) Secondary Cooling loop; iv) Reactor cell; and v) Reactor confinement. Table 6-2 summarizes all the monitoring devices considered for the UFTR-RPS.

Table 6-2: UFTR Monitoring devices and their locations for the RPS

Segment	Monitoring Device	Location
Core	Channel 1[a]: BF3 + FC Channel 2[b]: IC	Thermal column Thermal column
Primary coolant loop	-Temperature sensor -Flow meter -Water level	-Inlet, top of 6 fuel boxes, and outlet -Inlet & outlet -Top of the fuel
Secondary coolant loop	-Temperature sensor -Flow meter	-Inlet & outlet -Inlet
Reactor cell	-Radiation monitor -Water level	-North, South, East, and West walls (half-way) -Water Shield Tank
Reactor Confinement	-Core Ventilation -Dilution fan	-Primary equipment pit -Bottom of the stack

[a]Channel 1 includes BF3 (or B10) for monitoring the low power range, and FC (Fission Chamber) for the remainder of the power range
[b]Channel 2 includes only an Ion Chamber (IC), which is enabled to monitor the whole power range

As will be discussed in the next Section, majority of the above monitors can cause actuation of the reactor trip system (RTS). The TXS system will process all the signals and according to Section 6.1.2 would determine whether to continue reactor operation or cause a trip that would shut down the reactor.

Reactor power (i.e., core) is monitored by two diverse NI channels, which operate simultaneously for achieving a higher confidence. The reactor is tripped if any one of the NI Channels yields an invalid signal.

In the case of the primary coolant loop, simultaneous monitoring of temperature and flow rate provides further confidence on the safe operation of the core. In the case of the secondary coolant loop, the inlet temperature and flow rate and the outlet temperature are monitored. For the reactor cell, three of the radiation monitors are required and the fourth monitor increases the availability of the reactor.

Finally, the purpose of the monitors of the reactor confinement segment is to monitor the release of radioactivity into the environment.

6.1.2 UFTR Reactor Trip System

The TXS system shall provide the capability of actuation of the RTS, according to the UFTR Technical Specifications, /6/. UFTR has two types of trips: i) Control blade drop; ii) Control blade drop and opening of the dump valve. The 2nd type is referred to a 'Full,' which is implemented whenever the trip is induced by the NIs. Both trip types can be actuated either automatically or manually. Table 6-3 lists the required UFTR automatic and manual trips, and their specifications and types.

Table 6-3: List of RPS Trips, their types and specifications

(Technical Specification, /6/, Table 3-1)

List of Trips and their Specifications	Type of Trip
Automatic	
Period ≤ 3 sec	Full
Power ≥ 119% of full power	Full
Loss of NI high voltage ≥ 10% Loss of electrical power to control console	Full Full
Primary cooling system Loss of primary pump power Low water level in core (≤ 42.5") No outlet flow Low inlet water flow (≤ 41 gpm)	Blade-drop
Secondary cooling system (≥ 1 kW) Loss of flow (well water ≤ 60 gpm) Loss of secondary well pump power	Blade-drop
High primary coolant inlet temperature (≥ 99°F)	Blade-drop
High primary coolant outlet temperature (≥ 155°F)	Blade-drop
Shield tank low water level (6" below established normal level)	Blade-drop
Ventilation system Loss of power to stack dilution fan Loss of power to core vent fan	Blade-drop
Manual	
Manual scram bar	Blade-drop
Console key-switch OFF	Full

Section 6.2 describes each trip in detail and provides the necessary functional diagram and associated algorithm for implementation on the UFTR-TXS system.

6.2 UFTR RPS Functional Requirements

Note: All numerical values shown for setpoints or their associated algorithms are initial values that will be finalized during detailed design phase. These values and all parameters shall be adjustable settings unless specifically stated otherwise.

6.2.1 Reactor Period

6.2.1.1 General Description

Channel 1 of the NI system (Table 6-2) is utilized in the startup range for monitoring source count and during reactor operation for calculating reactor period. This information is utilized to:

a) Provide a minimum source count inhibit @ 2cps.
b) Provide a trip of the reactor should the Period be less than or equal to 3 sec.
c) Provide for a test of the period system.

A calibration and test mechanism will be provided to allow calibration and test of the detectors and their period functionality.

6.2.1.2 Description of Trip Functions

a) When a period of less than or equal to 3 sec is detected, a reactor shutdown is initiated by control blade-drop.
b) If two (2) or more control blades are also off the bottom limit, then the primary moderator/coolant is dumped to the coolant storage tank.

6.2.1.3 Description of Associated Functions

a) Reactor Period Indicator
b) Reactor Period Trip Annunciator

6.2.1.4 Set points for Trip Functions

Period is $\leq$ 3 sec

6.2.1.5 Algorithm for Trip Functions

IF Reactor Period $\leq$ 3 sec
THEN
Drop Control Blades
AND IF 2 or more control blades off low limit

THEN

Dump Primary Coolant

END IF

END IF

6.2.1.6 Input Signals

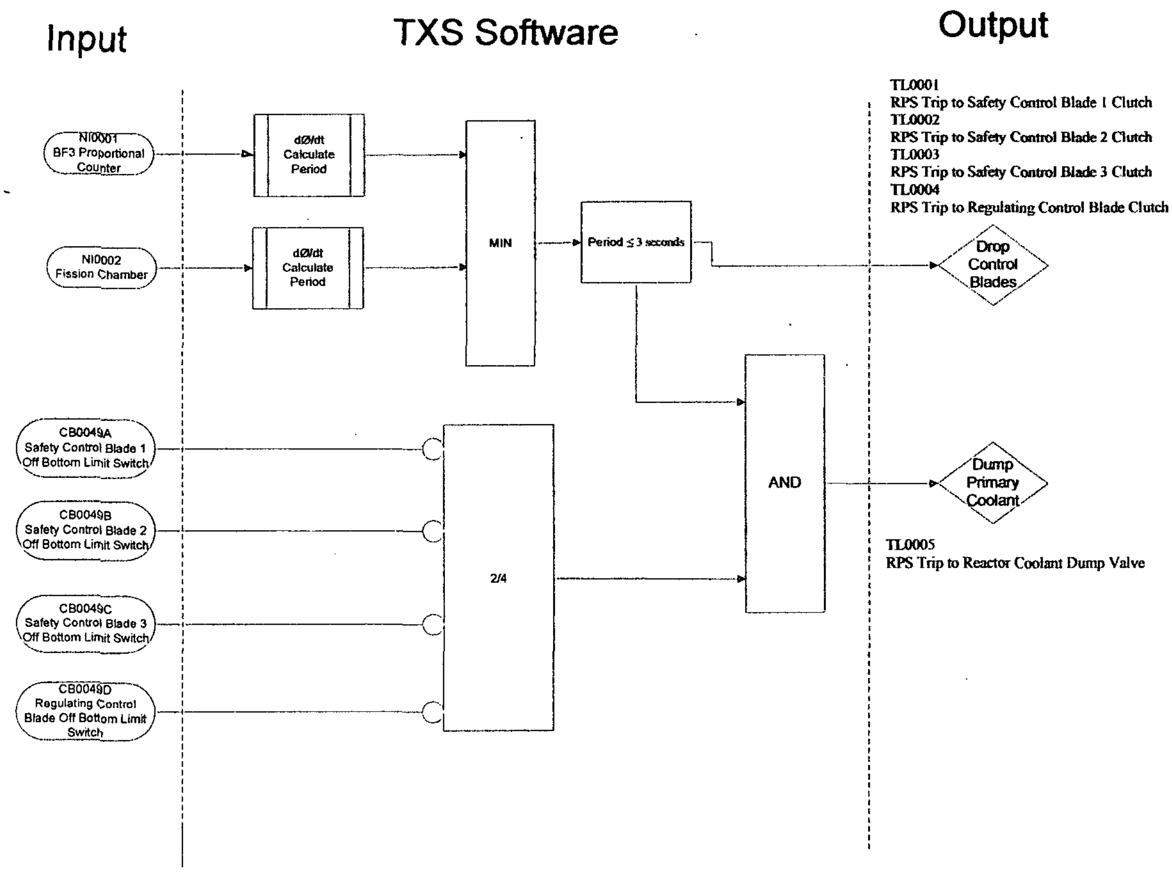
ID Code	Description	Physical Range	Electrical Range
NI0001	BF3 proportional counter (Ch 1)	$10^{-8} - 10^{-4}$ %	4 – 20 mA
NI0002	Fission Chamber (Ch 1)	10^{-8} – 150%	4 – 20 mA
CB0049A	Safety Control Blade 1 Off Bottom Limit Switch	Open/Closed (Off Bottom/On Bottom)	0-24VDC
CB0049B	Safety Control Blade 2 Off Bottom Limit Switch	Open/Closed (Off Bottom/On Bottom)	0-24VDC
CB0049C	Safety Control Blade 3 Off Bottom Limit Switch	Open/Closed (Off Bottom/On Bottom)	0-24VDC
CB0049D	Regulating Control Blade Off Bottom Limit Switch	Open/Closed (Off Bottom/On Bottom)	0-24VDC

6.2.1.7 Output Signals

ID Code	Description	Physical Range	Electrical Range	Destination
TL0001	RPS Trip to Safety Control Blade 1 Clutch	Open/Closed (De-energized/Energized)	0-120VAC	RTS
TL0002	RPS Trip to Safety Control Blade 2 Clutch	Open/Closed (De-energized/Energized)	0-120VAC	RTS
TL0003	RPS Trip to Safety Control Blade 3 Clutch	Open/Closed (De-energized/Energized)	0-120VAC	RTS
TL0004	RPS Trip to Regulating Control Blade Clutch	Open/Closed (De-energized/Energized)	0-120VAC	RTS
TL0005	RPS Trip to Reactor Coolant Dump Valve	Open/Closed (De-energized/Energized)	0-24 VDC	RTS

6.2.1.8 Functional Diagram

Following diagram depict the TXS logic for actuation of the RTS in case of violation of limits on the reactor period and minimum detector count rate. Note that the reactor period is either calculated by the NI system of the TXS or through software implemented on the TXS processing units.



6.2.2 High Flux Trip

6.2.2.1 General Description

Two independent NI channels are provided for measuring reactor power, and both are required for operation of the reactor. Each channel monitors the whole range of power $\sim 10^{-8}$ to 150% in power range operations.

Power level from either channel in excess of high limit setpoint will result in a full trip.

a) The High Flux Trip is provided to prevent damage to the fuel and fuel clad from reactivity excursions too rapid to be detected by pressure or temperature measurements of the RPS.
b) The UFTR SAR, /5/, requires that the reactor power cannot exceed 125% (Allowable Value). Actual RPS setpoints are set to be $\geq$ 119% of full power for conservatism.

6.2.2.2 Description of Trip Functions

a) NI Channel 1 provides an analog signal to the RPS. The value of the signal is processed and the RTS is actuated if power exceeds the setpoint.
b) NI Channel 2 also provides an analog signal to the RPS. The value of the signal is processed and the RTS is actuated if inferred power exceeds the setpoint.
c) If the measured power from any of the channels exceeds the setpoint, the RTS is actuated.

6.2.2.3 Description of Associated Functions

a) Flux Values Display
b) High Flux Warning Indicator
c) High Flux Trip Indicator

6.2.2.4 Set points for Trip Functions

a) Actuates a reactor trip at High Flux Trip point of ≥ 119% of Rated Thermal Power (RTP).

6.2.2.5 Algorithm for Trip Functions

```
IF (NI(1)  ≥ setpoint OR NI(2) ≥ setpoint)
    THEN
        Drop Control Blades
    AND IF (2 or more control blades off low limit)
        THEN
            Dump Primary Coolant
    END IF
END IF
```

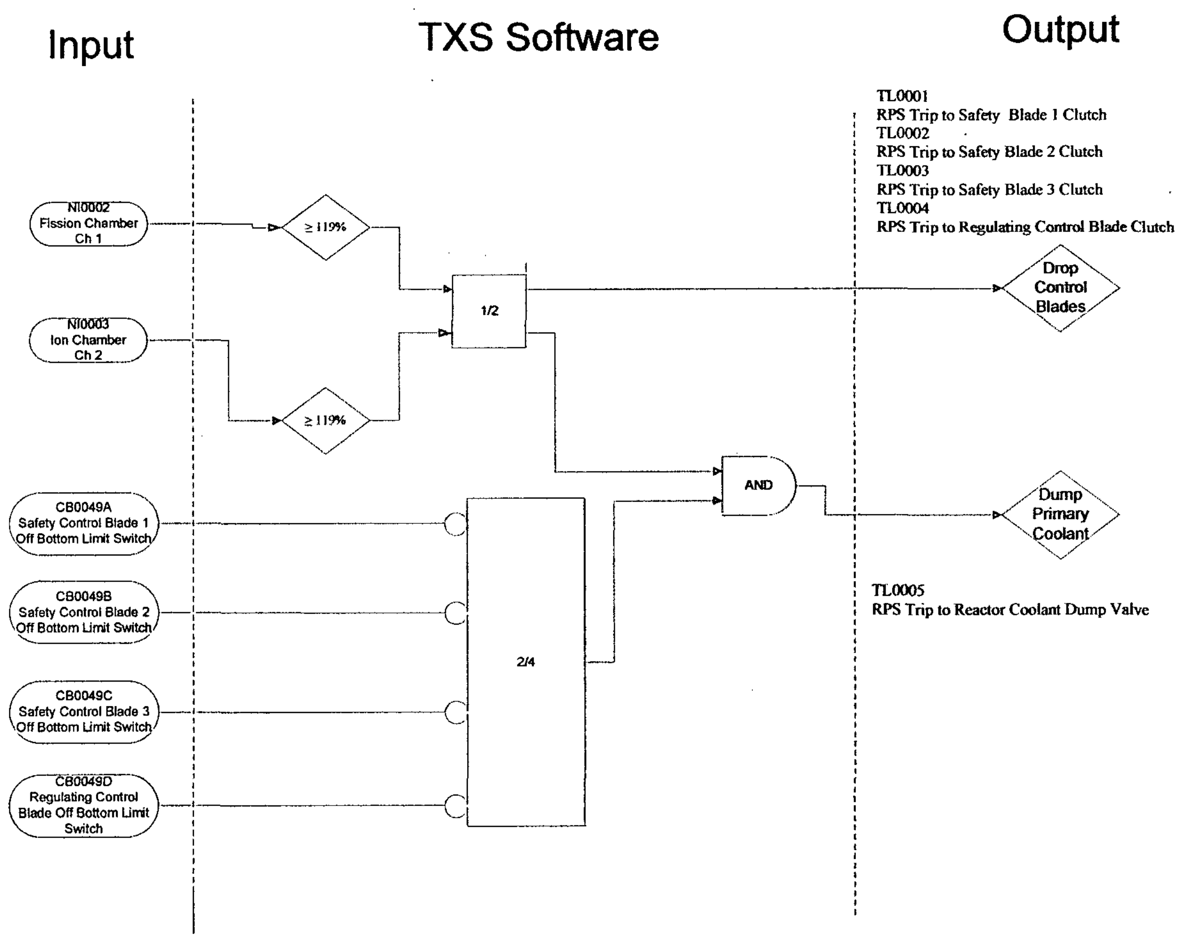
6.2.2.6 Input Signals

ID Code	Description	Physical Range	Electrical Range
NI0002	Fission Chamber (Ch 1)	10^{-8} –150% Power	4 – 20 mA
NI0003	Compensated Ion Chamber (Ch 2)	10^{-8} –150% Power	4 – 20 mA
CB0049A	Safety Control Blade 1 Off Bottom Limit Switch	Open/Closed (Off Bottom/On Bottom)	0-24VDC
CB0049B	Safety Control Blade 2 Off Bottom Limit Switch	Open/Closed (Off Bottom/On Bottom)	0-24VDC
CB0049C	Safety Control Blade 3 Off Bottom Limit Switch	Open/Closed (Off Bottom/On Bottom)	0-24VDC
CB0049D	Regulating Control Blade Off Bottom Limit Switch	Open/Closed (Off Bottom/On Bottom)	0-24VDC

6.2.2.7 Output Signals

ID Code	Description	Physical Range	Electrical Range	Destination
TL0001	RPS Trip to Safety Control Blade 1 Clutch	Open/Closed (De-energized/Energized)	0-120VAC	RTS
TL0002	RPS Trip to Safety Control Blade 2 Clutch	Open/Closed (De-energized/Energized)	0-120VAC	RTS
TL0003	RPS Trip to Safety Control Blade 3 Clutch	Open/Closed (De-energized/Energized)	0-120VAC	RTS
TL0004	RPS Trip to Regulating Control Blade Clutch	Open/Closed (De-energized/Energized)	0-120VAC	RTS
TL0005	RPS Trip to Reactor Coolant Dump Valve	Open/Closed (De-energized/Energized)	0-24 VDC	RTS

6.2.2.8 Functional Diagram



6.2.3 Nuclear Instrumentation (NI) High Voltage

6.2.3.1 General Description

The NIs are provided a bias voltage to function. This bias must be stable in order for a given power reading to be consistent over multiple cycles of the reactor.

To ensure the integrity of power indication and the associated high power trips, a reactor trip shall be initiated whenever high voltage bias to any NI is less than or equal to 90% normal value.

6.2.3.2 Description of Trip Functions

a) High Voltage to the NIs is measured by 90 % of operating voltage. If power to any NI is ≤ 90% from normal value, then a reactor trip is initiated by dropping the control blades.
b) If power to either NI is ≤90% deviation from normal value, and two or more control blades are off their low limit, then a reactor trip is initiated by dropping the control blades and the reactor dump valve is opened to remove the moderator from the core.

6.2.3.3 Description of Associated Functions

a) NI Voltage Indicator
b) NI High Voltage Scram Indicator

6.2.3.4 Set points for Trip Functions

a) Fission Chamber NI voltage ≤90 %.
b) Compensated Ion Chamber NI voltage ≤90 %.
c) BF3 Counter Voltage ≤90 %.

6.2.3.5 Algorithm for Trip Functions

IF (Fission Chamber Voltage ≤ 90% normal
OR
Primary Supply Voltage Compensated Ion Chamber ≤ 90% normal
OR
Compensation Supply Voltage ≤ 90% normal)
OR
BF3 Counter Voltage ≤90 %.
THEN
Drop Control Blades
AND
IF (2 or more control blades off low limit)

THEN

Dump Primary Coolant

END IF

END IF

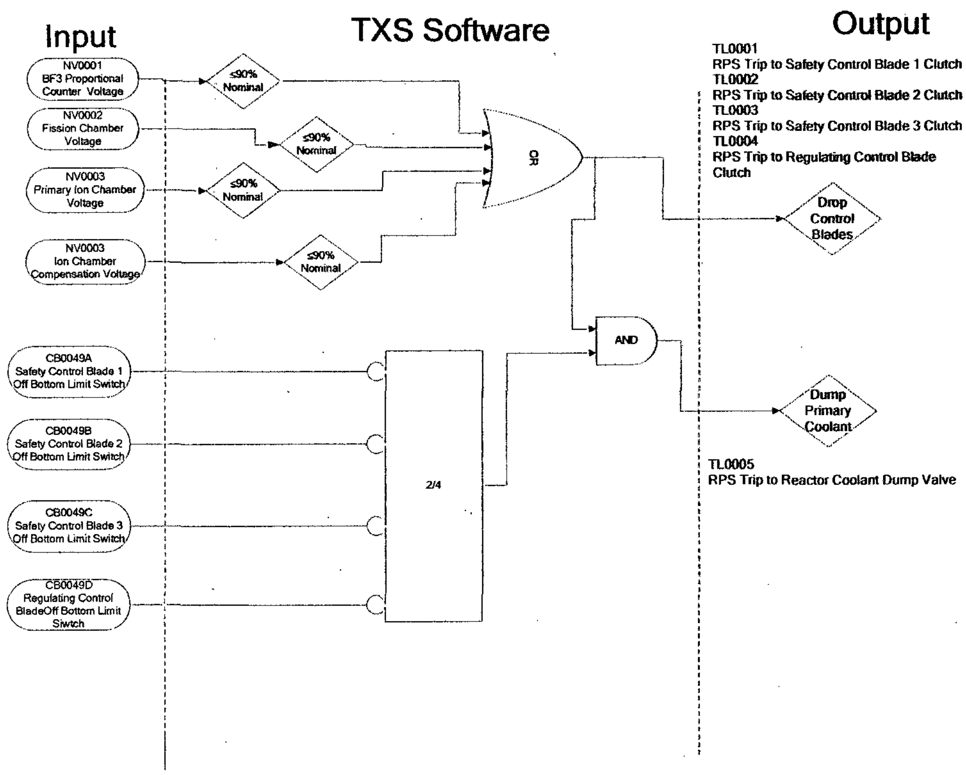
6.2.3.6 Input Signals

ID Code	Description	Physical Range	Electrical Range
NV0001	Power Supply Voltage BF3 Proportional Counter	TBD	TBD
NV0002	Power Supply Voltage Fission Chamber	TBD	TBD
NV0003	Power Supply Voltage Compensated Ion Chamber	TBD	TBD
NV0004	Compensation Supply Voltage Compensated Ion Chamber	TBD	TBD
CB0049A	Safety Control Blade 1 Off Bottom Limit Switch	Open/Closed (Off Bottom/On Bottom)	0-24VDC
CB0049B	Safety Control Blade 2 Off Bottom Limit Switch	Open/Closed (Off Bottom/On Bottom)	0-24VDC
CB0049C	Safety Control Blade 3 Off Bottom Limit Switch	Open/Closed (Off Bottom/On Bottom)	0-24VDC
CB0049D	Regulating Control Blade Off Bottom Limit Switch	Open/Closed (Off Bottom/On Bottom)	0-24VDC

6.2.3.7 Output Signals

ID Code	Description	Physical Range	Electrical Range	Destination
TL0001	RPS Trip to Safety Control Blade 1 Clutch	Open/Closed (Trip/No Trip)	0-120VAC	RTS
TL0002	RPS Trip to Safety Control Blade 2 Clutch	Open/Closed (Trip/No Trip)	0-120VAC	RTS
TL0003	RPS Trip to Safety Control Blade 3 Clutch	Open/Closed (Trip/No Trip)	0-120VAC	RTS
TL0004	RPS Trip to Regulating Control Blade Clutch	Open/Closed (Trip/No Trip)	0-120VAC	RTS
TL0005	RPS Trip To Reactor Coolant Dump Valve	Open/Closed (Trip/No Trip)	0-24 VDC	RTS

6.2.3.8 Functional Diagram



6.2.4 Loss of Offsite Electrical Power

6.2.4.1 General Description

Main Offsite AC power is monitored by an AC power relay.

If Offsite Power is lost a reactor trip is initiated by inserting all control blades into the core and the reactor dump valve is opened to remove the moderator from the core.

6.2.4.2 Description of Trip Functions

Offsite AC power is monitored by a normally energized relay. Upon loss of offsite power, the relay de-energizes and opens a contact.

The relay contact position is monitored by the protection computers. A "CLOSED" contact is interpreted as a logic value of "1", indicating power is available. An "OPEN" contact is interpreted as a logic value of "0", indication no power is present.

6.2.4.3 Description of Associated Functions

Loss of Offsite Electrical Power Trip Indicator

6.2.4.4 Set points for Trip Functions

a) Loss of Offsite AC Power = 0 (De-energized)

6.2.4.5 Algorithm for Trip Functions

IF (Offsite AC Power = 0)
THEN
Drop Control Blades AND Dump Primary Coolant
END IF

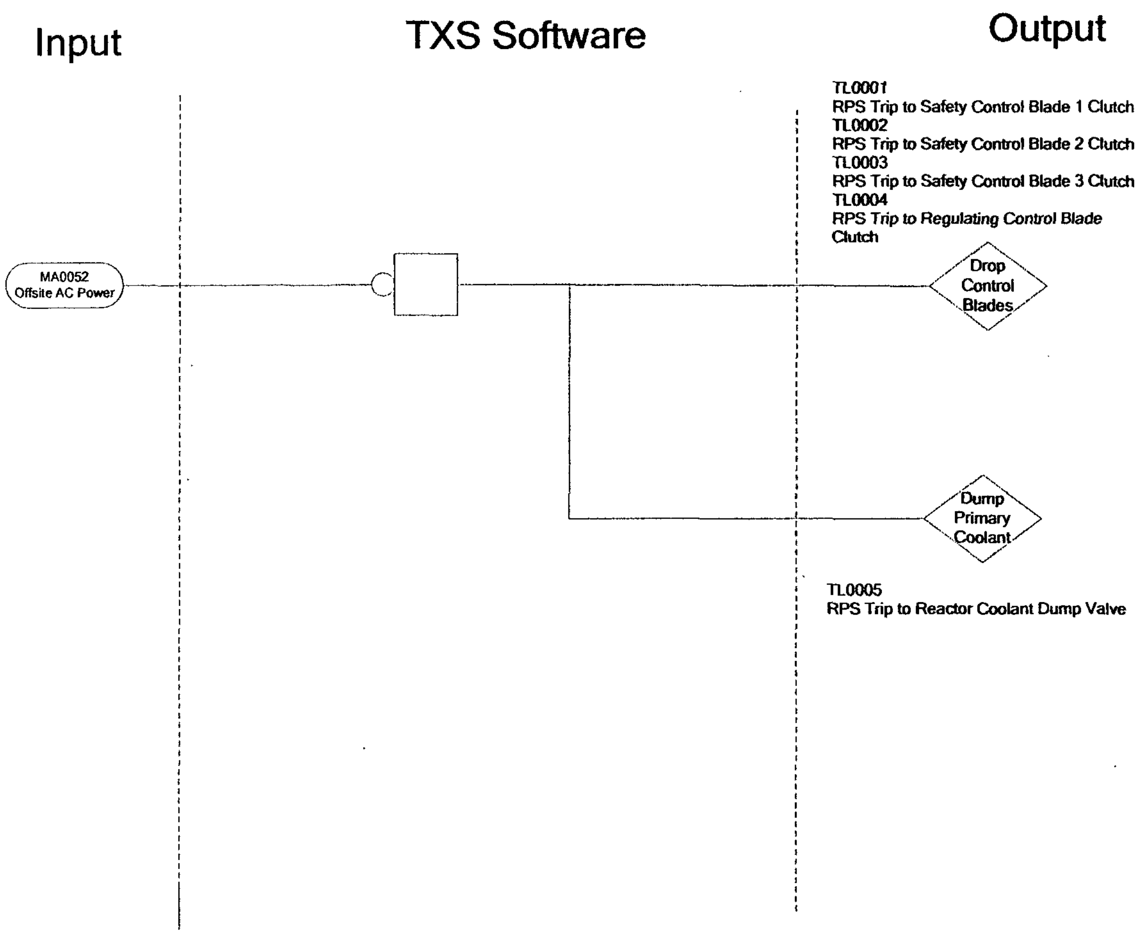
6.2.4.6 Input Signals

ID Code	Description	Physical Range	Electrical Range
MA0052	Offsite AC Power Available	Energized= 1 De-energized = 0	0-24VDC
CB0049A	Safety Control Blade 1 Bottom Limit Switch	Open/Closed (Off Bottom/On Bottom)	0-24VDC
CB0049B	Safety Control Blade 2 Bottom Limit Switch	Open/Closed (Off Bottom/On Bottom)	0-24VDC
CB0049C	Safety Control Blade 3 Bottom Limit Switch	Open/Closed (Off Bottom/On Bottom)	0-24VDC
CB0049D	Regulating Control Blade Bottom Limit Switch	Open/Closed (Off Bottom/On Bottom)	0-24VDC

6.2.4.7 Output Signals

ID Code	Description	Physical Range	Electrical Range	Destination
TL0001	RPS Trip to Safety Control Blade 1 Clutch	Open/Closed (Trip/No Trip)	0-120VAC	RTS
TL0002	RPS Trip to Safety Control Blade 2 Clutch	Open/Closed (Trip/No Trip)	0-120VAC	RTS
TL0003	RPS Trip to Safety Control Blade 3 Clutch	Open/Closed (Trip/No Trip)	0-120VAC	RTS
TL0004	RPS Trip to Regulating Control Blade Clutch	Open/Closed (Trip/No Trip)	0-120VAC	RTS
TL0005	RPS Trip To Reactor Coolant Dump Valve	Open/Closed (Trip/No Trip)	0-24 VDC	RTS

6.2.4.8 Functional Diagram



6.2.5 Primary Cooling System

6.2.5.1 General Description

The ‘Primary Cooling System’ trip is provided to protect the reactor fuel from excess temperatures caused by inadequate cooling of the fuel by the primary system. A trip is initiated whenever any of the following conditions apply.

a) Loss of primary pump power
b) Low water level in the core (≤ 42.5”)
c) No outlet flow
d) Low inlet water flow (≤ 41 gpm)

6.2.5.2 Description of Trip Functions

a) Loss of primary pump power - AC power for the Reactor Coolant Pump is monitored by Cooling Pump Power Monitor.

A relay is utilized to detect pump power status. During normal operation, the relay is energized and the contacts send a binary "1" to the RTS. The RTS recognizes this as an indication of the pump running. If power is lost to the pump, the relay de-energizes and a logic "0" is sent to the RTS. This logic state will initiate the blade-drop trip.

b) Low Water level in the core – The water level in the reactor core is measured by a reactor low level switch. The switch is open when water in the reactor is above the 42.5" setpoint. This sends a logic value "0" to the TXS. If the water level drops below setpoint, the float switch opens and a logic "0" is sent to the TXS. This logic state will initiate the blade-drop trip.
c) No outlet flow– The reactor outlet flow is monitored by a Primary Flow Switch during normal operation. The flow switch is closed and sends a logic value "1" to the safety computers (indicating normal conditions). If the Primary Flow Switch senses a loss of coolant flow, the switch will open. This produces a logic "0" to the TXS. This logic state will initiate the blade-drop trip.
d) Low Inlet Water Flow – The reactor inlet flow is monitored by the Primary Inlet Flow Sensor This sensor produces an analog signal to the TXS indicating the rate of flow. Should the indicated flow drops below the setpoint, the blade-drop trip is initiated.

6.2.5.3 Description of Associated Functions

a) Flow and Level indications
b) Primary Coolant Trip Indicator

6.2.5.4 Setpoints for Trip Functions

a) AC power to primary cooling pump = 0
b) Water level in the reactor = 0
c) Reactor outlet flow = 0
d) Reactor inlet Flow $\leq$ 41gpm

6.2.5.5 Algorithm for Trip Functions

IF ((AC Power to reactor primary cooling pump = 0)
OR
(Reactor Water Level) = 0)
OR

(Reactor Outlet Flow) = 0)
OR
(Reactor Inlet Flow ≤ 41 gpm))
THEN
Drop Control Blades
END IF

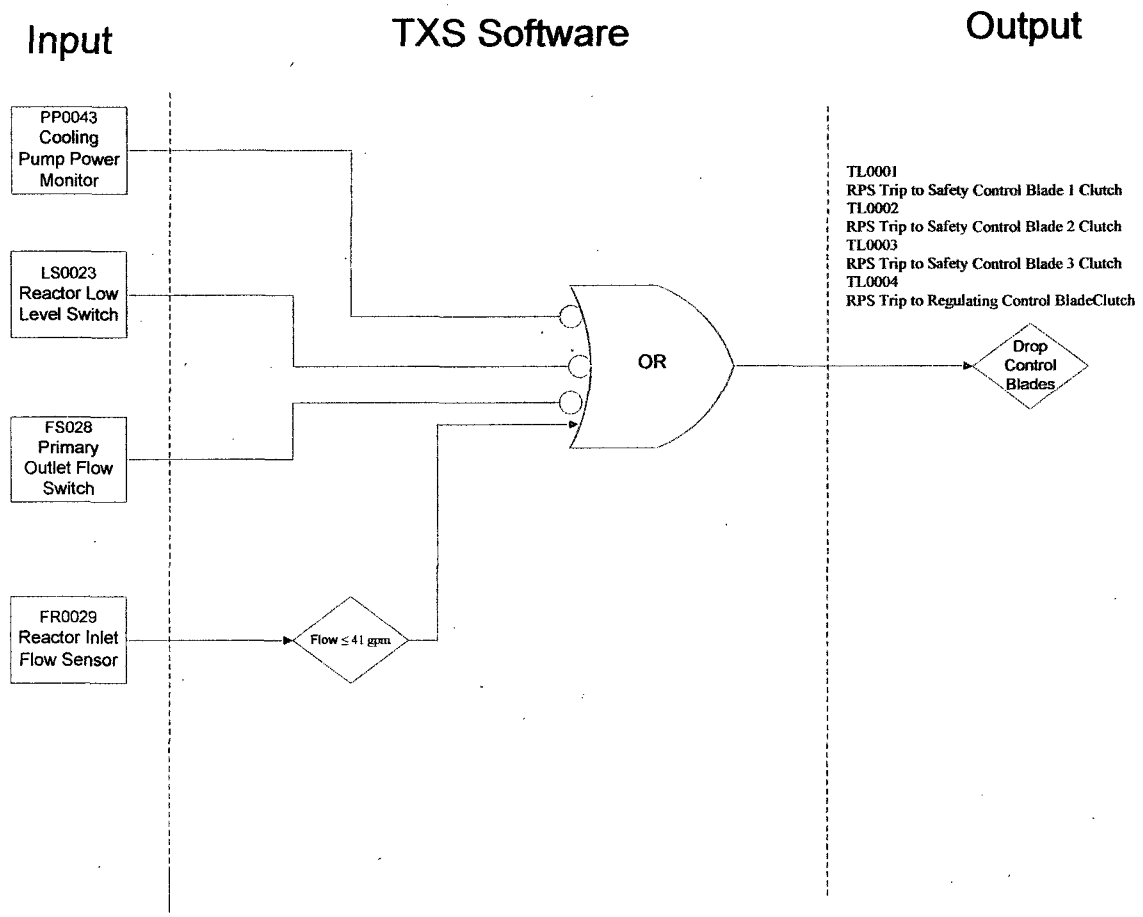
6.2.5.6 Input Signals

ID Code	Description	Physical Range	Electrical Range
PP0043	Primary Pump Coolant Power	Open/Closed (Pump off/Pump on)	0-24VDC
LS0023	Reactor Low Level Switch	Open/Closed (≤ 42.5 inches / > 42.5 inches)	0-24VDC
FS0028	Primary Outlet Flow Switch.	Open/Closed (No Flow/Flow)	0-24VDC
FR0029	Primary inlet flow sensor	0-65 gpm	4/20 mA

6.2.5.7 Output Signals

ID Code	Description	Physical Range	Electrical Range	Destination
TL0001	RPS trip to Safety Control Blade 1 Clutch	Open/Closed (Trip/No Trip)	0-120VAC	RTS
TL0002	RPS trip to Safety Control Blade 2 Clutch	Open/Closed (Trip/No Trip)	0-120VAC	RTS
TL0003	RPS trip to Safety Control Blade 3 Clutch	Open/Closed (Trip/No Trip)	0-120VAC	RTS
TL0004	RPS trip to Regulating Control Blade Clutch	Open/Closed (Trip/No Trip)	0-120VAC	RTS

6.2.5.8 Functional Diagram



6.2.6 Secondary Cooling System

6.2.6.1 General Description

Secondary system cooling is provided via well water. Loss of coolant flow or loss of power to the well pump will initiate a blade-drop trip.

6.2.6.2 Description of Trip Functions

When using the well water pump the following applies at power levels above 1 kW: If power to the well pump is lost, or well water flow is ≤ 60 gpm, the blade-drop trip is initiated.

6.2.6.3 Description of Associated Functions

Secondary Cooling Trip Indicator

6.2.6.4 Setpoints for Trip Functions

a) Well pump deenergized

b) Well Water Flow LOW (≤ 60 gpm)

6.2.6.5 Algorithm for Trip Functions

IF ((Reactor Power > 1kW
AND
Well pump power = 0)
OR
Well Water Flow ≤ 60 gpm)
THEN
Drop Control Blades
END IF

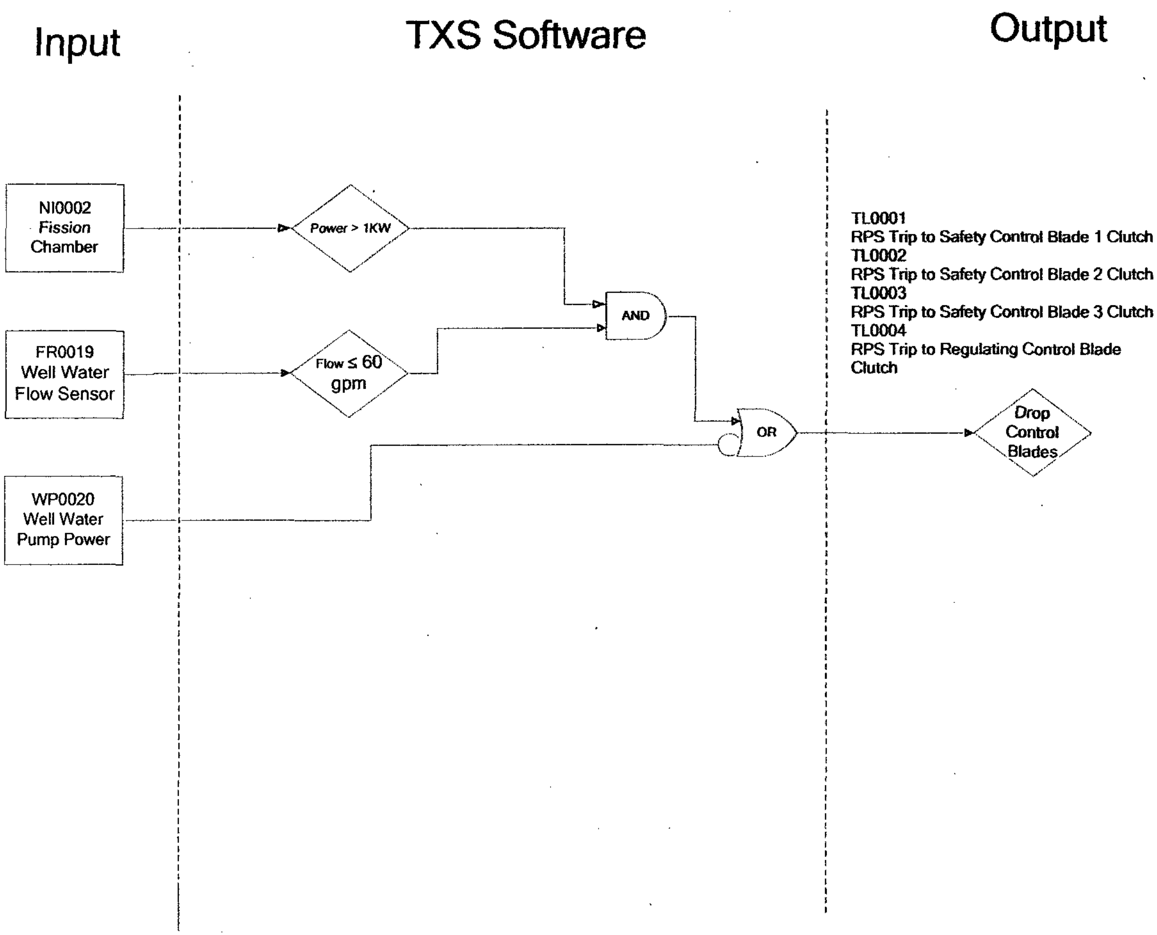
6.2.6.6 Input Signals

ID Code	Description	Physical Range	Electrical Range
NI0002	Fission Chamber (Ch 1)	10^{-8} – 150%	4 -20 mA
FR0019	Well Water Flow Sensor	≤ 60 gpm	4 -20 mA
WP0020	Well pump power available	Open/Closed (No power/Power)	0-24VDC

6.2.6.7 Output Signals

ID Code	Description	Physical Range	Electrical Range	Destination
TL0001	RPS trip to Safety Control Blade 1Clutch	Open/Closed (Trip/No Trip)	0-120VAC	RTS
TL0002	RPS trip to Safety Control Blade 2 Clutch	Open/Closed (Trip/No Trip)	0-120VAC	RTS
TL0003	RPS trip to Safety Control Blade 3 Clutch	Open/Closed (Trip/No Trip)	0-120VAC	RTS
TL0004	RPS trip to Regulating Control Blade Clutch	Open/Closed (Trip/No Trip)	0-120VAC	RTS

6.2.6.8 Functional Diagram



6.2.7 High Primary Coolant Inlet/Outlet Temperature

6.2.7.1 General Description

Coolant temperatures are measured at 6 points at the individual fuel box outlet pipes, and 2 points at the primary coolant bulk inlet and outlet piping. These points are monitored to assure that neither a power excursion nor a loss of cooling problem can occur without a thermal indication.

6.2.7.2 Description of Trip Functions

If the inlet temperature or the outlet of any fuel box exceeds the specified setpoint, the TXS actuates a blade-drop trip.

6.2.7.3 Description of Associated Functions

a) Primary Coolant inlet and outlet temperature indicators

b) Primary Coolant high inlet and outlet temperature warning indicators

c) Primary Coolant high inlet and outlet temperature trip indicators

6.2.7.4 Setpoints for Trip Functions

a) Inlet temperature ≥ 99°F

b) Fuel box outlet temperature ≥ 155°F

c) Primary outlet temperature ≥ 155°F

6.2.7.5 Algorithm for Trip Functions

IF ((Primary Inlet Temp ≥ 99°F)
OR
(Primary Fuel Box 1 Outlet Temp ≥ 155°F
OR
Primary Fuel Box 2 Outlet Temp ≥ 155°F
OR
Primary Fuel Box 3 Outlet Temp ≥ 155°F
OR
Primary Fuel Box 4 Outlet Temp ≥ 155°F
OR
Primary Fuel Box 5 Outlet Temp ≥ 155°F
OR
Primary Fuel Box 6 Outlet Temp ≥ 155°F
OR
Primary Outlet Temp ≥ 155°F))
THEN
Drop Control Blades
END IF

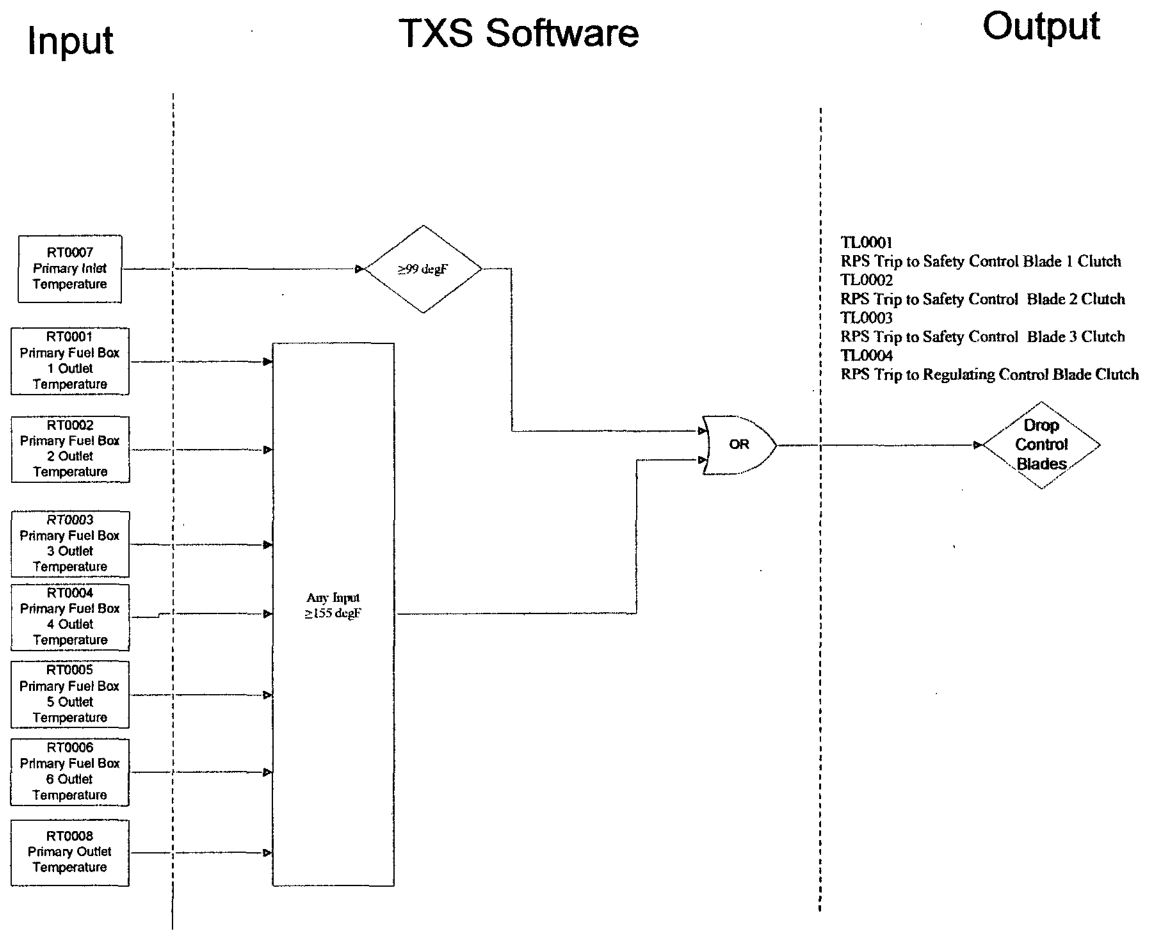
6.2.7.6 Input Signals

ID Code	Description	Physical Range	Electrical Range
RT0007	Primary Inlet Flow Temperature	0 – 250 °F	4 – 20 mA
RT0001	Primary Fuel Box 1 Outlet Temperature	0 – 250 °F	4 – 20 mA
RT0002	Primary Fuel Box 2 Outlet Temperature	0 – 250 °F	4 – 20 mA
RT0003	Primary Fuel Box 3 Outlet Temperature	0 – 250 °F	4 – 20 mA
RT0004	Primary Fuel Box 4 Outlet Temperature	0 – 250 °F	4 – 20 mA
RT0005	Primary Fuel Box 5 Outlet Temperature	0 – 250 °F	4 – 20 mA
RT0006	Primary Fuel Box 6 Outlet Temperature	0 – 250 °F	4 – 20 mA
RT0008	Primary Outlet Temperature	0 – 250 °F	4 – 20 mA

6.2.7.7 Output Signals

ID Code	Description	Physical Range	Electrical Range	Destination
TL0001	RPS trip to Safety Control Blade 1 Clutch	Open/Closed (Trip/No Trip)	0-120VAC	RTS
TL0002	RPS trip to Safety Control Blade 2 Clutch	Open/Closed (Trip/No Trip)	0-120VAC	RTS
TL0003	RPS trip to Safety Control Blade 3 Clutch	Open/Closed (Trip/No Trip)	0-120VAC	RTS
TL0004	RPS trip to Regulating Control Blade Clutch	Open/Closed (Trip/No Trip)	0-120VAC	RTS

6.2.7.8 Functional Diagram



6.2.8 Low Water Level in Shield Tank

6.2.8.1 General Description

A water level detector is located at the top of the reactor shield tank to continuously monitor the water level within the shield tank. If the water level in the shield tank diminishes to a minimum value the blade-drop trip is initiated.

6.2.8.2 Description of Trip Functions

If the level in the shield tank decreases to a preset value, the RPS will trip the reactor and cause control blades to drop.

6.2.8.3 Description of Associated Functions

a) Shield Tank Water Level Indicator
b) Low Water Level Trip Indicator

6.2.8.4 Setpoints for Trip Functions

Shield Tank Level < 160 inches (6" below normal operating level)

6.2.8.5 Algorithm for Trip Functions

IF (Shield Tank level <160 (6 inches Below Nominal)
THEN
Drop Control Blades
END IF

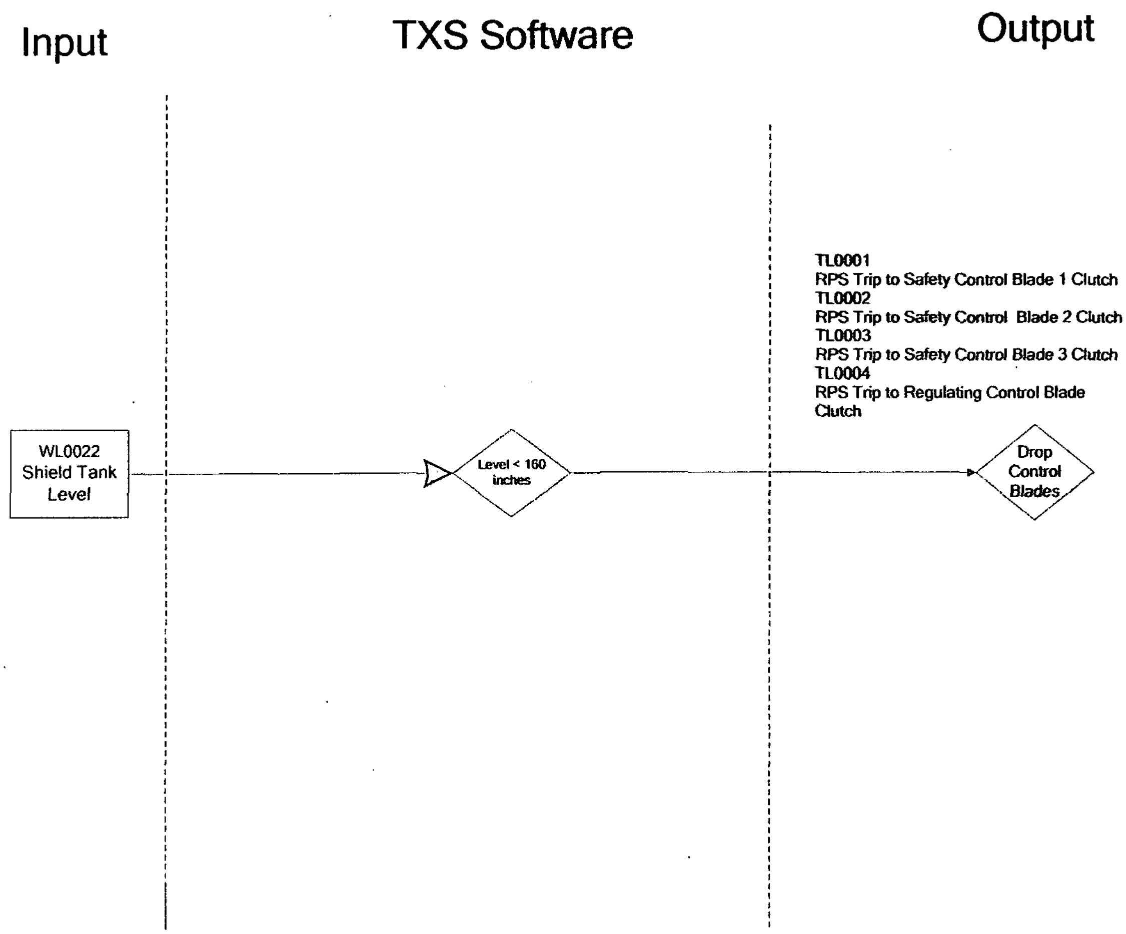
6.2.8.6 Input Signals

ID Code	Description	Physical Range	Electrical Range
WL0022	Shield Tank Level Sensor	0 – 172 inches	4 – 20 mA

6.2.8.7 Output Signals

ID Code	Description	Physical Range	Electrical Range	Destination
TL0001	RPS trip to Safety Control Blade 1 Clutch	Open/Closed (Trip/No Trip)	0-120VAC	RTS
TL0002	RPS trip to Safety Control Blade 2 Clutch	Open/Closed (Trip/No Trip)	0-120VAC	RTS
TL0003	RPS trip to Safety Control Blade 3 Clutch	Open/Closed (Trip/No Trip)	0-120VAC	RTS
TL0004	RPS trip to Regulating Control Blade Clutch	Open/Closed (Trip/No Trip)	0-120VAC	RTS

6.2.8.8 Functional Diagram



6.2.9 Ventilation System

6.2.9.1 General Description

The Ventilation System removes air from the reactor building. The air travel is from least contaminated areas to areas of higher contamination and then out of the building to ensure minimal spread of contamination to people spaces.

6.2.9.2 Description of Trip Functions

a) Upon loss of power to the stack dilution fan, a reactor trip is initiated.
b) Upon loss of power to the core vent system, a reactor trip is initiated.

6.2.9.3 Description of Associated Functions

The core vent fan is interlocked with the stack dilution fan and will not run unless the stack dilution fan is running. A deenergization of the stack fan will automatically deenergize the core vent fan.

a) Core Vent Fan shutdown signal
b) Core Vent Fan Power Fault trip Indicator
c) Stack Dilute Fan Power Fault Trip Indicator

6.2.9.4 Setpoints for Trip Functions

a) Loss of power to the stack dilution fan.
b) Loss of power to the core vent fan.

6.2.9.5 Algorithm for Trip Functions

```
IF ((Stack Dilution Fan Power = 0)
   OR
   (Vent Fan Power = 0))
   THEN
      Drop Control Blades
END IF
```

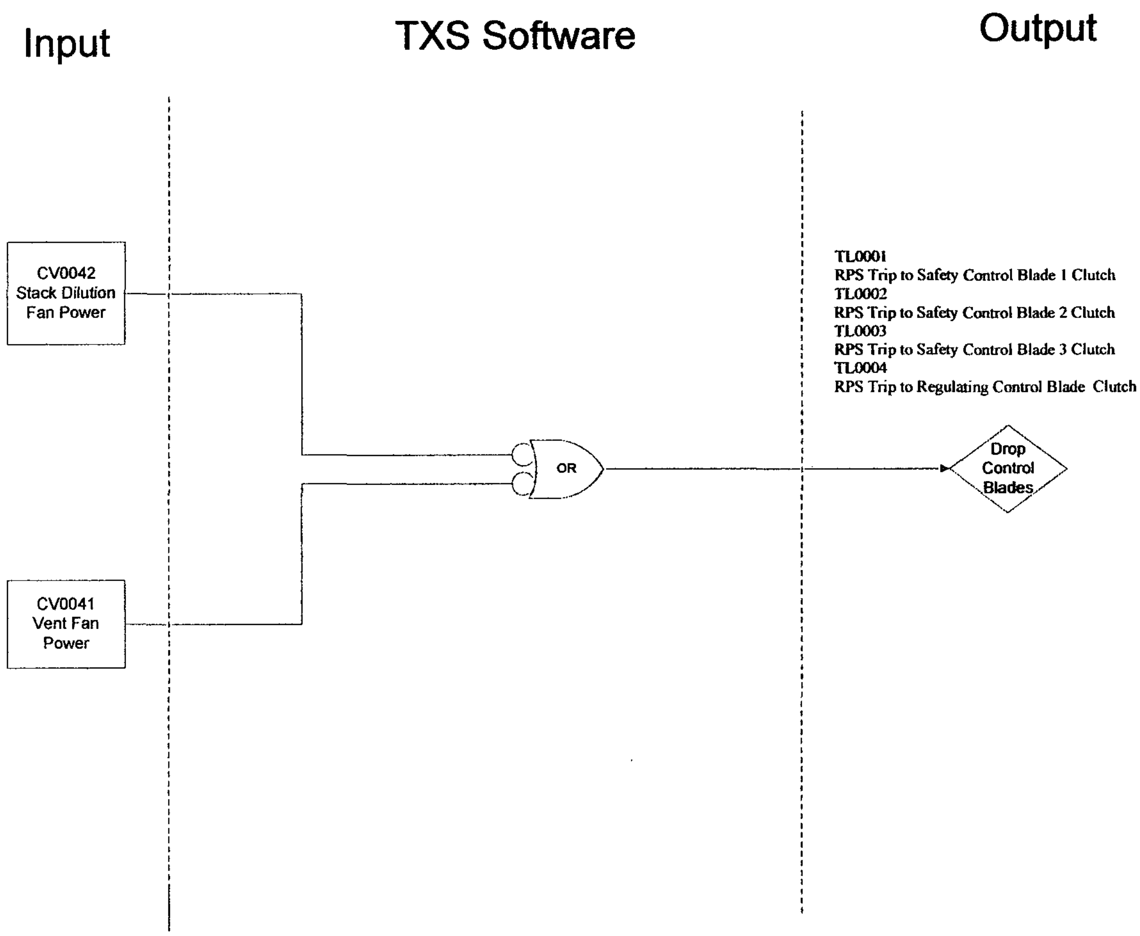
6.2.9.6 Input Signals

ID Code	Description	Physical Range	Electrical Range
CV0042	Stack Dilution Fan Power Available	On/Off (Closed/Open)	0-24 VDC
CV0041	Vent Fan Power Available	On/Off (Closed/Open)	0-24 VDC

6.2.9.7 Output Signals

ID Code	Description	Physical Range	Electrical Range	Destination
TL0001	RPS trip to Safety Control Blade 1 Clutch	Open/Closed (Trip/No Trip)	0-120VAC	RTS
TL0002	RPS trip to Safety Control Blade 2 Clutch	Open/Closed (Trip/No Trip)	0-120VAC	RTS
TL0003	RPS trip to Safety Control Blade 3 Clutch	Open/Closed (Trip/No Trip)	0-120VAC	RTS
TL0004	RPS trip to Regulating Control Blade Clutch	Open/Closed (Trip/No Trip)	0-120VAC	RTS

6.2.9.8 Functional Diagram



6.2.10 Area Radiation Monitors and the Evacuation Siren

6.2.10.1 General Description

Radiation levels in the reactor building are monitored at all times. If two or more monitors are in alarm condition an automatic evacuation and a blade drop trip is initiated. The Evacuation Siren system alerts personnel in the reactor building of an evacuation condition. The siren can be actuated manually (in continuous mode) or automatically (in lilting mode). When the Evacuation Siren starts, the stack dilution fan is tripped and the associated interlocks shutdown the core ventilation fan and HVAC. This subsequently drops the control blades.

6.2.10.2 Description of Trip Functions

a) Automatic Mode:

If two or more monitors are in alarm condition an automatic evacuation and a blade-drop trip is initiated. The evacuation siren runs in lilting mode, the stack fan will de-energize, the HVAC unit will de-energize, and the blade-drop will initiate.

b) Manual Mode:

The evacuation siren runs in continuous modes based on manual switch actuation, the stack fan will de-energize, the HVAC unit will de-energize, and the blade-drop will initiate.

6.2.10.3 Description of Associated Functions

a) Stack dilution fan shutdown signal
b) Core vent fan shutdown signal
c) HVAC shutdown signal
d) Evacuation alarm power status indicator
a) Radiation warning indicator ≥ 5.0 mR/hr for each channel.
b) Radiation alarm indicator ≥ 20 mR/hr for each channel.
c) High Radiation High Level Trip indicator.
d) Analog style and digital level display for each channel
e) Operator bypass for failed channels.

6.2.10.4 Setpoints for Trip Functions

The Radiation high level alarm is set ≥ 20 mR/hr.

6.2.10.5 Algorithm for Trip Functions

IF (≥ 2 Radiation Monitors are in alarm condition)
THEN
Drop Control Blades
END IF

IF ((Manual Siren Switch = 1)
OR
(≥ 2 Radiation Monitors are in alarm condition))
THEN
Automatic Evacuation
AND
Shut off Air Conditioning and Ventilation System
END IF

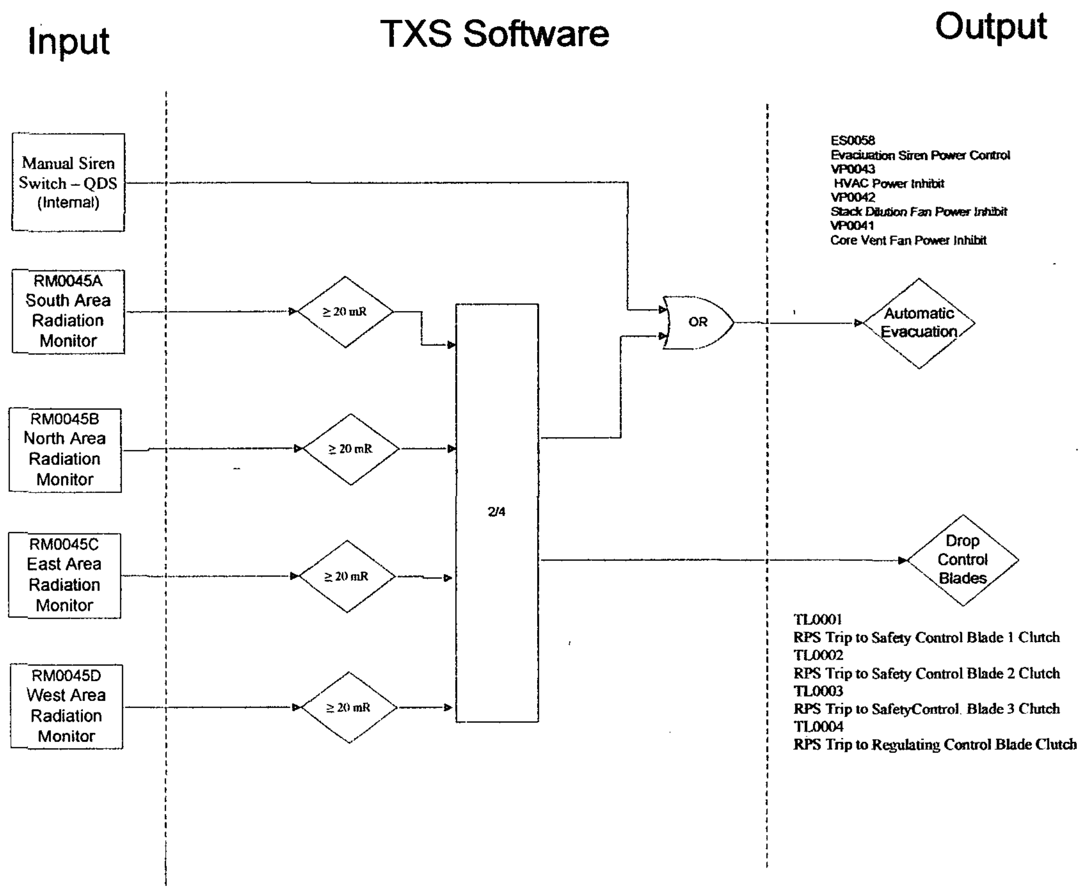
6.2.10.6 Input Signals

ID Code	Description	Physical Range	Electrical Range
RM0045A	South Area Radiation Monitor	10 μR/hr – 10 R/hr	4 – 20 mA
RM0045B	North Area Radiation Monitor	10 μR/hr – 10 R/hr	4 – 20 mA
RM0045C	East Area Radiation Monitor	10 μR/hr – 10 R/hr	4 – 20 mA
RM0045D	West Area Radiation Monitor	10 μR/hr – 10 R/hr	4 – 20 mA
internal	Manual Siren Switch – QDS	On/Off	N/A

6.2.10.7 Output Signals

ID Code	Description	Physical Range	Electrical Range
ES0058	Evacuation Siren (close to actuate)	On/Off (closed/open)	0-24VDC
VP-0043	HVAC Power Inhibit (close to actuate)	On/Off (closed/open)	0-24VDC
VP0042	Stack Dilution Fan Power Inhibit (close to actuate)	On/Off (closed/open)	0-24VDC
VP0041	Core Vent Fan Power Inhibit (close to actuate)	On/Off (closed/open)	0-24VDC

6.2.10.8 Functional Diagram



6.3 Automated Surveillance

Surveillances at the UFTR are performed based on the UFTR Technical Specifications, /6/. The surveillances are intended to ensure the reactor protective and control systems operate properly prior to reactor startup. Automatic tests of the protective system shall be initiated from the SU, while the reactor is in a shutdown condition. The tests shall consist of complete input and output signal verification and blade withdrawal interlock checks. A complete specification of these surveillance requirements will be described in the Periodic Surveillance Concept Document.

6.4 UFTR RPS Design Requirements

6.4.1 UFTR RPS Design Criteria

6.4.1.1 UFTR RPS Redundancy

The UFTR RPS does not require system level redundancy.

6.4.1.2 Separation and Electrical Independence

Redundant 24VDC power supplies will have auctioneered outputs such that should one fail the other will be capable of supplying UFTR RPS loads.

6.4.1.3 UFTR RPS I/O Interface Requirements

The UFTR RPS I/O List (Attachment #2) defines the input and output signals. The I/O List consists of analog signal inputs, discrete digital inputs, analog outputs, and digital contact outputs.

6.4.2 Interfaces – UFTR RPS Boundaries

6.4.2.1 I/O Power Supply

The I/O will be powered from a single 120 VAC UPS supply and shall be converted to 24VDC as need for the TXS equipment and other field equipment. The supplied 24VDC for TXS equipment and instrument power shall be auctioneered and designed such that a single power supply failure shall not result in a reactor trip or failure of the RPS protection function.

6.4.2.2 I/O - UFTR RPS Input Signals

The routing and wiring of plant input signals from their plant locations to the I/O field terminal block in the cabinet is the responsibility of UF. The UFTR RPS boundary exists at the field terminal block that will be provided by the RPS supplier.

6.4.2.3 UFTR RPS and Annunciator System Interface

The UFTR RPS shall utilize QDS Displays for all RPS protection related indications and alarms. The UFTR RPS shall utilize T3000 displays for all informational indications and alarms.

6.4.2.4 UFTR RPS Field Terminal Blocks

The field terminal blocks are placed in the cabinets.

6.5 UFTR RPS Technical Requirements

The following sections provide technical requirements of the UFTR RPS System and subsystems. It is noted that the upgraded digital UFTR RPS system will not be the limiting factor in meeting the specified system requirements. The UFTR RPS digital upgrade system will operate within the limits of the associated electrical and mechanical systems.

6.5.1 General Requirements

This section describes the hardware and software requirements for the new digital RPS. The new system shall include all central processing units, read only memory (ROM) and random access memory (RAM), and other I/O devices necessary to replace the existing analog equipment as well as to operate, test and make adjustments to the system.

6.5.2 Service Life

The system design shall accommodate upward compatibility of future module revisions. Suppliers shall support procurement of replacement parts/modules over the service life of the UFTR RPS. A documented policy statement regarding upward compatibility of future module revisions shall be provided.

6.6 UFTR RPS Design

6.6.1 General Layout/Architecture

As discussed in Section 6.1, the new RPS includes three blocks: TXS, MRS, and T-3000. Attachment # 4 "TXS System Diagrams" presents the TXS system including AQP, MSI, SU, QDS, and GW units and the layout of two cabinets for the proposed TXS system. It is worth noting that to prevent any inadvertent false input by the T-3000, there is only a one-way communication line from the TXS to T-3000.

The UFTR RPS shall meet the functional requirements defined by the UFTR RPS Functional Diagrams and other requirements as follows:

a) The UFTR RPS shall be a microprocessor-based system with the capability of reacting to changes of state that require trip action (or shutdown), or equipment status changes that affect the overall safety and operation of the UFTR.
b) The UFTR RPS shall be designed with the necessary security systems to prevent unauthorized operation, transfer of operation, or tampering.
c) Cycle Time - Signal processing for the UFTR RPS protection logic including the I/O response time, shall occur within 200 milliseconds or less.
d) Time critical tasks shall be performed once per cycle period, including:
    - Read all hardwired inputs (both analog and binary)

- Perform reasonability checks on input signals
- Perform routine operations and calculations, including alarms and interlocks
- Update all UFTR RPS outputs

e) Floating point math computations shall be supported.

f) Configuration tools for maintenance and modification of application software algorithms using IEC-1131, /11/, part 3 compliant function blocks and/or ladder logic programming is encouraged.

g) The UFTR RPS shall not utilize electro-mechanical devices (i.e., hard drives, optical drives, etc.) to perform its specified critical functions. Electro-mechanical devices are acceptable only in the Historian/Data Interface or other non-protection functions.

6.6.2 Signal Validation

The UFTR RPS shall include signal validation features, so as to be able to detect invalid inputs, outputs or other signals. The RPS shall have the ability to perform range checking and flagging of "out-of-range" signals. Detected failures shall be handled in accordance with Section 6.6.7.

6.6.3 Programmable Module Utilization

Each programmable module (or component or calculating module) shall have a computational reserve of at least fifty percent (50%) while running the application programs as described in this Specification.

6.6.4 Programmable Module Memory

Each programmable module shall have at least 50% reserve memory for storage of configuration and program in excess of that required for the operating requirement during maximum loaded conditions.

6.6.5 Application Software Parameters

Setpoints, coefficients, reset values, and algorithm variables shall be adjustable utilizing software using the TXS Service Unit. When an adjustable parameter can be entered from a TXS Service Unit the TXS Service Unit shall enforce the range limits on the entered value. The stated range limits on calculated values are the expected ranges of the calculated value and are not meant to imply limits unless otherwise specified. The parameter values for the Application Software shall be provided during the design phases in a Software Parameters Calculation.

6.6.6 Process Inputs/Outputs

The UFTR RPS shall interface with other systems and components and control room panels and displays. These interfaces are made with hardwired contacts or analog signals and data links of various designs. Signals for monitoring/information are also implemented with data links.

The I/O shall be isolated to provide protection to the logic voltage level systems and isolate the process devices from the computational devices where possible.

The design of I/O interfaces shall accommodate the existing field wiring (i.e., unshielded, not twisted) that may carry elevated induced voltages and current even when field contacts are open (zero (0) condition). Thus a "0" condition may read as a "1" at the I/O module interface, thus causing an incorrect UFTR RPS input. To accommodate such a condition, interposing relays (provided by others) are an acceptable means of alleviating unacceptable problems due to I/O interfaces.

6.6.7 Failure Handling

Analog signals from field sensors that deviate from predetermined parameters shall be alarmed to the QDS/Gateway.

Alarms shall occur on any process input signal fault. This includes signals that are out of range of sensor transmitter output range either high or low.

Alarms shall occur on any communications failure includes:

- Communication failure between TXS and T3000
- Communication failure between TXS and QDS
- Other failures that may be defined later.

6.6.8 Indications

All analog signals from field sensors shall be sent to the OAC gateway.
All binary signals from field sensors shall be sent to the OAC gateway.

6.6.9 Alarm, and Annunciation

The UFTR RPS shall provide the operator with appropriate and meaningful alarms and annunciations when a reactor condition is reached or as it is approached, dependent on the type and criticality of the process being monitored.

The signals critical to the UFTR operation safety will generate an audible sound to the alarm and annunciation system through the QDS/Gateway for the conditions as set forth in Table 6-3.

When possible, the signal shall be alarmed for the condition as it approaches a trip setpoint to provide the operator with warning of pending conditions. All alarms and annunciations will be ported directly to the QDS and through the Gateway to adjacent support systems (T3000) for alarm and archive.

Table 6-3 depicts Alarm Groups and Types that will be detailed during the design phase of the project. Alarms are defined into specific groupings. Display indicates where the alarm or trip will be displayed. The "ALARM TYPE" defines the condition. The "ANNUNCIATOR" defines what it is annunciated on the T3000.

Table 6-3 - Alarm and Display Groupings

ALARM GROUP	DISPLAY	ALARM TYPE	ANNUNCIATOR
Neutron Monitoring			
FAST PERIOD	QDS/T3000	HIGH/HI HI TRIP	HIGH/HI HI TRIP
HIGH POWER	QDS/T3000	HIGH	HIGH
HIGH POWER TRIP	QDS/T3000	HI HI TRIP	HI HI TRIP
LOW VOLTAGE TRIP	QDS/T3000	LOW/LO LO TRIP	LO/LO TRIP
Control Blade Status			
CONTROL BLADE TRIP	QDS/T3000	TRIPPED	TRIPPED
CONTROL BLADE OFF BOTTOM	QDS/T3000	OFF BOTTOM	OFF BOTTOM
Fuel Temperature			
FUEL BOX INLET TRIP	QDS/T3000	HIGH/HI HI TRIP	HIGH/HI HI TRIP
FUEL BOX OUTLET TRIP	QDS/T3000	HIGH/HI HI TRIP	HIGH/HI HI TRIP
Water Level			
PRIMARY COOLANT LOW TRIP	QDS/T3000	LOW/LO L O TRIP	LOW/LO LO TRIP
SHIELD TANK LEVEL LOW	QDS/T3000	LOW/LO LO TRIP	LOW/LO LO TRIP
Flow			
PRIMARY INLET FLOW LOW	QDS/T3000	LOW/LO LO TRIP	LOW/ LO LO TRIP
PRIMARY OUTLET FLOW LOW	QDS/T3000	LOW/LO LO TRIP	LOW/LO LO TRIP
WELL WATER FLOW	QDS/T3000	LOW/ LO LO TRIP	LOW/LO LO TRIP
WELL PUMP POWER	QDS/T3000	AVAILABLE/TRIP	TRIP
Fans			
VENT FAN POWER	QDS/T3000	AVAILABLE/TRIP	TRIP
DILUTION FAN AVAILABLE	QDS/T3000	AVAILABLE/TRIP	TRIP
Radiation Monitors			
AREA RAD MONITORS HIGH	QDS/T3000	HIGH/HI HI TRIP	HIGH/HI HI TRIP
Power			
AC POWER AVAILABLE	QDS/T3000	AVAILABLE/TRIP	TRIP

6.6.10 Data Stream Input/Output

The protection system shall have the ability to send data to other devices on the system data network without impeding the standard flow of protection process information within the protection system.

The data communications shall be one-way data transmission for all interfaces to systems external to the RPS.

6.6.11 Clock Interface

The UFTR RPS shall operate asynchronously in order to minimize common mode failures.

6.6.12 Historian/Sequence of Events Data Interface

All data collected by the TXS RPS shall be transmitted to the T3000 control system for archive and storage. This function should be automatic.

I/O signals indicated in the I/O List (Attachment #2) as sequence of event points shall be sent hardwired to the T3000 system for archive and storage.

6.6.13 Self Test and On-Line Diagnostics

The UFTR RPS self-test and on-line diagnostic's shall be capable of identifying failures of I/O cards, buses, power supplies, processors, and inter-processor communications paths. These features shall identify the presence of a fault, and determine the location of failure to a replaceable module level.

The Protection System shall be microprocessor based with continuous on-line, self-diagnostic and status indication capability. Diagnostic features shall include all necessary indications and alarms to allow an operator to take corrective or alternative actions. The RPS shall have the following diagnostic capabilities:

a) Continuous on-line self-diagnostics for hardware and software
b) A watchdog timer to ensure the protection system is active

Diagnostic Software shall check and verify the correct operation of the system hardware. This shall include both on-line and off-line diagnostic tools. On-line diagnostics for the hardware shall be provided by the system. Off-line diagnostics or self-test capabilities for the hardware for the system shall be included to assist in isolating problems with devices or communication links. Standard diagnostic capabilities provided in the system shall be defined, as well as any additional diagnostics that are provided in the application.

6.6.14 Component Access and Maintainability

The UFTR RPS shall be designed so that it is easily accessible to the end-users and maintenance personnel and does not interfere with physical or visual access to other equipment. System component access and maintainability shall be considered in the layout plan, with provisions for isolating components without impacting processes. All parts of the UFTR RPS shall be accessible to technicians without the need for disassembly of any portion of the system.

The UFTR RPS shall require minimal periodic maintenance (minimal calibrations each refueling outage, or less often), and shall be maintainable to the extent that as many failures as possible of the system shall be repairable by means of removing one plug-in assembly and replacing it with a spare identical plug-in assembly

The UFTR RPS shall include design features to prevent all unauthorized access or changes to the UFTR RPS hardware and software configuration. This includes lockable cabinet doors and password protection for access to system administrator functions.

6.6.15 Modular Design and On-Line Replacement

All electronic equipment shall be accessible, removable and replaceable during plant operation Modules required for a particular use will be clearly documented and locally identified both in documentation and panels. Wherever possible, electronic units shall conform to modular system and plug-in units. Sufficient modularization will be provided so that any single control system (all control panels) can be replaced of the failed system. During design, and prior to committing to fabrication of control panels, a detailed panel arrangement and wiring diagrams shall be provided. The UFTR will review and concur with the proposed modular design of connections, access to equipment, and ease of maintenance.

If circuit cards or modules are used, they shall be replaceable without affecting system safety or reliability. Provisions for testing circuit cards or modules while they are in the chassis shall be provided. Easily accessible test points will be provided in the electronic equipment in order to allow testing during plant operation.

Automatic surveillance systems shall be provided to rapidly detect and alert of any malfunction in an electronic module. The loss of power to an indicator and/or equipment in the instrument loop will cause the indicator to read off-scale to differentiate between power supply failures and other failures. All supply voltages shall be sufficiently filtered and stabilized.

6.6.16 System Grounding

Equipment Ground– The safety ground of all non-current carrying metal parts of the UFTR RPS shall be connected together electrically and shall be referred to as the "Equipment Ground."

Signal Ground (Instrument Ground) - All power supply commons and instrumentation and control signal reference grounds shall be connected together and shall be referred to as the "Signal Ground." The Signal Ground shall be of high quality and free of noise; and power conditioning and isolation shall be performed at each module to eliminate potential for ground loops.

Equipment and signal grounds shall be connected together only at a single point. At all other points the "signal ground" and "equipment ground" shall be separated, and insulated from each other, as necessary to prevent connection of the two ground systems, including when the UFTR RPS equipment may be subject to vibration conditions. All grounding shall meet the requirements of IEEE STD 1050-2004, /10/.

6.6.17 Field Wiring Interfaces

Any special cable interfaces that will connect to the UFTR field wiring shall be provided. Also, any special hardware instructions or wiring precautions shall be provided.

6.6.18 Response Time

Signal processing for the UFTR RPS protection logic, including the I/O response time and communication delays, meets the UFTR requirements.

6.6.19 Environmental Operating Conditions

The UFTR RPS Remote I/O shall be suitable for the Control Room and any special conditions identified in this Specification. Air filters, gaskets, and door seals shall be implemented at all cabinet openings as required to control dust and to ensure requisite conditions for proper function, performance, and operating life of supplied equipment.

6.6.20 Electrical Power

6.6.20.1 Power Supply Electrical Requirements

The UFTR RPS will be supplied by a single 120 VAC uninterruptible power sources. The UFTR RPS shall be capable of performing all functional requirements as specified herein with power supply variations of 120 VAC ± 10%, 60Hz ± 1%. These AREVA supplied converters will provide 24VDC to the equipment and field.

The UFTR RPS shall be powered from a single 120 VAC UPS supply and shall be converted to 24VDC as need for the TXS equipment and other field equipment. The supplied 24VDC for TXS equipment and instrument power shall be auctioneered and designed such that a single power supply failure shall not result in a reactor trip or failure of the RPS protection function

Each power supply shall be monitored and alarm actuated if a failure occurs. Loss of power detector(s) shall be provided as required to detect and alarm loss of power conditions. The UFTR RPS shall transmit loss of power alarm signal(s) to the Control Room.

The Uninterruptible Power Supply (UPS) load requirements to comply with the intent of reliability and failure immunity of the control system shall be clearly stated. Power from 120V AC single-phase feeders from the UPS system shall be provided to the UFTR RPS.

6.6.20.2 Equipment Power Consumption

The equipment power requirements for the RPS shall be provided by the RPS vendor.

The UFTR RPS shall be capable of supplying power to its lights, indicators, controllers, network and any required input/output relays. A calculation to verify that power supplies are adequately sized considering the loss of a redundant power supply shall be provided. The calculation shall document loads due to I/O, interfacing relays, UFTR RPS controllers, and the Profibus network.

6.6.20.3 Equipment Heat Loads

The amount of heat load in BTU/hr being added to the existing equipment enclosures or cabinets being supplied shall be documented early in the design of the UFTR RPS. Heat rise within the cabinet shall not exceed the UFTR RPS equipment operating capabilities.

6.6.21 UFTR RPS Cabinet Design

6.6.21.1 General Cabinet Requirements

Equipment furnished under this Specification shall be designed, fabricated, and constructed as stated herein meeting the appropriate codes and standards.

The UFTR RPS controllers shall be mounted in the cabinets shown in Attachment #4.

6.6.21.2 Cabinet Size

The cabinets shall not individually exceed 48 inches wide x 7.5 feet high (90 inches high) x 24 inches deep and shall not weigh in excess of 1000 lbs. The cabinet size shall be sufficient to contain the mounting hardware needed for redundant UFTR RPS controllers, their power supplies, control power transformers, if needed, relays, terminal blocks, fiber optic media couplers, panduit channel (panduit shall be halogen-free) and power circuit breakers.

Consideration shall be made to accommodate UFTR limitations for transporting the new cabinet to its final destination (i.e., doorways, pathways, lifting restrictions). The supplied equipment shall fit through a 36 inch man door.

6.6.21.3 Cabinet Doors

Hinged access doors shall be provided on both the front and rear of the cabinet. Dual doors shall be provided on each side. The cabinet doors shall have keyed locks for greater security to the system. Locks for both front and rear doors shall use the same key code. Spare keys shall be provided.

6.6.21.4 Cable Entry

The cabinet shall accommodate cable entry through the bottom of the cabinet.

6.6.21.5 Cabinet Grounding

The cabinet shall include an insulated ground bus for connection to ground in accordance with IEEE Standard 1050, /10/. Refer to Section 6.6.16 for additional grounding requirements. The cabinet doors shall be grounded to the same reference point as the cabinet itself.

6.6.21.6 Terminal Blocks

Terminal blocks shall be provided for all wiring entering or leaving new enclosures with the exception of wiring that must be connected directly to certain rack modules. Terminal blocks shall be rated at 600 volts, heavy duty having a minimum rating of 20 amps with marker strips for identification of all wiring. Unless otherwise approved by the UFTR, all wires shall identify termination points on both ends using white marker tags. Terminal blocks for field cable termination shall accommodate #12 AWG cable or smaller wire. Enclosures shall provide for 25 percent excess capacity for future use.

6.6.21.7 Cabinet Structure

The UFTR RPS cabinet design shall be constructed to standards of commercial grade quality. The cabinet is not required to withstand a design basis seismic event.

6.6.21.8 Labeling and Nameplate Requirements

All equipment and devices located inside the cabinets shall be identified with nameplates. Each nameplate shall clearly identify each device and reflect the same nomenclature as used on the drawings.

The nameplates shall use markings that cannot be easily altered. The markings shall have a life of 35 years and shall not fade. All operator devices mounted on the face of cabinet shall include nameplates.

Each enclosure, control panel, and major equipment item shall have a nameplate affixed to it. If mounted in an enclosure, a nameplate shall be provided on the panel so it can be accessed without opening the panel. Nameplates shall be provided for the cabinet. Nameplates shall be securely attached with screws or adhesive.

Rows inside the cabinet shall be labeled and indexed from top to bottom. Module mounting positions within the cabinet shall be labeled and indexed from left to right.

6.7 Wiring

6.7.1 Equipment Wiring

All equipments shall be completely wired, with all UFTR connections identified on the approved drawings and brought out to terminal blocks for connection.

6.7.2 Cabinet Wiring

Terminal blocks shall be mounted in accordance with NEC regulations. Any wire bend radii shall meet any pertinent NEC or IEEE regulations.

6.7.2.1 Wiring Terminations for Cabinets

No more than two (2) wires shall be terminated on one side of any terminal. Only one wire shall be crimped into any crimped connection. Minimum bending radii shall be in accordance with NEC requirements.

6.7.2.2 Splices or Tee Connections for Cabinets

All wiring shall be point to point, without splices or tee connections. Power, control, and low level signal wiring shall be segregated within the panels.

6.7.2.3 Wiring/Cable Protection for Cabinets

The wiring, except at doors, shall be in conduit or neatly tucked in raceways and adequately supported to prevent damage. Suitably flexible wiring, bundled and protected from damage, shall be provided over doors and other locations where the leads are subject to flexing. Cable entrances shall have molded trim at steel edges to prevent tearing of cable jackets during installation.

6.7.3 Electromagnetic Shielding

Electromagnetic shielding shall be provided on all signal sensitive wiring. Low-level signal wiring and sensitive instruments shall have electrostatic and magnetic shielding to reduce the possible effects of electromagnetic noise. Shielded, twisted, 300 Volts rated instrumentation cable shall be used. The minimum size for single pair or single triad instrumentation cable shall be No. 16 AWG stranded copper.

6.7.4 Terminal Blocks, Wire and Device Markings

All terminal blocks, wires and devices shall be permanently and uniquely marked. Wire markers shall be the slide on heat shrinkable tubing type. Adequate space shall be provided on both sides of terminal blocks for connection wires and wire markers. To allow for stripping and bending of incoming cables, terminal blocks shall be located a minimum of 8 inches away from the top and/or bottom of panels.

6.7.5 Fiber Optic Cables

Fiber optic cables shall be the glass fiber type with ST connectors.

6.7.6 Control Wire

a) Switchboard wire rated at 600 Volts, stranded copper with heat, moisture, and flame resistant, cross-linked polyethylene insulation, Type SIS or approved equal, for control wiring shall be provided.
b) Control wiring, which terminates at field interface terminal blocks, shall be single conductor, No. 14 AWG minimum with flexible stranding.
c) Wires associated with DC and AC control circuits shall have adequate short circuit protective devices.
d) All wire shall be free from abrasions and tool marks and shall have a minimum bending radius of ¼ inch.
e) Wire bundles shall not exceed 1¼ inch in diameter. All wires shall be adequately supported to prevent sagging and breakage.
f) All wires within a panel or unit shall be continuous.
g) Electrical control wiring and low-level signal wiring shall be run in separate raceways. These raceways shall not contain wires associated with power, lighting, and heating. If accidental short-circuiting of certain wires can result in malfunction of equipment, these wires shall not be terminated on adjacent terminal block points.

h) Permanent print wire markers using heat-shrinkable tubing shall be provided on both ends of a wire with designations in accordance with the approved and issued wiring diagrams.

6.7.7 Overloads and Short Circuit Protection

Circuits shall be adequately protected against overloads and short circuits. The wire type and size shall be consistent with the requirements of the circuit in which it is installed. Means for the detection of blown or open-circuited fuses shall be provided.

6.7.8 Wiring of Spare Devices

All spare contacts on relays and auxiliary switches shall be wired to terminal blocks future connections.

6.7.9 Wire/Cable Insulating Materials

Insulating materials shall be flame retardant. All wiring shall meet the requirements of vertical flame test as per UL44.

6.7.10 Segregation of Wiring by EMF Type

Connections of different voltage levels shall be segregated and grouped, according to the voltage level.

6.7.11 Torque Requirements

Torque requirements/values for all bolted connections shall be supplied in the instruction manual.

7. Software Requirements

This section describes the required characteristics of the operating system, application software, software utilities and database of the system. The UFTR shall develop and supply all applications software required to satisfy the functional requirements of the UFTR RPS system described within this Specification.

7.1 General

All the UFTR RPS software shall be installed and operated, and completely documented according to the UFTR QAPP, SCMP, SQAP, SSP, and related documents specified by the QAPP.

The RPS Supplier shall provide a license for all software applicable to all systems used at site including separate maintenance support equipment.

Future revisions to software design will not affect the successful operation of the system (i.e. backward compatible). All revisions will have a unique version name and number for tracking purposes.

7.2 Application Software

The application software shall meet all the UFTR RPS functional requirements as specified within this Specification.

The application software shall emulate the protection logic described in the functional diagrams and as described within this Specification.

The application software shall provide all functional improvements described herein.

Existing UFTR RPS documentation that may be useful to aid in the development of the application software shall be used to the extent practical. This shall include UFTR RPS elementary diagrams, logic diagrams and drawings for the existing system, UFTR RPS operating procedures; I&C's calibration, maintenance, and tuning procedures; operator and maintenance training literature, and any other information that may be deemed useful.

7.4 Software Development Tools & Utilities

The utility software shall operate on-line without jeopardizing other system functions.

It shall include the necessary system tools such as compilers, debuggers and other utility programs that were used in software development. Software tools may include simulator software that can aid with off-line testing and debugging of software and logic.

7.5 Software Design Characteristics

This section specifies characteristics of system software. These characteristics apply both to the software associated with the platform and to the application software developed to implement UFTR requirements.

7.5.1 Use of Standard Software

The UFTR RPS system software and development software shall be a standard offering from the RPS vendor.

7.5.2 Use of Programming Languages

Programming techniques shall conform to industry programming standards and conventions suitable for developing and configuring software for nuclear station systems. The system software shall be written in high-level language(s) to the greatest extent possible. Use of a graphical language such as IEC 1131-1993, /11/, type function blocks is required for application software.

7.5.3 Modularity

All software shall be designed with sufficient modularity to minimize the time and complexity involved in making a change to any program. Communication among programs for data or program control shall be symbolic rather than absolute so that a given program is essentially an independent unit. Changes required in one program necessitated by changes in another shall be minimized.

7.5.4 Maintainability

For commercial off-the-shelf products from major equipment manufacturers, the RPS vendor shall not alter or have the equipment manufacturer alter any associated firmware included in these products.

7.5.5 Data Validation

The software shall contain logic to perform integrity checks on the validity of the input values and on the validity of any intermediate results. This system check shall try to limit/inhibit the output of erroneous results. There shall be no known input value or combination of known input values to the system that will cause any system processor to cease functioning.

7.5.6 Expansion

The software package shall initially be sized to support the current configuration of I/O processing and logic and shall be design so as to accommodate future expansion of the system.

7.5.7 The I/O Processing

The operating system shall contain all of the device handler software necessary to support all of the different hardware devices included in the system. The RPS device handlers shall conform to coding standards and be callable by normal programs.

7.5.8 Processor Restart and Initialization

Software shall be able to restart or initialize the execution of the system functions. Restart and initialization shall be protected from unauthorized initiation. Initialization shall be a complete system initialization and shall normally take less than 5 minutes. The system shall be designed to minimize the necessity for complete system initializations.

8. Materials

All materials and special processes requirements identified in Section 6.5 shall apply to the supplied cabinet and UFTR RPS equipment.

9. Spare Parts

A complete list of components and parts and available replacements shall be provided. The UFTR shall update this list as required as parts become obsolete to enable the UFTR to locate and purchase equivalent replacements.

9.1 Commissioning

A documented list of spare parts inventory necessary to support the pre-commissioning and/or startup testing period for the system(s) shall be provided. This list shall include pricing, availability, lead time, and recommended number of spares.

9.2 Maintenance

A documented list of spare parts inventory necessary shall be provided. This list shall be appropriate to insure that downtime experienced as a result of single component failure is minimized and that availability can be maintained. This list shall include pricing, availability, lead time, and recommended number of spares.

10. Training

10.1 General

The RPS supplier will offer a training program that shall cover all equipment and address engineering, operating, and maintenance aspects of the complete system. Engineering training shall be conducted on a schedule established the UFTR at project initiation. Operations and Maintenance training shall be conducted following shipment of equipment on a schedule established by the UFTR prior to system turnover for operation.

10.2 Scope of Training

The RPS supplier shall provide the following training including, but not limited to engineering, operations, maintenance and installation of equipment:

a) Engineering and Maintenance Personnel:

1) Basic UFTR RPS components
2) UFTR RPS interface and configuration
3) UFTR RPS trouble shooting and repair
4) UFTR RPS preventive maintenance
5) Application software
6) Communication software
7) Access to and interpretation of faults, alarms, and failure information from human-system interface

b) Operations Personnel:

1) Operation from the control room and engineering workstation
2) Faults and alarm annunciation
3) Resetting alarms and faults from the control room

11. Fabrication and Assembly

The RPS supplier shall conform to fabrication and assembly requirements identified in Section 6.6 for the RPS supplier providing cabinets and UFTR RPS equipment. These items must use the kind, make and quality of components and materials set forth in the UFTR Specifications. They shall be in strict accordance with the Specifications and plans. If it becomes necessary to use materials other than those specified, the alternates must be approved by the UFTR before being incorporated in the work.

12. Enclosures, Cleaning and Painting

12.1 UFTR RPS Enclosures

Enclosures for the UFTR RPS shall meet the following requirements:

a) All non-galvanized surfaces shall be primed and finish painted.
b) All welding shall be finished and properly cleaned prior to painting.
c) Door systems shall be hinged and mechanically lockable.
d) Full height doors shall be mechanically locked in at least three locations (top, center, and bottom).

12.2 Enclosure Climate Control

a) Enclosures shall be adequately ventilated by means of louvers or some other device to permit ample circulation of air within the enclosure to maintain temperature at allowable limits. These ventilation ports shall be designed to prevent the entry of insects or rodents.
b) Enclosures shall be equipped with a ¼-inch x 1-inch copper ground bus for equipment grounding. If required, a separate insulated ground bus shall be provided for low-level signal wiring.
c) All insulated ground buses shall be radially connected and grounded with a No. 6 AWG minimum, 600 Volts insulated, copper conductor to a common insulated ground bus, which will be tied to a single point, according to Section 6.7.12.
d) All bus work or exposed conductors shall be adequately supported or braced within enclosures to withstand short circuits.
e) All instrument supporting surfaces shall be adequately reinforced to withstand buckling or sagging. Instruments such as switches, meters, or indicating lights shall be surface mounted.
f) Relays shall be mounted inside enclosures and shall be freely accessible for maintenance or testing.
g) Dedicated wire-ways shall be provided for power, control, and instrumentation circuits.
h) Adequate spacing and supports shall be provided to terminate and support UFTR cables. UFTR I/O Interface and Power cables will enter from the bottom of the enclosure.
i) Terminal blocks shall be arranged to minimize congestion and be freely accessible.

12.3 Painting of Enclosures and Parts

RPS Supplier shall provide standard Paint Specifications to the UFTR for approval prior to fabrication.

Manufacturers paint instructions shall be followed during surface preparation, application, drying, and handling.

13. Testing and Qualification

13.1 UFTR RPS Testing

The UFTR or a representative shall have the option to be present when test(s) are performed or test results are analyzed.

All testing shall be performed in accordance with written procedures whether by the UF or by the RPS Supplier. Each procedure shall contain the following as a minimum:

a) Test Objectives
b) Prerequisites
c) Precautions and Limitations
d) Required test equipment, test equipment calibration and calibration control procedures and data
e) Detailed step by step instructions for the conduct of the tests
f) Acceptance Criteria for determining acceptability of test results
g) Test Results
h) Test non-conformances and anomalies
i) Actions required if results do not meet the acceptance criteria or testing difficulties are encountered
j) Actions to take to conclude the testing
k) A test log for person(s) conducting the test to record significant observations during the test
l) Date and Signature - Places for the person(s) conducting the test and person(s) reviewing, and approving the test results to sign and date the completed procedure.
m) Any other section that the UFTR seems necessary.

13.2 Factory Acceptance Test

Standard factory tests shall be performed. These tests shall to include the following:

a) Printed circuit board inspection and test
b) Point to point wiring tests
c) Insulation tests
d) Power supply loading tests
e) System tests
f) Failure detection test
g) Single failure immunity tests

Tests shall be performed in accordance with written procedures. All test procedures shall be prepared by the UFTR. Revised tests shall be performed only in accordance with written procedures. No tests shall be performed without prior approval.

All anomalies observed during testing shall be documented, along with all actions required to resolve the anomaly. Testing shall be repeated as required to demonstrate that anomalies were successfully resolved. Equipment and software shall not be considered acceptable for shipment or use until all required testing has been successfully completed with all acceptance criteria satisfied.

13.3 Installation, Post Modification Testing, & Commissioning

The equipment and associated system software intended for use in the UFTR shall be tested at the factory, per Section 13.1, prior to shipment to UF, and tested again after installation by the UFTR.

A final startup and commissioning plan shall be completed and approved before scheduled installation and testing.

The UFTR will review the plan, provide comments and approve.

The final startup and commissioning plan shall indicate the minimum time required to perform the tests.

The intent of the final site acceptance test (SAT) is to demonstrate that the system meets the requirements including any modifications deemed necessary to be implemented during the course of the design, installation or commissioning. All required modifications identified during factory or UFTR testing shall have been made to plant equipment prior to performing the SAT.

The UFTR shall be responsible to prepare and perform the test procedures required for all functional testing. UFTR testing shall demonstrate that the new UFTR RPS can perform all UFTR RPS functional requirements within acceptable limits.

The RPS supplier will have available experienced and qualified, site designated installation and commissioning personnel who will be active in providing technical direction for equipment installation and mechanical completion, performance and acceptance testing.

The intent of these Specifications is to ensure adequate numbers of competent RPS Supplier representatives are available to meet the UFTR schedule from a point prior in time to the delivery of the equipment through installation and mechanical completion, commissioning, performance testing, and final Acceptance and commissioning.

13.4 Repair and Re-Testing

If the UFTR RPS fails to pass any test, additional tests shall be performed to determine the cause of the failure. After repair or replacement of failed parts, the test that initially failed shall be repeated to ensure that the repaired UFTR RPS meets the Specification in all respects.

The UFTR project team including the UFTR and the RPS supplier shall review any items where the test failed.

Testing or regression testing shall be performed as described in the test plan and in accordance with V&V requirements.

The RPS supplier and the UFTR shall keep a record of all failures found during or after tests, rework or repair, and test data taken after repairs have been completed.

Instruments used to measure and record tested variables and quantities shall be those, which are regularly calibrated using the UFTR QA program, including standards traceable to a National Standard. Records of such calibrations shall be documented and available for inspection. If instruments are not regularly calibrated, they shall be calibrated immediately before and after each test using standards traceable to a National Standard.

Each test procedure shall be submitted for approval by the UFTR.

Complete test reports shall include the identification of components requiring maintenance and/or replacement during testing that may have been required to enable the equipment to be operable and/or maintain or extend equipment life.

14. Shipping and Handling

Packing and shipping from the RPS supplier plant to the UFTR or other designated destination shall be the responsibility of the RPS Supplier. (All parts, supplies and shipments of TXS are FOB origin).

14.1 Packing Requirements

The equipment shall be adequately protected to prevent damage to components during handling, shipping, and storage. The equipment shall be appropriately packaged to meet the requirements of ANSI/ASME N45.2.2 for items classified Level B. Packaging shall be subject to review and approval by the UFTR.

14.2 Shipping Requirements

All equipment, parts, materials, and documentation described in this Specification shall be prepared for shipment in accordance with ANSI/ASME N45.2.2 for items classified Level B. Each package, crate, or part shall be clearly marked showing the name of the consignee shipping destination, order number, and such other markings as required. Complete packing lists shall be supplied, showing the contents and identity of each package. One copy of the list shall be securely attached to the outside of each shipping unit, and two copies shall be sent by mail to the UFTR at the time of shipment.

After cleaning and drying, all openings shall be closed immediately with tight-fitting covers, which are to be firmly secured in place and arranged so that no dirt or moisture can enter the equipment during transit or storage. All fittings and openings shall be sealed.

Unless otherwise approved by the UFTR, a desiccant shall be packaged with the equipment where moisture in the equipment is particularly harmful. Equipment supplied with internal desiccants shall have a tag with a statement to that effect.

When containers are used, make provision to ensure that containers are protected from punctures. Extended equipment parts subject to damage shall be suitably protected against mechanical abuse.

15. Documentation

Documents shall be submitted to the NRE Department to facilitate:

a) installation the equipment in UFTR,
b) proper application of the equipment,
c) interface with existing/to-be-modified/new structures and systems,
d) proper operation of the equipment,
e) interface with regulatory organizations, which have jurisdiction, and
f) maintenance of the equipment.

15.1 General

A Certificate of Conformance (CoC) will be supplied with each relevant shipment. RPS Supplier shall provide the following information:

a) Equipment weights of all components
b) Electrical power requirements of all components
c) Acceptable environmental conditions (pressure/temperature/humidity) for the control system
d) Heat loads generated by the control system
e) Special testing equipment

The following Supplier (or other Vendor) information shall be located in the standard title/revision block location (lower right-hand corner of drawing):

a) Vendor's name
b) Vendor's drawing number and, if applicable, sheet number
c) Vendor's drawing revision number and date
d) Vendor's drawing title

All documents shall be identified with the UFTR, NRE Department:

a) Name
b) Purchase Order Number
c) Equipment Identification Number

Drawing submittals shall be accompanied by a transmittal letter. Each letter shall contain the following minimum information for all drawings submitted:

a) Vendor's name
b) Vendor's drawing number and, if applicable, sheet number
c) Vendor's drawing revision number
d) the NRE Department purchase order number
e) the UFTR project name and unit number
f) Equipment identification number

Vendor shall provide a list of all drawings, data, information and documents required. List shall include expected submittal schedule.

Drawings shall be submitted electronically. Final copies of all approved drawings and documents shall incorporate all review.

All documentation provided to the UFTR from the RPS Supplier or any of its sub-suppliers shall be in the English language with measurements based on the U.S. Customary System of units. Specific exceptions may be permitted with prior approval from the NRE Department.

Although USCS units are preferred, an exception is granted for the use of non–USCS units (e.g. metric units) on certified material test reports.

15.2 Required Submittals

15.2.1 System Design Description

The UFTR shall develop a System Design Description (SDD), which may consist of text, tables, drawings, etc. This SDD shall provide a detailed description of the system configuration and logic for operation.

15.2.2 Analysis and/or Test Reports Required per this Specification

a) Engineering Studies and Calculations performed for the UFTR RPS
b) Software Verification and Validation Report or Software Test Report

15.2.3 Software

All application software documentation shall include functional descriptions, detailed design descriptions, program flow charts or equivalent, application code, detailed operating instructions, database descriptions and descriptions of all hardware and software interfaces, but not be limited to, the items listed below:

15.2.4 Software and Firmware Documentation Inventory

This inventory shall be maintained throughout the project and shall include software title, version and manufacturer's name. Software and firmware revisions required throughout the project shall be clearly identified with reason for revision, and installed versions shall be controlled to ensure correct installed revision.

15.2.5 Software Licenses and Inventory of Licenses

Software Licenses shall be supplied and an Inventory of Licenses with any special requirements and descriptions shall be maintained.

15.2.6 Verification and Validation (V&V) Documentation

V&V documentation shall be developed and maintained by UF in accordance with IEEE Std. 1012, /9/. A statement of conformance shall be initiated for the V&V documentation not issued.

15.2.7 Reference/User Manuals and Instruction Books for all Software

15.2.8 Certification Software is Virus-Free

15.2.9 Software Quality Assurance Plan (SQAP)

A software quality assurance plan in accordance with IEEE Std. 730-1998, /8/, shall be in force during software designed and development phases of the project. Additional documentation shall also be developed that includes the following documentation during project execution:

a) Software Safety Plan (SSP)
b) Software Verification and Validation Plan (SVVP)
c) Software Configuration Management Plan (SCMP)
d) Software Test Plan
e) Software Integration Plan
f) Software Installation Plan
g) Software Operation and Maintenance Plan
h) Software Training Plan
i) Software Audit Plan
j) Copies of all completed Tests.

15.2.10 Software Changes, Test Failures, and Resolution Documentation

Documentation of all software changes, software test failures, and resolution from the start of the Testing until completion and acceptance of the site installation testing.

15.2.11 I/O List

The I/O list (Attachment #2) includes basic functional description and any alarm or trip parameters.

15.2.12 Hardware Documentation Inventory

This inventory shall be maintained throughout the project.

15.2.13 Bill of Material (BOM)

A Bill of Material (BOM) listing all hardware will be supplied including the manufacturer's name and model number. Serial numbers shall be documented on the BOM unless it is a self documenting feature of the system, which is available on a real time basis.

15.2.14 Others

Other documentation that shall be obtained and maintained:

a) Instruction Books, both paper copies and electronic formats
b) Recommended On-site Parts list
c) Certificates of Compliance
d) Warranty certificates

15.2.15 Instruction Books (Maintenance Manual)

The Instruction Book (electronic copy) shall provide detailed and specific (not "typical") information for all equipment to be furnished. Advertising brochures or technical information on other equipment shall not be included as a part of the instruction book.

The instruction book shall address all commissioning procedures, tests, and onsite measurements deemed necessary to assure reliable performance of the energized unit.

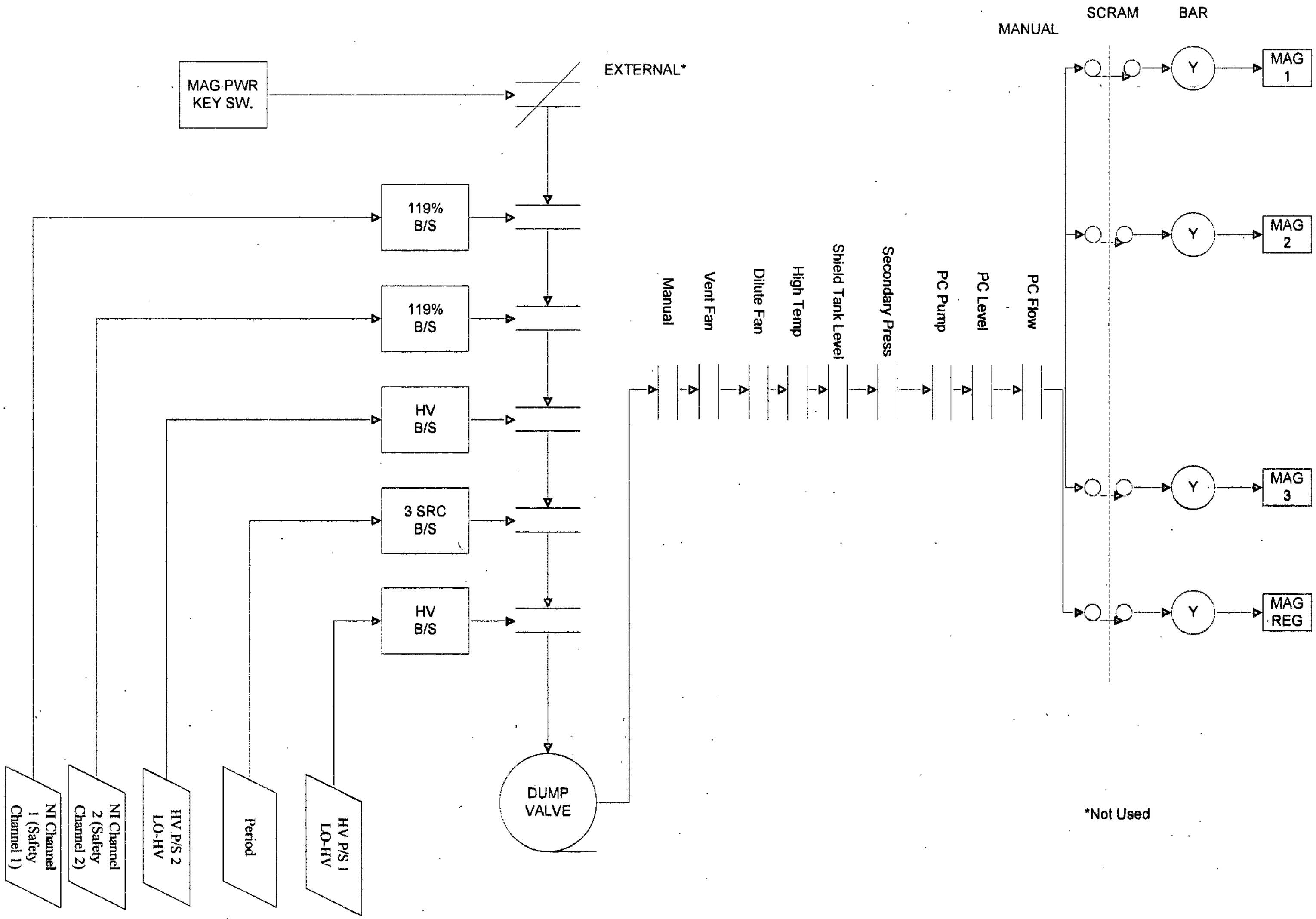
The requirements for handling the equipment at the job site shall include such data as location of balance point, jacking points, and lift points, type of hoisting sling and methods of attachment, use of spreader bar, susceptibility to shock damage and precautions concerning possible contamination. If dimensions and locations are not easily defined otherwise, a drawing or sketch should be included.

The requirements for storing the equipment at the job site shall cover such items as inside or outside storage, temperature and humidity control, and any other precaution considered pertinent to insure the integrity of the equipment or material.

15.2.16 Test Reports

Certified reports are required for all tests specified herein.

Attachment 1. UFTR RPS General Arrangement Diagram



Attachment 2. I/O List

	I/O Type	TAG-ID	Initial TAG Info ONLY	Safety	Non Safety	Hard/Soft	VENDOR	DESCRIPTION	SOE	Comment
								Nuclear Instrumentation		
1	AI	NI0001	NI-001	S		Hard	AREVA	BF3 Proportional Counter (Ch 1)		Input to NI Electronics
2	AI	NI0002	NI-002	S		Hard	AREVA	Fission Chamber (Ch 1)		Input to NI Electronics
3	AI	NI0003	NI-003	S		Hard	AREVA	Compensated Ion Chamber (Ch 2)		Input to NI Electronics
4	AI	NV0001	TBD	S		Hard	AREVA	Power Supply Voltage BF3 Proportional Counter		Input to NI Electronics
5	AI	NV0002	TBD	S		Hard	AREVA	Power Supply Voltage Fission Chamber		Input to NI Electronics
6	AI	NV0003	TBD	S		Hard	AREVA	Primary Supply Voltage Compensated Ion Chamber		Input to NI Electronics
7	AI	NV0004	TBD	S		Hard	AREVA	Compensation Supply Voltage Compensated Ion Chamber		New input Point for CIC support requires change to FRS Logic
								Temperature Sensors		
8	AI	RT0001	AI-TE01	S		Hard	AREVA	PRIMARY FUEL BOX OUTLET 1 TEMP		Convert to 4 wire RTD
9	AI	RT0002	AI-TE02	S		Hard	AREVA	PRIMARY FUEL BOX OUTLET 2 TEMP		Convert to 4 wire RTD
10	AI	RT0003	AI-TE03	S		Hard	AREVA	PRIMARY FUEL BOX OUTLET 3 TEMP		Convert to 4 wire RTD
11	AI	RT0004	AI-TE04	S		Hard	AREVA	PRIMARY FUEL BOX OUTLET 4 TEMP		Convert to 4 wire RTD
12	AI	RT0005	AI-TE05	S		Hard	AREVA	PRIMARY FUEL BOX OUTLET 5 TEMP		Convert to 4 wire RTD
13	AI	RT0006	AI-TE06	S		Hard	AREVA	PRIMARY FUEL BOX OUTLET 6 TEMP		Convert to 4 wire RTD
14	AI	RT0007	AI-TE07	S		Hard	AREVA	PRIMARY INLET FLOW TEMP		Convert to 4 wire RTD
15	AI	RT0008	AI-TE08	S		Hard	AREVA	PRIMARY OUTLET FLOW TEMP		Convert to 4 wire RTD
16	AI	RT0009	AI-TE09	S		Hard	AREVA	SECONDARY INLET FLOW TEMP		Convert to 4 wire RTD
17	AI	RT0010	AI-TE10	S		Hard	AREVA	SECONDARY OUTLET FLOW TEMP		Convert to 4 wire RTD
								Fans		
18	DI	CV0041	DI-CV041	S		Hard	AREVA	VENT FAN POWER AVAILABLE	y	
19	DI	CV0042	DI-CV042	S		Hard	AREVA	STACK DILUTION FAN POWER AVAILABLE	y	
20	DO	VP0041	DO-CV041	S		Hard	AREVA	CORE VENT FAN POWER INHIBIT		
21	DO	VP0042	DO-CV042	S		Hard	AREVA	STACK DILUTION FAN POWER INHIBIT		
22	DO	VP0043	DO-CV-043	S		Hard	AREVA	HVAC POWER INHIBIT		
								Water level Sensor		
23	AI	WL0022		S		Hard	AREVA	SHIELD TANK LOW LEVEL SENSOR	y	New Input Point for Sheld Tank Level
24	DI	LS0023	DI-PC023	S		Hard	AREVA	REACTOR LOW LEVEL SWITCH	y	
								Flow rate sensors		
25	AI	FR0029	AI-PC029	S		Hard	AREVA	PRIMARY INLET FLOW SENSOR		
26	AI	FR0028	AI-PC028	S		Hard	AREVA	PRIMARY OUTLET FLOW SENSOR		
								Auxiliary		
27	DI	SW0001	DI-S001	S		Hard	AREVA	SYSTEM PARAMETER CHANGE ENABLE		New Input
								Control Blades -bottom		
28	DI	CB0049A	DI-RP049A	S		Hard	AREVA	SAFETY CONTROL BLADE 1 OFF BOTTOM		
29	DI	CB0049B	DI-RP049B	S		Hard	AREVA	SAFETY CONTROL BLADE 2 OFF BOTTOM		
30	DI	CB0049C	DI-RP049C	S		Hard	AREVA	SAFETY CONTROL BLADE 3 OFF BOTTOM		
31	DI	CB0049D	DI-RP049D	S		Hard	AREVA	REGULATING CONTROL BLADE OFF BOTTOM		
								Console		
32	DI	MA0052	DI-RP052	S		Hard	AREVA	OFFSITE AC POWER AVAILABLE	y	
33	DI	CD0053	DI-RP053	S		Hard	AREVA	CONSOLE DC POWER AVAILABLE		
								Primary & Secondary -Auxiliary		
34	DI	PP0043	DI-PC043	S		Hard	AREVA	PRIMARY COOLANT PUMP POWER AVAILABLE		
35	AI	FR0019	DI-SC019	S		Hard	AREVA	WELL WATER FLOW SENSOR		Modified to be sensor vs DI switch
36	DI	WP0020	DI-SC020	S		Hard	AREVA	WELL PUMP POWER AVAILABLE	y	No Isolation Needed
								Control Blades - Clutch Engagement		
37	DO	TL0001	DO-TL1	S		Hard	AREVA	RPS TRIP TO SAFETY CONTROL BLADE 1 CLUTCH		
38	DO	TL0002	DO-TL2	S		Hard	AREVA	RPS TRIP TO SAFETY CONTROL BLADE 2 CLUTCH		
39	DO	TL0003	DO-TL3	S		Hard	AREVA	RPS TRIP TO SAFETY CONTROL BLADE 3 CLUTCH		
40	DO	TL0004	DO-TL4	S		Hard	AREVA	RPS TRIP TO REGULATING CONTROL BLADE CLUTCH		
								Dump Valve		
41	DO	TL0005	DO-TL5	S		Hard	AREVA	RPS TRIP TO REACTOR COOLANT DUMP VALVE		
								Key		
42	DI	PC0039	DI-PC039	S		Hard	AREVA	MAGNET POWER KEY (run signal)	y	Reactor Operate Enable
								Siren		
43	DO	ES0058	DO-RP058	S	NS	Hard	AREVA	EVACUATION SIREN		
								Radiation Monitors		
44	AI	RM0045A	AI-RM045A	S		Hard	CANBERRA	SOUTH AREA RADIATION MONITOR		Output from Canberra to Input of TXS
45	AI	RM0045B	AI-RM045B	S		Hard	CANBERRA	NORTH AREA RADIATION MONITOR		Output from Canberra to Input of TXS
46	AI	RM0045C	AI-RM045C	S		Hard	CANBERRA	EAST AREA RADIATION MONITOR		Output from Canberra to Input of TXS
47	AI	RM0045D	AI-RM045D	S		Hard	CANBERRA	WEST AREA RADIATION MONITOR		New Rad Monitor Input

Attachment 3. TXS Base Configuration

TABLE 1

University of Florida - Base Configuration (Options 0) w/ NI

Itemized BOM and Supplier

Functional Group	Item			GmbH	Alpharetta	Quantity
	No	ID	Description			
Base Configuration (Option 0)						
AQP/ERV Acquisition & Processing		I/O				
	1	SDI1	Digital Input	X		2
	2	SDO1	Digital Output	X		1
	3	SAI	Analog Input	X		4
	4	SPC-IO02	Plug Cable	X		8
	5	SGPIO1	Universal I/O	X		1
		Proc.Unit				
	6	SVE2	TXS Processing Unit	X		1
		Comms				
	7	SL22	L2 Comms Module	X		1
		Other				
	8	SAA1	Analog Signal Conditioning	X		9
	9	SNV1	Analog Signal Isolation Amplifier	X		13
	10	SR-3U	Subrack for 3U Modules	X		2
	11	SIC-61	Keyswitch	X		1
MSI Monitoring Service I/F		I/O				
	12	SDI	Digital Input	X		1
	13	SDO1	Digital Output	X		1
		Proc.Unit				
	14	SVE2	TXS Processing Unit	X		1
		Comms				
	15	SL22	L2 Comms Module	X		1
	16	SCP3	Comms Processor	X		2
	17	SES1	H1 Ethernet el/opt	X		2
	18	F/O Cable	F/O Cable	X		2
		Other				
	19	SIC-61	Keyswitch	X		1
Common						
	20	SC9422	TXS Cabinet 900x400x2200	X		1
	21	SRACK2	TXS Split Subrack w/ PS Modules	X		1
	22	SFAN1	Fan Unit	X		1
	23	SCM2	Cable Module	X		8
	24	SPM2	Plug Module	X		8
	25	SCMU1	Cabinet Monitoring Unit	X		1
	26	SCBU2	Circuit Breaker Module	X		1
	27		ETA-breakers	X		1
	28	SCSU2	Power Supply Module 120/24V	X		2
	29	SSF1	Power Supply Filter	X		1
	30	SOB1-24	Overvoltage Barrier	X		6
	31	SRB1/2	Relais Module	X		1
	32	SPLM1-CMU1	Cabinet Monitoring Unit	X		1
	33	SIC4	Annunciation Module	X		1

TABLE 1

Universty of Florida - Base Configuration (Options 0) w/ NI

Itemized BOM and Supplier

Functional Group	Item			GmbH	Alpharetta	Quantity
	No	ID	Description			
	34	SPDM1	Potential Distribution Module	X		3
	35	SMM1	Monitoring Module	X		2
	36	SDM2	Signal Isolation	X		2
	37	SDM1	Signal Isolation	X		2
	38	SDM4	Insertion Monitoring	X		1
	39	SPS2	Power Supply	X		2
	40	SCB1	Capacitor Bank	X		2
	41	SSD2	Supply Diode Module	X		12
	42	SPS4	Power Supply Module	X		6
Cabinet (Computer)						
Equipment						
	43	QDS	QDS System CPU	X		1
	44	QDS	QDS System 19" Touchscreen	X		1
	45	QDS	QDS System 19" Keyboard	X		1
	46	MC1	Rail Mounted Media Converter		X	2
	47	QDS	Rack	X		1
	48	SEPC1	Embedded PC (SU and GW)	X		2
	49	KVM	Keyboard & Monitor		X	1
	50	ETH1	Ethernet Switch (6 port minimum)		X	1
	51	Cables	Ethernet(5), KVM (3), Optic (2)		X	10
Common						
	52	8MF	Cabinet 37.5" x 23.5" x 72"		X	1
	53		Commercial UPS power supply		X	1

Attachment 4. TXS System Diagrams

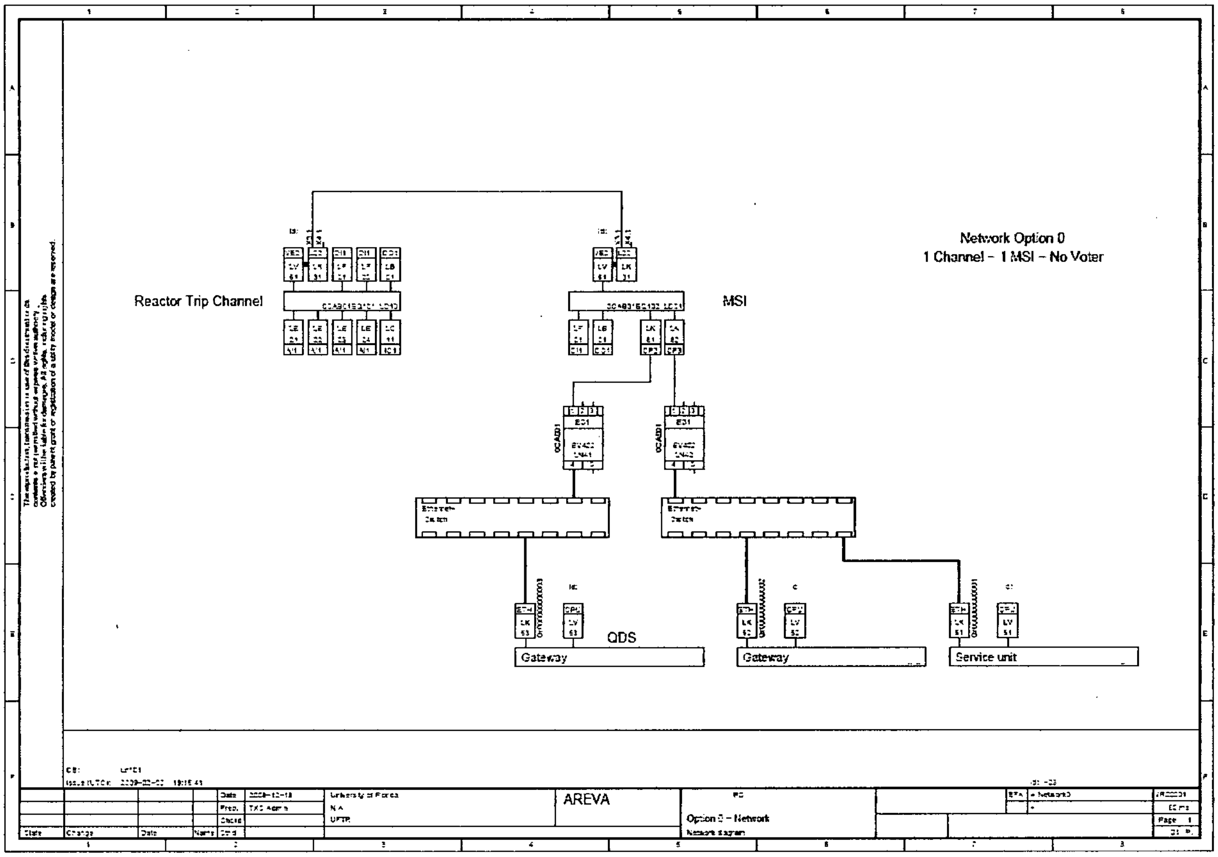


Figure A1. TXS System Network Diagram

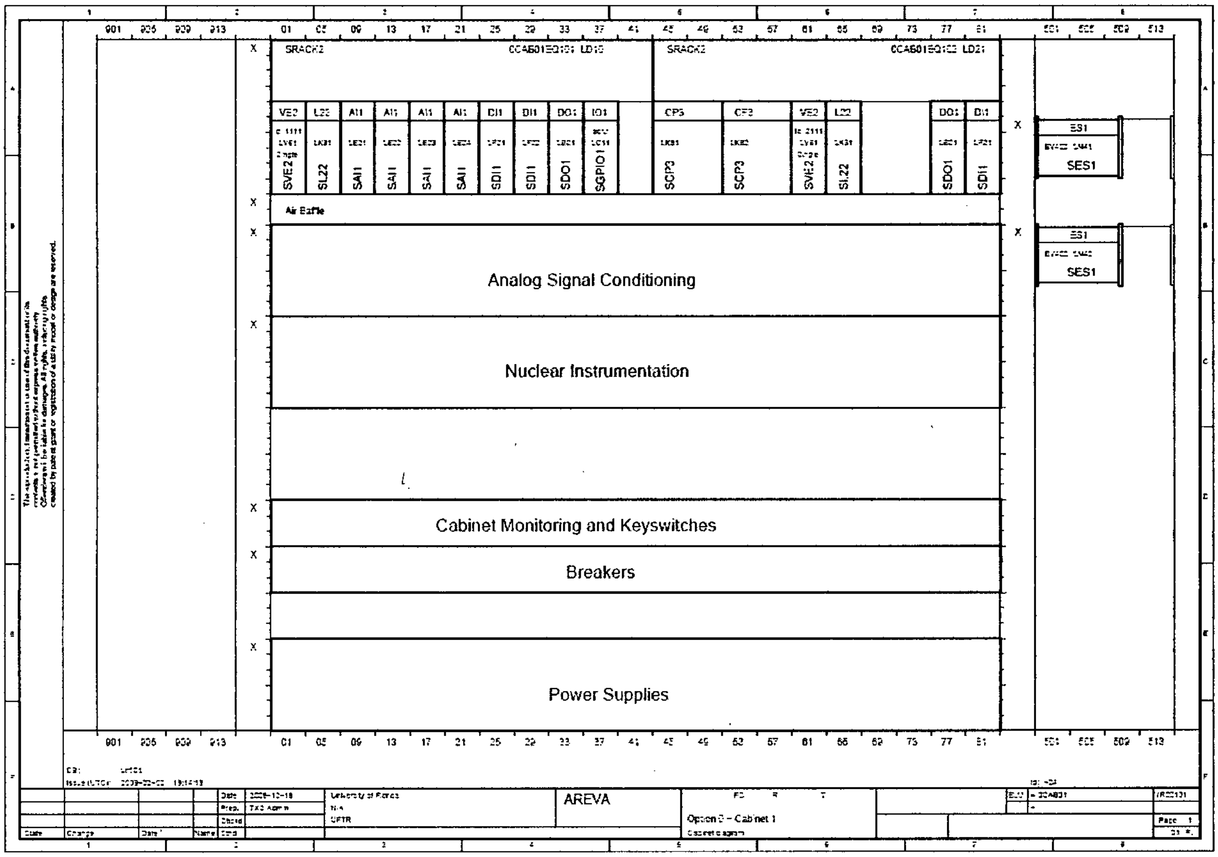


Figure A2. UFTR TXS Cabinet 1 (Including AQP, NI signal processing)

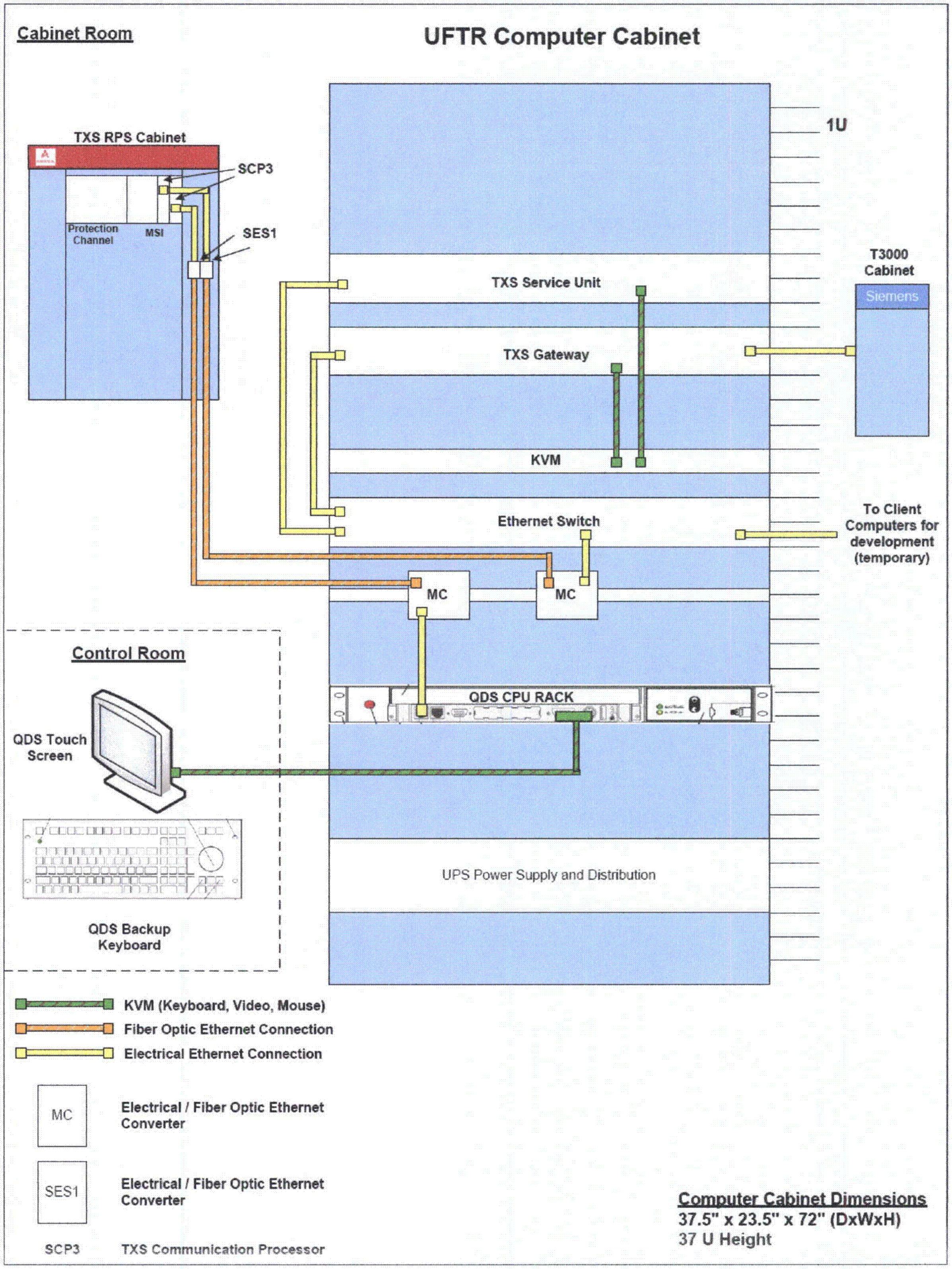


Figure A.3 UFTR TXS Cabinet 2 (Including SU, GW, MSI, &QDS)