Control System Common Specification

7.4.39.1**- Rev. 4**

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Revision History

Revision	*Date*	*Description*	*Author*
A	2000-01-10	Draft.	W. Eric Norum
0	2000-01-10	Issued for use.	W. Eric Norum
B	2001-06-25	Updated to reflect revised design. Issued for Review.	E. D. Matias
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1	2001-08-21	Incorporated comments from J. Vogt, M. de Jong, G. Wright, N. Johnson, S. Abell-Smith, and L. Dallin. This document supersedes and replaces CLS 2.1.39/8.2.60.1. Issued for use.	E. D. Matias
2A	2002-03-27	Updated for use in beamlines procurement.	E. D. Matias
2	2002-04-24	Added specific equipment model numbers and incorporated reviewer comments. Issued for use.	E. D. Matias
2B	2006-03-20	Updated for use in beamline Phase 2 Procurement. Control System Design information moved to 7.2.39.2.	M. McKibben
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3A	2009-02-09	Added compliance to NUREG-0700 and updated table for colours of piping. Updated stepper motor specifications.	M. Smith/ M. McKibben
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1.0 INTRODUCTION

1.1 PURPOSE

This document describes the common components used in the Canadian Light Source (CLS) control system. Suppliers of hardware and/or software must follow these guidelines. Deviation from the standards set out in this document must have prior written approval from CLS.

1.2 SCOPE

This document contains a list of all commonly used control system components that are used at the CLS. The control system components are used in the accelerator/booster ring/storage ring and in the beamlines.

1.3 BACKGROUND

There are several reasons to use common components through out the CLS control system. The first reason is to reduce the number of different spare components in stock. The second is to reduce the number of control devices requiring software development, thus reducing software development costs. Also, user familiarity with components reduces maintenance and trouble shooting time when problems arise.

If compelling arguments to use a non-standard component can be presented, those parts can be used with written consent of the CLS.

2.0 HARDWARE

2.1 CABLING

2.1.1 All cabling must meet relevant CSA standards with a CSA or UL_C certification.

2.1.2 The cable must be used within manufacture specification and the CSA rating.

2.1.3 CLS Technical Specification 7.4.39.14 Rev 0 lists CLS preferred cabling. Suppliers may substitute alternative suppliers and cable types provided compliance with relevant CSA standards are maintained.

2.2 CONTROLLER BUS TECHNOLOGIES

2.2.1 VME

2.2.1.1 CLS would prefer to use VME bus components over other bus technologies.

2.2.1.2 VME modules shall be compatible with VME IEEE 1014 or ANSI/VITA 1.1-1997 (VME64x version).

2.2.1.3 All VME modules shall be 6U.

2.2.1.4 CLS has standardized on the WIENER UEV6023/UEP6021 (CLS custom) crate, VME64x version.

2.2.1.5 CLS uses the Struck SIS3100 and SIS1100 PCI-VME interface instead of a slot 0 controller.

2.2.1.6 The CLS control system supports the modules listed in Table 1.

Table 1 - CLS Standard VME Modules

Modules	Manufacture	Part No.
Scaler	SIS	3820
16 bit sampling ADC	Sensoray	118-6U
24 bit ADC 32 Channels	General Electric Fanuc	110b1 (CLS custom)
Digital I/O 32 Channels	General Electric Fanuc	VMIC2536
Charge Integrating ADC	CAEN	V792N
TDC (multiHit)	CAEN	V1290N
16bit DAC 16 Channels	Precision Analog Systems	PAS9816/AO
Scaler	CAEN	V820
16 bit scanning ADC	HYTEC	MADC 2508
Diode Input Board	Budker Inst. of Nuclear Physics	SM1
Stepper Motor Controller	Pro-Dex	MAXv

2.2.2 NIM

2.2.2.1 NIM bins shall be compliant with DOE/ER-0457T or equivalent.

2.2.2.2 All NIM bins shall supply ± 6V DC and 120V AC.

2.2.2.3 CLS has standardized on the WIENER UEN03/UEP22 NIM bin.

2.2.2.4 Table 2 lists the CLS supported NIM modules.

Table 2 - CLS Supported NIM Modules

Modules	Manufacture	Part No.
High Voltage Supply	Ortec	556
High Voltage Supply	ISEG	NHQ203A
Voltage to Frequency Converter	Nova	N101VTF
NIM-TTL Adaptor	CAEN	N89
NIM Dual Timer	CAEN	N93B
NIM-ECL/ECL NIM Adaptor	CAEN	N638
Logic FAN IN/OT	CAEN	N454

2.2.3 National Instruments FieldPoint

2.2.3.1 Where PLC hardware is not present and only slow monitoring or control through EPICS is required National Instruments Field Point equipment may be used.

2.2.3.2 Preference shall be given for the modules listed in Table 3.

Table 3 - CLS Standard National Instruments Field Point

Modules	Part No.
RS232/RS485 Interface module to EPICS IOC	FP-1000
8-channel Thermocouple Module	FP-TC-120
8-channel 3-wire RTD Module	FP-RTD-122
Terminal Block for FP-AO-V10B	FP-TB-10
8-channel SPST Relay Output	FP-RLY-420
16 channel 24V DC Sinking	FP-DI-301
8 Channel 5-48 V DC Sinking/Source or 5 - 240 V AC	FP-DI-330
16 channel Sourcing Digital Output	FP-DO-401
2 channel Analog Output -10 to 10 V	FP-AO-V10B
Terminal Block for all modules except FP-AO-V10B and FP-TC-120	FP-TB-1
Terminal Block for FP-TC-120	FP-TB-3

2.2.4 Compact PCI/PXI

2.2.4.1 Preference shall be given for VME64x compliant crates and IO over Compact PCI.

2.2.4.2 Compact PCI and PXI equipment shall be compatible with PXI System Alliance Specification Version 2.0.

2.2.4.3 All CompactPCI and PXI equipment shall be 3U.

2.2.4.4 PXI compatible crates shall be used in favour of CompactPCI crates.

2.2.4.5 CLS makes use of the equipment listed in Table 4. Preferences shall be given for these modules where possible.

Table 4 - CLS Standard CompactPCI/PXI Modules

Modules	Manufacture	Part No.
Crate	National Instruments	PXI-1010
Multi-Function Card	National Instruments	PXI-6052E
MXI (Compact PCI/PCI Bridge)	National Instruments	PXI-PCI 8335-MXI-3

2.2.5 VXI

2.2.5.1 VXI modules and crates shall be compatible with VXI Consortium VXIbus System Specification VXI-1 Rev. dated August 1998.

2.2.5.2 VXI equipment shall be C-size.

2.2.5.3 The CLS control system supports or will support the modules listed in Table 5.

Table 5 - CLS Standard VXI Modules

Modules	Manufacture	Part No.
Programmable Delay Unit	Highland Technology	V951
VXI Crate	National Instruments	VXI-1501
VXI To GPIB Interface	Agilent	HPE1406A

2.2.6 CAMAC

2.2.6.1 CAMAC equipment shall not be used.

2.2.7 FASTBUS

2.2.7.1 FASTBUS equipment shall not be used.

2.3 PROGRAMMABLE LOGIC CONTROLLERS

2.3.1 IEC 61131-5 shall be considered in the design, installation and use of PLC equipment.

2.3.2 CLS makes use of the Telemecanique MODICON-Momentum line of PLC equipment using an Ethernet processor/communications module. Table 6 lists the modules in use at CLS.

Table 6 - CLS Standard MODICON Momentum Modules

Modules	Part No.
M1 Processor Adaptor, 512 K RAM 1Meg Flash /w Ethernet	171CCC96030
IO Bus Communications Adaptor	170INT11000
RTD, Thermocouple or mV Input – 4 Channels	170-AAI-520-40
Analog Input – 16 Channels 0-20 mA, 24 V DC	170-AAI-140-00
Analog Input – 4 Channels 0-24 V DC & Analog Output – 2 Channels	170-AMM-090-00
Analog Output – 16 Channels	170-AAO-921-00
Digital Input – 32 Channels 24VDC	170-ADI-350-00
Digital Output – 32 Channels 24 VDC	170-ADO-350-00
Digital Input 16 and Output 16 Channels	170-ADM-350-10
Frequency Counter	

2.3.3 CLS makes use of Siemens S7/300 and Siemens S7/400 PLC hardware. Table 7 lists the S7/300 modules in use at CLS. Table 8 lists the S7/400 H modules in use at CLS.

Table 7 - CLS Standard Siemens S7/300 Modules

Modules	Part No.
Power Supply, 10 A 2VDC	6ES7390-1KA00-0AA0
Power Supply, 5 A 24VDC	6ES7307-1EA00-0AA0
CPU 315-2 DP, 64K RAM WITH PROFIBUS-DP MASTER/SLAVE	6ES7315-2AF03-0AB0
Backup Battery for CPU	6ES7971-1AA00-0AA0
FEPROM Memory Card For S7-300, 64Kbytes	6ES7951-OKF00-0AA0
SM 332 Analog Output – 4 channels 16 bit	6ES7332-5HD01-0AB0
SM 331 Analog Input – 8 channels 16 bit	6ES7331-7NF00-0AB0
SM 321 Digital Input – 32 channels 24VDC	6ES7321-1BL00-0AA0
SM 322 Digital Output – 32 channels 24 VDC	6ES7322-1BL00-0AA0
SM 322 Digital Output – 8 channels Relay	6ES7322-1HF10-0AA0
Interface Module IM360 IM-S	6ES7 360-3AA01-0AA0
Interface Module IM361 IM-R	6ES7 361-3CA01-0AA0
RS-485 Repeater	6ES7 972-0AA01-0XA0
20 PIN Front Connector	6ES7392-1AJ00-0AA0
40 PIN Front Connector	6ES7392-1AM00-0AA0

Table 8 - CLS Standard S7/400 H Series Failsafe Modules

Modules	Part No.
AS414-4-1H4000AC2 (10A), COMPL. AS WITH 1XCPU S7-414-4H, 115/230 VAC/MEM. 2 X 384KB, UR2, 1 MB RAM	6ES7-654-2UB04-0XX0
SIMATIC S7 MEMORY CARD 5V FLASH- EPROM, 1MB	6ES7-952-1KK00-0AA0
SM 326Digital Input - 24 channels 24 VDC	6ES7-326-1BK00-0AB0
SM 326 Digital Output – 10 channels 24VDC	6ES7-326-2BF00-0AB0
SM336 Analog Inputs – 6 channels 14bit	6ES7-336-1HE00-0AB0
RAIL FOR ET 200M	6ES7-195-1GA00-0XA0
BUS UNIT FOR ET200M	6ES7-195-7HC00-0XA0
40 PIN Front Connector	6ES7-392-1AM00-0AA0
F-RUNTIME LICENSE (Failsafe Software)	6ES7-833-1CC00-6YX0
ET 200M INTERFACE	6ES7-153-2AB01-0XB0
BUS UNIT FOR ET200M F	6ES7-195-7HD00-0XA0
PROFIBUS OLM/G12 OPTICAL LINK MODULE	6GK1-502-3CB00

2.3.4 Vendors shall provide all PLC/touch pane configuration and source files.

2.4 DATA ACQUISITION

2.4.1 Table 9 lists data acquisition equipment that is used at the CLS.

Table 9 - CLS Data Acquisition Equipment

Description	Model #
Keithley Pico Ammeter	6485
Keithley Multimeter	2000
Keithley Constant Current Source	220
Keithley Current Amplifier	428
Stanford Research Systems Pre-Amplifier	SR570

2.5 MOTION CONTROL

2.5.1 The standard stepper motor controller used at the CLS is the Pro-Dex MAXv.

2.5.2 The CLS stepper motor control system can accommodate a variety of stepper motor drives. All drives must be panel mountable

2.5.3 Table 10 lists the stepper motor drives that have been used at the CLS. Preference will be given to these drives.

Table 10 - CLS Preferred Stepper Motor Drives

Manufacturer	Model
Kohzu	KR-535G
Kohzu	MD501A
Oriental	RBD245A-V
Oriental	RKD507-A
Oriental	RKD514L-A
Parker	E-AC
Parker	E-DC
Parker	VIX – 250M
Parker	Zeta 8
Parker	Zeta 12

2.5.4 All motors shall have limit switches at both ends of travel.

2.5.5 Table 11 lists the stepper motors that have been used at the CLS. Preference will be given to these motors.

Table 11 - CLS Preferred Stepper Motors

Manufacturer	Model Number
Slo-SYN	KLM061-F05E
Phytron	ZSS41.200.2.5
Phytron	VSS52.200.5
Phytron	VSS80.500.3.5
Phytron	VSS52.500.2.5
Phytron	VSS25.200.0.6
Phytron	ZSS57.200.2.5.50:1
Phytron	VSS43.200.2.5.56:1
Phytron	VSS52.200.2.5
McLennan	23-HSX-306
McLennan	23HS104
McLennan	23HS304
Parker	TS33B
Parker	HV series

2.5.6 All motors shall connect to the control system using Amphenol 97-3102a-22-14p connectors. The standard connector pinout is given in Table 12

Table 12 - CLS Standard Stepper Motor Connector Pinout

Pin	Function
A	Motor Phase A+
B	Motor Phase A-
C	Motor Phase B+
D	Motor Phase B-
E	Limit Return
F	CW limit
G	CCW Limit
H	Encoder Phase A +
J	Encoder Phase A -
K	Encoder Phase B +
L	Encoder Phase B -
M	Linear potentiometer Vref
N	Linear potentiometer position
P	Linear potentiometer return
R	Encoder 5V return
S	Encoder Index +
T	Encoder Index -
V	Home
U	Encoder +5V

2.5.7 CLS will consider other motor control options.

2.6 SIGNAL LEVELS

2.6.1 Whenever possible, fast digital signals (electrical) interconnecting modules or devices should use NIM or ECL levels. LVDS may be used in systems without negative supply voltages. PECL shall not be used. If TTL levels must be used in timing-critical applications, CLS Technical Specification 7.8.48. 1 shall be followed.

2.6.2 For control, 24VDC shall be used for digital signals. The use of 48V or 120V is strongly discouraged.

2.6.3 The use of 24VAC is acceptable only in building automation systems.

2.6.4 Whenever possible, fibre optic signals interconnecting modules or devices should be 820-850 nm multimode using ST connectors.

2.6.5 Interlocks and controls should be designed to be failsafe.

2.6.6 A safe state shall be indicated by a closed contact sending a +24V signal.

2.6.7 An unsafe state shall be indicated by an open contact that blocks the +24V signal.

2.6.8 On power failure the system should indicate an unsafe state.

2.6.9 "On" control should be identified by a 0 to +24V transition. An "Off" control should be identified by a loss of +24V signal.

2.6.10 In the case of EPICS communication with a PLC an "On" request shall be a momentary contact, normally where the 0 to +24V transition is associated with pressing a button and the +24V to 0 transition with releasing the button. A separate variable will normally be used for the off request signal; with Off overriding On.

2.6.11 When equipment is designed to receive separate control signals: an "Off" signal shall always override an "On" signal.

2.6.12 For analog control signals 4-20 mA shall be used.

2.7 HIGH VOLTAGE

2.7.1 Whenever possible, SHV or 10kV connectors should be used for high voltage supplies and cables. The use of a Glassman style coax connectors is also acceptable.

2.7.2 MHV connectors shall not be used.

2.7.3 All high voltage supplies and connection shall be labeled "Danger--High Voltage" and "Danger--Haute Tension" in letters that are not less than 50 mm in height on a contrasting background

2.7.4 Several types of high voltage supplies are in use at CLS. For computer controlled high voltage, modules compatible with CAEN SY2527 crates are preferred.

2.8 VIDEO

2.8.1 Table 13 shows the video equipment commonly used at the CLS.

Table 13 - CLS Standard Video Equipment

Component	Manufacture	Part No.
Television	Bosch	LTC2009/61
TV Rackmount	Bosch	LTC9009/00
CCTV	Bosch	LTC0335/60
CCD Digital Camera	Cohu	6612-3000-0000
CCD Digital Camera	Sony	XC-55
CCD Digital Camera	Sony	DFW SX-910
Power Supply for 6612	Cohu	8385-5
CS-Lens 7-70mm Zoom(auto iris)	GVI-Samsung	GV7.70-ADC
CS-Lens 7-70mm Zoom(manual iris)	GVI-Samsung	GV7.70-M
CS-Lens 6-12mm Zoom(auto iris)	Pentax	TS2V114E
CS Lens 2x Mag	Pentax	2EX(C80034)
Motorized Zoom Lens	Navitar	1-51200
Web Camera PTZ	Axis	213
Web Camera Fixed	Axis	2120

2.9 GENERAL – HARDWIRED CONTROLS

2.9.1 Hardwired controls shall be clearly labeled with equipment name, operating state and fault indication (green shall be used for run and red for fault).

2.9.2 For equipment that can be manually or locally operated a three way “Hand-Off-Auto” switch shall be used.

2.9.3 When in Hand the unit will turn on if machine protection interlocks are satisfied. Where the control system implements machine protection functionality, the permissive from the control system will override hand operation.

2.9.4 When in Off the unit will not turn on either locally or remotely.

2.9.5 When in Auto the unit will turn on or off as directed by control system programming or OPI command.

2.10 GENERAL – CUSTOM ELECTRONICS

2.10.1 Custom electronics shall be developed using Eagle or ORCAD. Suppliers shall provide drawings in a format that can be imported into one of these tools. Preference is given for Eagle developed by CadSoft GmbH.

2.10.2 Printed copies of electronics drawings shall be stored in the Electronics Development Lab (Room 2015). Electronic copies of all PCB schematics and layouts shall be stored as part of the main CLS CAD archives under the Electrical Engineering (EE) area code, and an entry is made in the CAD database.

2.11 HUMAN FACTORS

Human factors are critical to effective use and operation of the facility as well as licensing. These requirements are intended to reduce the cognitive burden placed on humans when moving from one system to another system.

2.11.1 Power Distribution Colour Coding and Identification

CLS has developed a colour coding convention to distinguish between generator power feeds, safety systems, fire alarm, control wiring, convenience, clean and regulated power distributions (Johnson 2006).

2.11.2 Local Switches

On the local control panel of the equipment or associated MCC for motors, one of two types of local switches are used. Local switches are either Hand-Off-Auto Switches (shown in Figure 1) or Momentary Contact Switches (shown in Figure 2).

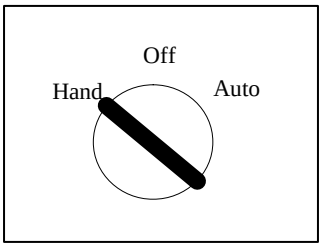


Figure 1 – Hand-Off-Auto Switch

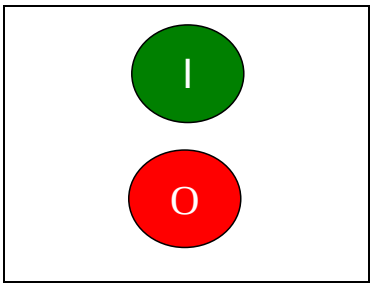


Figure 2 – Momentary Contact Switch

The Hand-Off-Auto (HOA) switch is commonly used in process control applications. Hand corresponds to “Local-Hand” operation, Off corresponds to “Local-Off” and Auto corresponds to control of the equipment being relinquished to the automation system either under operator or computer control.

For equipment that normally requires operator presence to be turned on (either locally or remotely) a momentary On and Off push button is used. The green “I” button is used for on and the red “O” button is used for off.

Hardwired and/or software implemented interlocks can inhibit “Local-Hand” operation. Under these conditions the control system provides a “permissive” to the system, that will permit the equipment to operate.

2.11.3 Indicators

These types of system normally also include some LED or bulb indication of the state of the equipment as well as on operator screens. Indicators are always labeled in English and follow the following colour coding:

a) Run – Green – The equipment is operating

b) Fault – Red – There is a fault with the equipment

c) Warning or Standby – Yellow – The control (hardwired and software based) interlocks are satisfied and the equipment will run if requested.

d) Off - Black – The equipment is off.

e) Unknown - White – No data communication available.

2.11.4 Strobe Indicators

For safety applications strokes are used as follow:

a) Radiation Hazard – Red

b) Oxygen Depravation Hazard – Blue

c) Motion Hazard – Yellow

d) Fire Hazard – White

Strokes shall be used only for safety indicators.

2.11.5 Emergency Off Switch

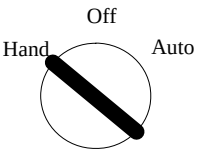
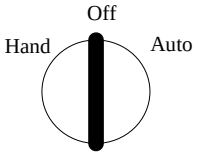
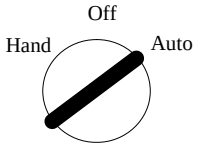
Emergency off switches are installed on CLS equipment. Twist to release switches, without key locks are normally installed on CLS designed equipment, (ie. Telemecanique ZB4BS44 – 35439, ZB4BZ009-35600, ZBE102 – 35564). Key locked emergency off switches and switches that are spring loaded with covers are installed in some locations, they are to be avoided in CLS designed equipment.

Spring loaded with covers are used on motor controls instead of a local disconnect.

2.11.6 Equipment Command State

Table 14 defines the command states used to define how start and stop commands are accepted for a piece of equipment. A devices can be in “Local – Hand”, “Local – Off”, “Auto-Operator”, or “Auto – Software” operation. Depending on manufacture some pieces of equipment (e.g., magnet power supplies) may display “Remote” instead of “Auto”, the two terms are analogous in this context.

Table 14 - Command States

Position of HAO Switch	Control State	Description
	Local – Hand	Device is turned on in the field. Depending on the equipment inhibits and interlocks from the control system.
	Local – Off	Device is forced off in the field. This over-rides remote user operation of the device. Note: Some equipment (e.g., Danfysik power supplies) permit remotely switching the unit into Auto, this behaviour is normally not implemented in the CLS control system. Equipment must be placed into Auto/Remote in the field.
	Auto – Operator	Device is under remote operator control. Software will not automatically start of stop the device, however software may still inhibit or interlock operation.
	Auto – Software	Device is under autonomous software control. Under these conditions the define will start or stop automatically based on pre-programmed information.

HOA switches are not to be used to lock-out equipment. This is usually done on a main contactor in the MCC. When auxiliary contacts are used to monitor contactors, these will show up on control system screens as “Local-Out of Service”.

2.11.7 Interlocks and Inhibits

An interlock will cause a device to trip. Once tripped manual intervention is required to reset and restart the device. Once reset the device returns to the previous command state.

Inhibits will cause a device to remain off until the permissive on the device is satisfied and then immediately start.

Preference in the design of the control system is to implement interlocks over inhibits. However under some situations the use of inhibits may be warranted.

3.0 SYSTEM REQUIREMENTS

3.1 DOCUMENTATION

3.1.1 Three copies of all documentation (including software requirements, design, test reports and installation instructions) shall be provided

Rationale: CLS requirements for design documentation records management.

3.1.2 Documentation shall be provided for all communications protocols not based on an international (ISO, IEC, ICU) standard.

Rationale: Provide support for CLS communication with the equipment as requirement.

3.1.3 Equipment is designed to be self-protecting, rather than relying on network-bound data or remote control for machine protection.

Rationale: This provides for more robust machine protection functionality that should be simpler in design and relies on fewer components to implement thus increasing the reliability. This provides for a clear portioning of requirements between systems.

3.1.4 System partitioning is based on maximizing internal cohesion and reducing inter-system coupling

Rationale: This design principle normally leads to simpler and better-defined interfaces between systems.

3.1.5 A component manual shall be developed for each of the key area of the facility and each beamline as outlined in CLS Design specification 0.4.1.1.

3.1.6 The component manual shall define the functional behaviour of the software, the design and provides guidance on the use of the control system.

3.1.7 Control system drawings shall be based on Process and Instrumentation Drawing (P&ID) formations (available from CLS) or Unified Modeling Language, (OMG 1999).

3.1.8 Process and Instrumentation Drawings (P&ID) describe how the control and diagnostic system are logically connected to field equipment and loop drawings define the physical connections. In addition design notes are developed for generic software and hardware components.

3.2 PERFORMANCE

3.2.1 The control system software and control hardware shall not unduly limit the performance of the system.

3.3 SAFETY AND ENVIRONMENT

3.3.1 Any system where the control system is relied on to protect humans from potentially hazardous environments, over exposure to radiological hazards or positioning of a X-ray or electron beam on a human subject must be subject to a hazard analysis that will define a safety integrity level for the system. The hazard analysis is subject to CLS acceptance and approval.

3.3.2 Safety critical systems shall be implemented using IEC 61508 certified equipment and programming techniques for the applicable safety integrity level; these types of systems are not dependent on the main CLS control system.

Rationale: By minimizing and decouple safety critical components they typically become simpler and more reviewable. IEC 61508 is commonly recognized by Canadian regulators as being appropriate for use in safety critical applications and represents international consensus of the development of safety critical applications. The separation between the control system and special safety systems allows the control system to be developed using more conventional techniques.

3.3.3 For safety critical systems, vendors should attempt to use Siemens “S7/400 F” series of safety critical PLC equipment. Alternative suppliers must meet the requirements outlined in CLS Document 7.4.37.1 and be subject to prior approval by CLS.

Rationale: Reduced maintenance and operational cost from standardization of PLC equipment. This requirement ensures systems used at CLS are compliant with regulatory requirements.

3.3.4 The design of all safety critical software and control systems shall be subject to CLS design review and approval.

3.3.5 Computer equipment intended for use inside the building envelope shall function correctly within the normal ambient temperature range (19^{o}C to 29^{o}C) and shall not suffer damage in the extreme ambient temperature range (10^{o}C to 40^{o}C).

Rationale: The normal ambient temperature of the main experimental floor at CLS is 23^{o}C $\pm$ 1^{o}C. During operations the temperature in the main storage ring tunnel is 27^{o}C $\pm$ 0.1^{o}C. Mechanical areas (that also house computer equipment) are subject to less well-regulated temperature control.

The extreme temperature range may be experienced when the HVAC system is under maintenance. As a machine protection measure it is acceptable for computer equipment to be equipped with thermal sensors that power off equipment outside the normal ambient temperature.

3.3.6 Computer equipment intended for use outside the building envelope shall function correctly within the normal exterior ambient temperature range (-40°C to 40°C) and shall not suffer damage in the extreme exterior ambient temperature range (-50°C to 60°C). Outdoor equipment shall be housed in a NEMA Type 4 enclosure.

3.3.7 Computer equipment shall function correctly within the normal relative humidity range of 20% to 55% and shall not suffer damage in the extreme range of 0% to 90%.

3.4 APPLICABLE CODES, STANDARDS AND PROCEDURES

3.4.1 Hard-real-time and machine protection functions are implemented using PLC hardware and IEC 61131-3 programming languages;

Rationale: PLCs and computers running hard-real-time kernels are generally better suited to perform time sensitive operations. These machines typically have simpler operating system that have a tendency to yield more robust systems. IEC 61131-3 is commonly used in industry to perform these functions and therefore the impact of using diverse equipment is minimized.

3.4.2 Electrical and electronic equipment shall meet the requirements of the Saskatchewan Electrical Inspection Act, E6-3[1], with special attention to Section 18 "Manufacture, Sale, etc." of electrical equipment. This requirement may be satisfied either by certification to the relevant CSA standard by an authorized inspection agency or by special inspection carried out by an authorized inspection agency.

3.4.3 All electrical installations shall comply with the Canadian Electrical Code, Part 1, 2006.

3.5 QUALITY ASSURANCE

3.5.1 All custom software development shall be in accordance with ISO 9001, including the guidance layout in ISO 9000 Part 3.

3.6 INSPECTION, TESTING AND COMMISSIONING

3.6.1 For safety critical systems *the Safety System Ring-out Procedure* (CLS Document 7.7.52.1) shall be followed to verify installation of the system.

3.6.2 For safety critical systems an application specific verification and validation procedure shall be developed. This procedure shall be subject to CLS review and approval. Execution of this procedure shall be performed by individuals that were not involved in the design and installation of the system.

3.6.3 For non-safety critical systems at a minimum:

a) all electrical connection shall be verified after installation (refer to CLS Technical Procedures 7.7.90.1 and 7.7.90.2),

b) data points in the software shall be verified to field equipment,

[1] Available at *http://www.qp.gov.sk.ca/documents/English/Statutes/Statutes/E6-3.pdf*

c) functional behavior shall be verified against specifications,
d) all PID loops shall be tuned and
e) for HVAC systems air-balancing shall be performed.

3.6.4 For systems being developed by an outside supplier, the following design documents/drawings shall be subject to CLSI inspection and acceptance before proceeding to the next design stage:

a) requirements specification and P&I drawings,
c) wiring diagrams, schematics and PCB layouts,
d) software design description (if not CLS standard architecture)
e) installed software and hardware prior to commissioning and
d) installed software and hardware prior to turn-over to operations.

3.7 RELIABILITY AND MAINTENANCE

3.7.1 The control system and software reliability target is 98% availability during scheduled beam-time. The system design must be consistent with this target.

3.8 LAYOUT (PHYSICAL)

3.8.1 CLS makes use of a distributed control system. To the greatest extent possible, control hardware should be located near the system being controlled.

3.8.2 Physical layout shall be done to provide access to both the front and rear of 19inch racks.

3.8.3 For wall mount cabinets sufficient floor space shall be allocated to permit the cabinet doors to be fully opened.

3.9 VIBRATION AND ACOUSTIC NOISE

3.9.1 Control hardware shall not contribute mechanical vibration. The use of equipment with mechanical vibration shall be subject to the prior acceptance of CLS.

3.9.2 The noise level 1 meter from any control equipment when the enclosure is closed shall be below 50 dBA.

3.10 SERVICES

3.10.1 Suppliers shall identify power, cooling and instrument air requirements for control equipment. These shall be subject to prior acceptance by CLS.

4.0 SOFTWARE REQUIREMENTS

4.1 DESIGN

4.1.1 To the greatest extent possible accelerator technical systems and conventional (building automation) systems shall be controllable from the main control room through EPICS (Channel Access Protocol).

Rationale: This design principle allows for improved response time and reduces physical fatigue on operators especially on a shift schedule.

4.1.2 To the greatest extent possible beamlines equipment shall be controlled from the beamlines operator console through EPICS (Channel Access Protocol).

Rationale: This design principle allows for improved response time and reduces physical fatigue on operators and users especially on a shift schedule. In the case of the beamlines this strategy allows for more efficient and consistent turn-over of the beamline from one experimental group to another and the opportunity for remote beamline control.

4.1.3 A common interface shall be presented to the operator, regardless of supplier and technology used in the design.

Rationale: This design principle reflects the need to minimize problem recognition time and avoid confusion associated with inconsistent or contradictory feedback from the control system.

4.1.4 Data communication where possible is over the main CLS Ethernet network.

Rationale: After reviewing the use of industrial field busses and the option of a separate control system network, it was determined that a common Ethernet network using appropriate virtual local area network (VLAN) technology could meet control system performance, and reliability targets.

4.1.5 Where possible, pre-existing software and hardware is used instead of custom development.

Rationale: When factoring in labour, pre-existing software and hardware can usually be obtained for lower cost than custom developed equipment and hardware. There will be some cases where off-the-shelf components do not exist and CLS will need to develop custom in-house components.

4.1.6 The system is based on sound software engineering and design principles (such as ISO/IEC 12207) addressing areas such as maintainability and human factors.

Rationale: To permit the cost effective maintenance of the system in the longer-term and meet the control system reliability targets generally accepted software and system-engineering principles are being applied. Special attention is also directed at meeting regulatory human factors requirements and ensuring that operations and beamlines users can effectively utilize the system.

4.1.7 International standards are followed where practical in the selection of design methods, communications protocols and programming languages

Rationale: Given the intended lifetime of the facility and large investment made in custom system and software design, the use of commonly accepted international standards provides for the long-term protection of this investment through the useful life of the facility.

4.1.8 The software design may be captured in a mix of documentation and drawings.

4.1.9 Standard Programming Languages shall be used where possible, specifically:

a) ANSI C,
b) ISO C++
c) IEC 61131-3 standard languages for PLC programming
d) Java.

For PLC programming preference shall be given for structured test or function block over ladder logic and instruction list. For C/C++ POSIX standard libraries shall be used where practical. Use of other programming languages shall be with the prior acceptance of CLS.

CLS specific versions of operating systems and develop tools shall be used. The version numbers shall be verified with CLS at the beginning of the project. Specific versions are:

a) RTEMS Version 4.6.1,
b) EPICS Version R3.14.6,
c) RedHat Linux Version 7.2,
d) Scientific Linux 4.x,
e) MS-Windows XP Professional,
f) QT 3.3 Free Edition or QT 4,
g) Concept 2.6,
h) Siemens Step 7 Version 5.1,
i) MS-Visio 2000,
j) MKS Source Integrity Enterprise 8.1.

4.1.10 When using QT O/S specific classes (e.g. Qactive, Qmotif) shall not be used to permit portability between MS-Windows and Linux platforms.

4.1.11 Representative names shall be used for all variables, constants, types and function names.

4.1.12 Source code shall be documented and formatted in a method consistent with CLS coding conventions.

4.1.13 Control software shall be maintained under a configuration management system, preferably MKS Source Integrity.

4.1.14 Open source and software developed by CLS suppliers are placed under configuration control by CLS using the same procedures and processes for locally developed software.

4.1.15 Source Code, PLC programming, EPICS database configuration files, field programmable gate array programming, make files, scripts and other configuration items shall be stored in a common MKS project archive.

4.2 DESIGN – OPERATOR SCREENS

4.2.1 Operator Screens shall be designed using either C++ and QT or EDM.

4.3 DESIGN – NAMING CONVENTION

4.3.1 A raw (electrical) value is the ADC/DAC value read by the computer. These variables are identified by the equipment name with a "Raw" suffix.

e.g. TM24000-01Raw

4.3.2 A process value is the percentage of full scale (generally not used at CLS; if the variable is a percentage, such as a valve position it is normally treated as a scaled value). If a process value is required it is identified by the equipment name with a PV suffix.

e.g. TM24000-01PV

4.3.3 Scaled Value is the signal value in SI units. Scaled values are identified by the equipment name without an extension.

e.g., TM24000-01.

4.3.4 PID Loops:

Setpoint values are the value to which the control system regulates. These are identified with the SP suffix;

e.g. TM2400-01SP

Gains are applied to errors between the measured equipment scaled value and the setpoint. These are identified by the equipment name followed either the Pro, Int, Der or Lag suffix.

Proportional Gain:	Pro,	e.g., TM2400-01Pro
Integral Gain:	Int,	e.g., TM2400-01Int
Derivative Gain:	Der,	e.g., TM2400-01Der
Derivative Lag:	Lag,	e.g., TM2500-01Lag

In manual mode the forced output values are applied to the signal to the equipment under control. These are identified by the controlled equipment name followed by:

Manual Mode Control	Man,	e.g., TM2400-01Man
Manual Mode Output	ManOP	e.g., TM2400-01ManOP

The manual mode output should be a scaled value. When the PLC converts this to a raw value the extension changes to raw.

4.3.5 Last fault status information uses the name of the system being controlled with the Last suffix.

e.g. HCS2400-01Last

4.3.6 Variables defined only for interaction with EPICS computers rather than physical hardware, such as a remote On or Off are identified by the name of the system being controlled followed by the function followed by C.
e.g. HCS2400-01OnC or HCS2400-01MaxHeatC

4.4 GENERAL

4.4.1 Source code shall be provided for all custom-developed software (including PLC, PLD, and FPGA programming) on CD-ROM

Rationale: It has been CLS experience that vendors discontinue support for systems prior to the system needing to be replaced by CLS. Source code provides assurance that, if necessary, CLS can continue to maintain the product.

4.4.2 All executable software installed by the supplier (including PLC programming, FPGAs, drivers and operating systems) shall be provided on CD-ROM or DVD.

Rationale: Permits CLS to re-install software after a hardware failure (hard-drive crash, EPROM failure).

4.4.3 Include any proprietary compilers and other associated tools as well as document the vendor and version number of any commercial third-party tools need to re-compile the software.

Rationale: It has been CLS experience that vendors discontinue support for systems prior to the system needing to be replaced by CLS in the case of one-off or customised software. CLS requires the capability to continue to maintain the system if it should become unavailable from the original supplier.

4.5 HUMAN FACTORS

The human machine interface is a critical consideration in ensuring that operators/users can adequately determine the state of equipment and take appropriate and safe actions when using the equipment. For both the facility and beamlines these guidelines are intended to address both operational requirements for a sound user interface as well as regulatory human factors engineering requirements.

4.5.1 The operator interface shall be structured into three layers, as illustrated in Figure 3. The top layer supports supervisory control of the facility. The equipment operations layer supports control of individual components within the control system by operators. The bottom layer (detailed equipment setup layer) supports configuration and maintenance of equipment by service technicians, engineering and controls.

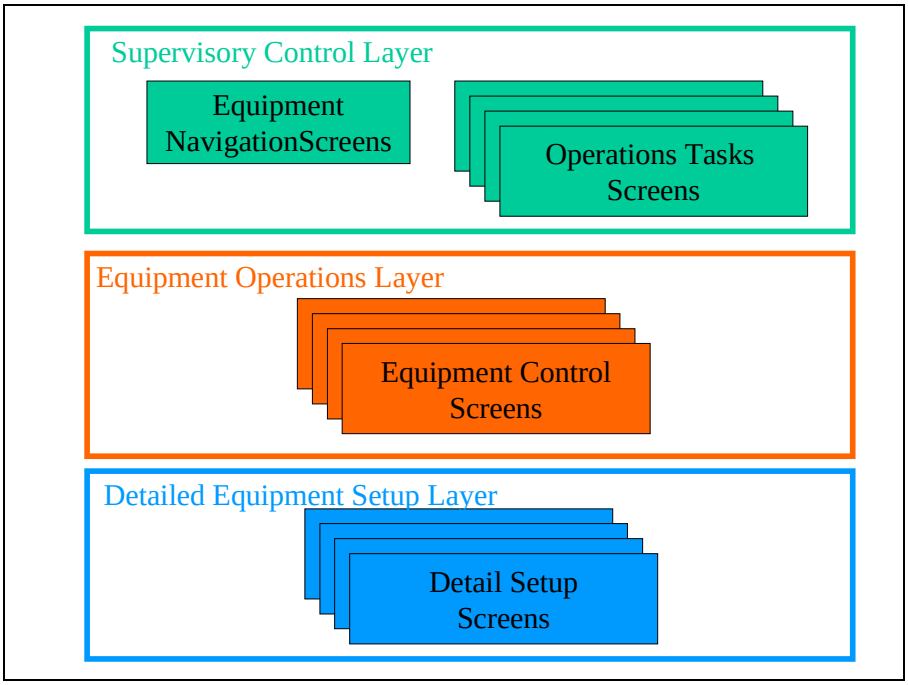


Figure 3 - Structure of Operation Interface Screens

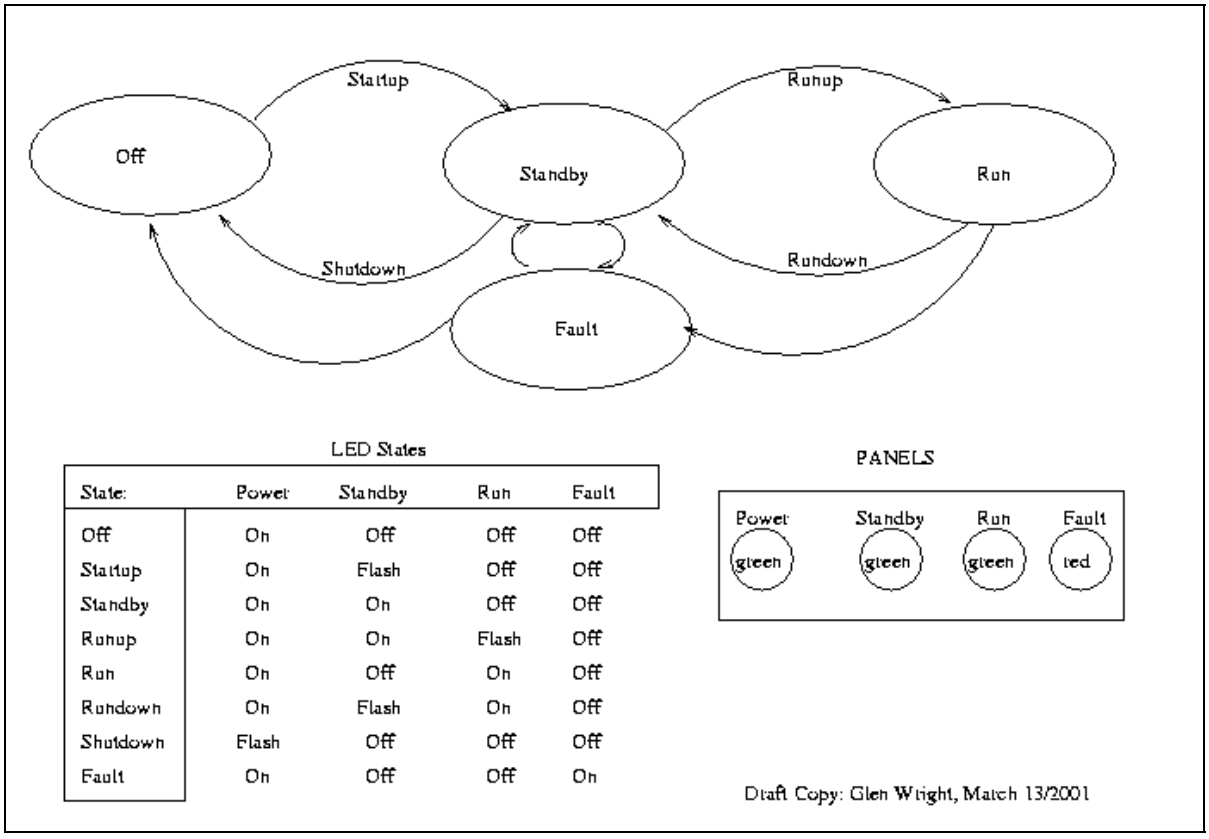
4.5.2 At the supervisory layer a series of equipment maps permit the operator to locate the relevant equipment based on the general arrangement within the system. For key machine set-up, operational, safety and maintenance tasks, task analysis is performed to determine the sequence of operations that must be performed and the information that is required to perform each of the tasks. Screens and automation is then developed to support these tasks. Using a heat exchanger as an example, at this level the user will be able to select if the accelerating section should be tuned or de-tuned. Details, such as the temperature associated with being tuned, are hidden at this layer.

4.5.3 The equipment operations layer (accessed from the supervisory layer) contains screens for controlling key pieces of equipment in the field. These screens are often based on P&ID drawings. Parameters and equipment feedback that is appropriate for use by an operator is presented at this layer. Using a heat exchanger as an examples, at this layer the operator will be able to modify the set-point used for tuned or de-tuned operation. Details, such as the PID configuration associated with the set-point, are hidden at this layer.

4.5.4 A Detailed Equipment Set-up layer (accessed from the equipment operations layer) contains screens for initial set-up of field equipment and diagnosis of failed equipment. Information presented at this layer requires a detailed understanding of the underlying equipment and would normally only be of interest to the equipment designer or maintenance staff. Using a heat exchanger as an example, at this level the user will be able to see and modify the gain values for the heat exchanger.

4.5.5 Standard State Machine Model

Figure 4 illustrates the standard state machine and machine status terminology used in the design of the CLS control system. To the greatest extent possible the CLS control system design should present the state of equipment using this model.



State:	Power	Standby	Run	Fault
Off	On	Off	Off	Off
Startup	On	Flash	Off	Off
Standby	On	On	Off	Off
Runup	On	On	Flash	Off
Run	On	Off	On	Off
Rundown	On	Flash	On	Off
Shutdown	Flash	Off	Off	Off
Fault	On	Off	Off	On

Power	Standby	Run	Fault
green	green	green	red

Figure 4 – Standard CLS Equipment State-machine

A standard panel layout, LED colour scheme and indication pattern is used for each of these states. Indicators that are not relevant for the specific piece of equipment can be omitted.

Table 15 defines each of the standard CLS states. Startup, Runup, Shutdown and Rundown are intermediate transition states. For some pieces of equipment it may be necessary to slowly bring up the equipment and after operation to run fans and other cooling until the equipment can be safely turned off. When required the control system maintains the equipment in a transition status until it is appropriate to enter the off, standby, or run state. For some equipment Standby is not necessary and can be omitted.

Table 15 - Standard CLS Equipment Operating States

State	Description
Primary States	
Off	Equipment is not operating, (some essential components and control components may be powered). This is the normally the initial state of equipment on power up.
Standby (Optional State)	Equipment is brought up and ready to operate but not operational.
Run	Equipment running in normal operation.
Intermediate Transition States	
Start-up	In the start-up state components are initialised and brought up to standby using an algorithm appropriate for the piece of equipment.
Run-up	In the run-up state equipment is brought online.
Shut-down	Equipment is moved into a safe state to be powered off.
Run-down	Equipment is moved into a standby state.

4.5.6 Operator Screens shall be designed using either KDE EDM.

4.5.7 For a beamline, EDM screens (see Figure 5) shall be based on an exported general arrangement drawing for AutoCAD and shall contain at a minimum the following screens:

a) Front End,
b) Beamline,
c) CCGs,
d) TCGs,
e) Flow Switches and Flow Transmitters,
f) ION Pumps,
g) Temperatures,
h) Diagnostics (Pico-Am Meters), and
i) Motors.

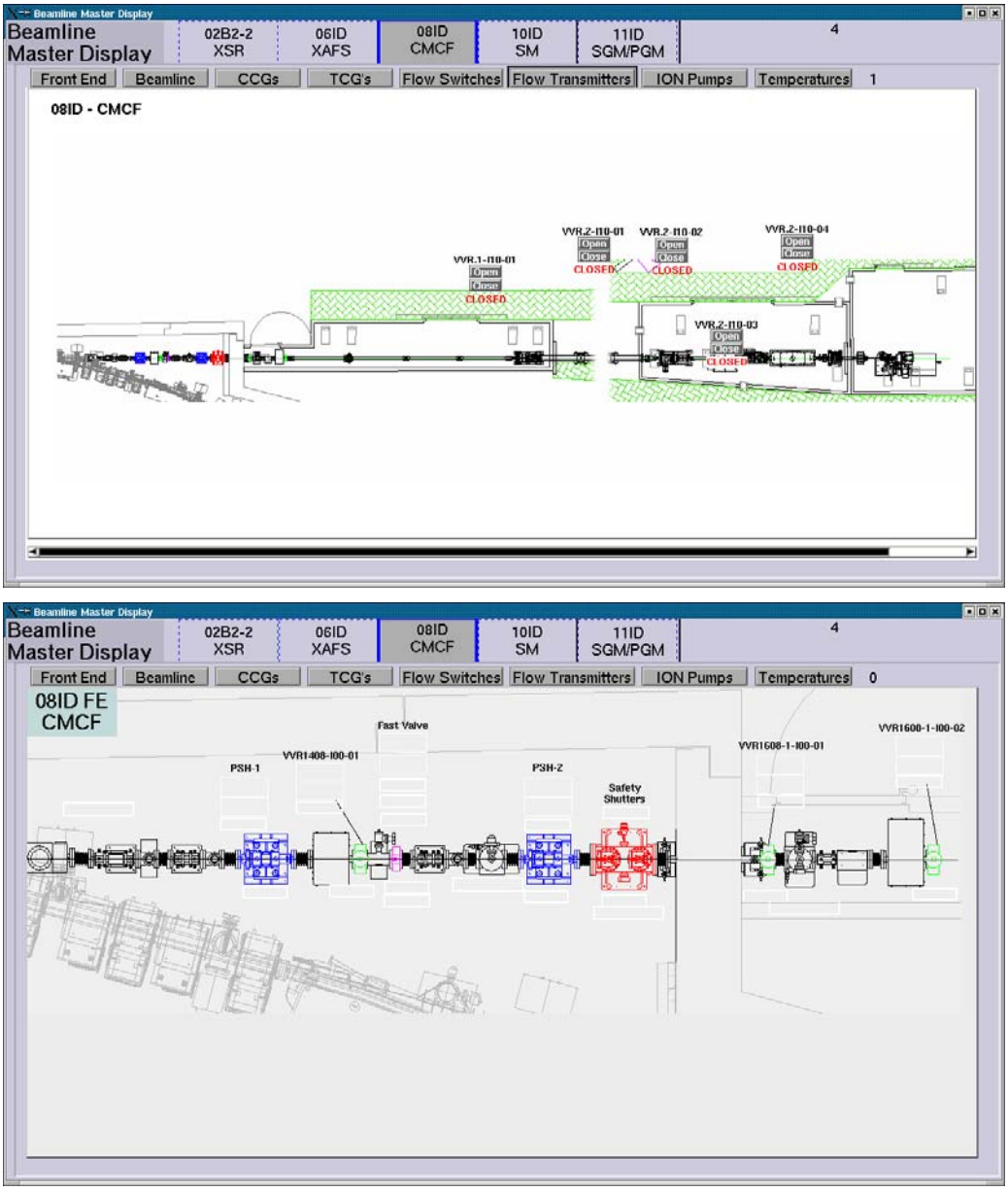


Figure 5 – Example EDM Screens

User Screens requirements:

a) Courier font shall be used for “numeric readouts”.

Rationale: The fixed-width emulates a panel meter and keeps the text stable when values change.

b) Numeric values are coded as follows:

i) Normal levels are shown in black text.
ii) Warning levels are shown in yellow text.
iii) Alarm levels are shown in red text.
iv) Stale signals are shown in white text.

c) The Helvetica font shall be used for annotation and titling.

d) The Colour scheme shown in Figure 6 shall be used for all screens where practical.

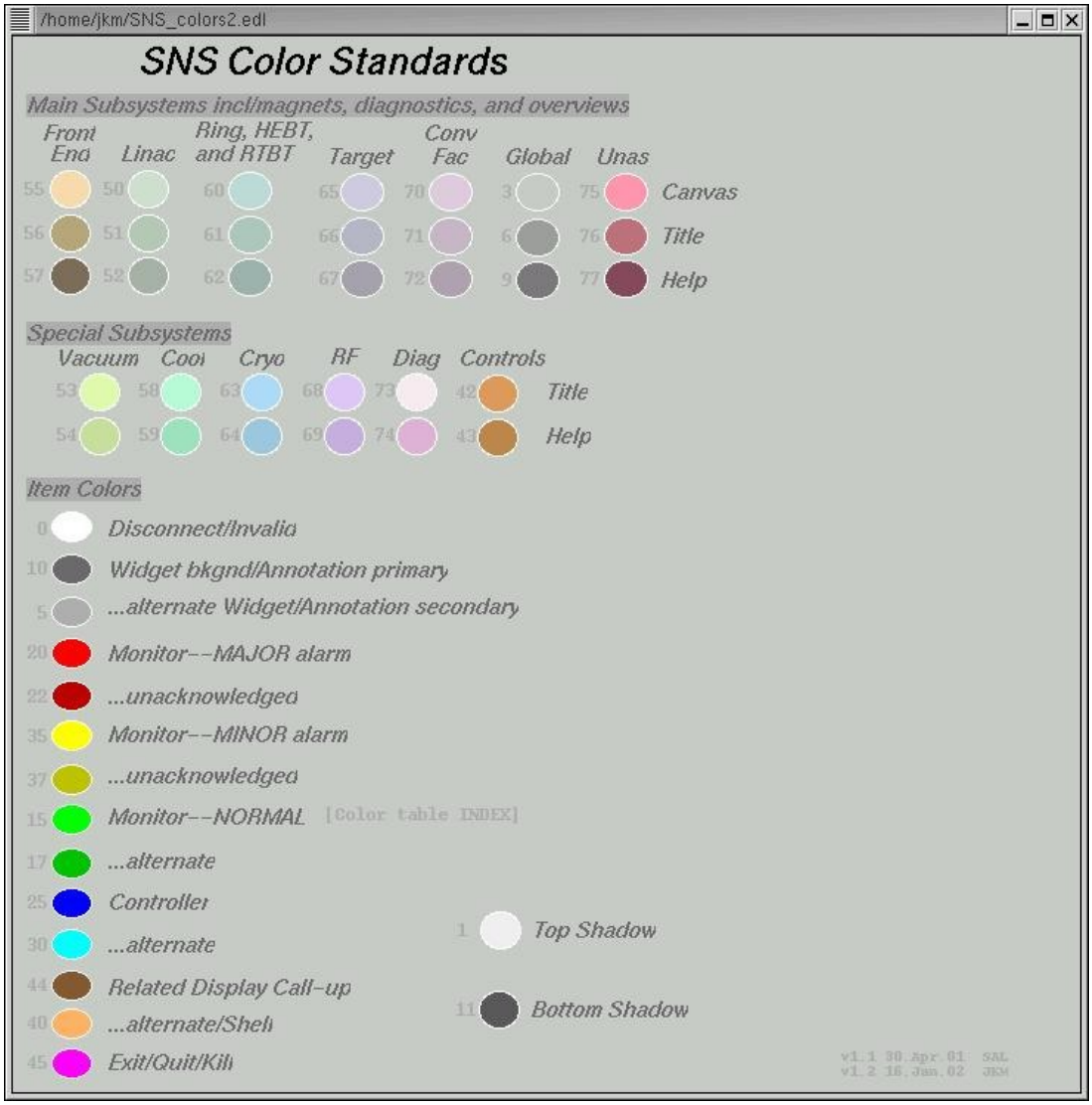


Figure 6 – SNS Colour Scheme

4.5.8 When preparing screens that show flow through pipes on screens, the following table (Table 16) shows the colours and notations that shall be used for piping on control screens. The table also shows the colours and notations used in the field.

Table 16 - Colours and Notations on Control Screens and in the Field

Piping	Colour in the field	Colour on screens
Domestic Cold Water	Green DCW	Blue DCW
Domestic Hot Water	Green DHW	Red DHW
Domestic Hot Water Recirculating (e.g. heating coils)	Green DHWR	Red DHW
Domestic Tempered Water (downstream of mixing valve)	Green DTW	Green DTW
Separated Water (downstream of backflow preventer)	Green SW	Green SW
Deionised Water	Green DIW	Green DIW
Reverse Osmosis Water	Green ROW	Green ROW
Fire Lines (Hose Cabinets Sprinklers)	Red F	Red F
Compressed Air	Yellow CA-kPa	Yellow CA-kPa
Natural Gas	Yellow NG	Yellow NG
Sanitary Sewer	Green SAN	Green SAN
Vacuum	Green VAC	Green VAC
Storm Sewer	Green RW	Green RW
Sewer Vent	Green SV	Green SV
Corrosion Resistant Waste Sewer	Green CRD	Green CRD
Corrosion Resistant Waste Vent	Green CRV	Green CRV
Steam - High Pressure (Above 413 kPag)	Yellow HPS	Red HPS
Steam - Low Pressure (104 kPag and under)	Yellow LPS	Red LPS
Condensate - High Pressure (Above 103 kPha)	Yellow HPC	Blue HPS
Condensate - Low Pressure (103 kPag and under)	Yellow LPC	Blue LPC
Pumped Condensate	Green PC	Green PC
Chilled Water Supply	Green CHS	Yellow CHS
Chilled Water Return	Green CHR	Yellow CHR
Steam Pressure Relief Valve Vent	Yellow SRV	Red SRV
Condensate Tank Vent	Green CV	Green CV
Hot Water Heating Supply	Green HWS	Red HWS
Hot Water Heating Return	Green HWR	Red HWR
Hot Water Heating Supply (Glycol)	Green HWS (G)	Gold HWS
Hot Water Heating Return (Glycol)	Green HWR (G)	Gold HWR
Heat Recovery Warm	Green HRW	Red HRW
Heat Recovery Cool	Green HRC	Red HRC
Fluid Cooler Evaporative Water Supply	Green EWS	Green EWS

Fluid Cooler Evaporative Water Return	Green EWR	Green EWR
Low Conductivity Cooling Water Supply	Green LCWS	Blue LCWS
Low Conductivity Cooling Water Return	Green LCWR	Blue LCWR
Glycol Cooling Water Supply	Green GLR	Gold GLR
Helium – Liquid	Blue LHe	Blue LHe
Helium - Gas Cold (<16 Kelvin)	Blue C-GHe	Blue C-GHe
Helium - Gas Warm (>16 Kelvin)	Blue W-GHe	Blue W-GHe
Nitrogen – Liquid	Blue LN2	Blue LN2
Nitrogen – Gas	Blue N2	Blue N2

4.5.9 User screens shall be developed using the guidelines identified in document NUREG-0700 Human-System Interface Design Review Guidelines. The requirements, from NUREG-0700, that are applicable are sections 2.2.2, 2.2.5, 2.3, 2.6, 2.7, 2.8, and 4.2. Appendix A shows the CLS compliance to these requirements.

5.0 REFERENCES

7.4.39.14 Rev 0. - Cable Specification for Class 2 Circuits, Johnson 2006.

VXI Consortium VXIbus System Specification VXI-1 Rev., August 1998.

7.8.48.1 Rev 0. – Transmission of Timing-critical Signals Using TTL Levels, Vogt 2000.

0.4.1.1 Rev 3. – Vendor Documentation Specification, Matias 2005.

Unified Modeling Language, OMG 1999.

7.4.37.1 Rev 0. – CLS Lockup PLC Technical Specification, Matias 2001.

Canadian Electrical Code, Part 1, 2006.

7.7.52.1 Rev 2. – Safety System Ring out Procedure, Tanner 2005.

7.7.90.1 Rev 0. – Testing CLS PLC Heat Exchangers, Guspodarchuk 2002.

7.7.90.2 Rev 0. – Testing CLS PLC Controlled Machine Protection, Johnson 2002.

8.11.16.3 Rev 0. – CLSI Colour Codes for Conduit Junction Boxes, Johnson 2006.

APPENDIX A

Compliance to NUREG-0700 Human-System Interface Design Review Guidelines

There is one row in the compliance matrix for each applicable requirement from NUREG-0700 Rev 2.

The columns in the compliance matrix are:

- Requirement number – the number of the requirement in NUREG-0700
- Requirement title – the title of the requirement as written in NUREG-0700
- CLS Compliance – Whether or not CLS is compliant with this requirement

The CLS compliance column is noted with the following symbols:

Symbol	Meaning of the symbol
Title	The requirement number is only for a title – there is no requirement with this number
√	Compliant
V√	Very Close to compliant such that it can be considered compliant. Non compliant items are noted
A√	Compliant using alternate view to the criteria. The alternate criteria is explained.
X	Not Compliant
X√	Not Compliant but intend to be compliant. The work to be done is explained.
n/a	Criteria is not applicable - reason explained.

Req. #	Requirement Title	CLS Compliance	
2.2	**User Input Formats**	**Title**	
2.2.2	**Menus**	**Title**	
2.2.2.1	General	Title	
2.2.2.1-1	Explicit Option Display	√	
2.2.2.1-2	Consistent Display of Menu Options	√	
2.2.2.1-3	Consistent Location for Menus	√	
2.2.2.1-4	Consistent entry Prompt	√	
2.2.2.1-5	Permanent Menus Minimized	√	
2.2.2.1-6	Activation of Pull-Down and Pop-Up Menus	√	
2.2.2.1-7	User Requested Menus: Pull-Downs and Pop-Ups	√	
2.2.2.1-8	Hiding Menus After a Command is Carried Out	√	
2.2.2.1-9	Programmable Keys	√	
2.2.2.1-10	Explanatory Title for Menu	√	
2.2.2.1-11	Complete Display of Menu Options	√	
2.2.2.1-12	Option Display Dependent on Context	√	
2.2.2.1-13	Function of Menu Should be Evident	√	
2.2.2.1-14	Menus Distinct from Other Displayed Information	√	

Req. #	Requirement Title	CLS Compliance	
2.2.2.1-15	Breadth and Depth of Menu Items	√	
2.2.2.1-16	Number of Options	√	Some menus have more than 8 options - e.g. CLS main menu.
2.2.2.1-17	Equivalent Keyboard Commands	√	
2.2.2.1-18	Continuous Presentation of Menu	√	
2.2.2.1-19	Providing Default Options	√	
2.2.2.1-20	Option Previews	√	
2.2.2.1-21	Visual Grouping of Menu Options	√	
2.2.2.1-22	Critical or Frequently Chosen Options	√	
2.2.2.1-23	Initial Cursor Position	√	
2.2.2.1-24	Menu Macro Capability	n/a	Not applicable for structure of our applications.
2.2.2.1-25	Use of Multiple Paths	X	We use short navigation paths instead of multiple paths
2.2.2.1-26	Representation of Menu Structure	√	
2.2.2.1-27	Indicating Selectable Menu Items	√	
2.2.2.2	Arrangement of Menu Options	Title	
2.2.2.2-1	Logical Ordering of Menu Options	√	
2.2.2.2-2	Default Ordering of Menu Options	√	
2.2.2.2-3	No Scrolling in Menus or Menu Bars	V√	In limited cases where it improves the usability of the software, scroll bars are used for pull down menus.
2.2.2.2-4	Single-Column List Format	√	
2.2.2.2-5	Fixed Menu Order	√	
2.2.2.3	Heirarchical Menus	Title	
2.2.2.3-1	Labeling Grouped Options	√	
2.2.2.3-2	Heirarchic Menus for Sequential Selection	√	
2.2.2.3-3	Consistent Design of Hierarchic Menus	√	
2.2.2.3-4	Labeling in Heirarchic Menus	√	
2.2.2.3-5	Visual Representation of Path	X√	Some applications need to be upgraded (e.g Facility App)
2.2.2.3-6	Minimal Steps in Sequential Menu Selection	√	
2.2.2.3-7	Return to Higher-Level Menus	√	
2.2.2.3-8	Indicating Current Position in Menu Structure	X√	Some applications need to be upgraded (e.g Facility App)
2.2.2.3-9	Distinct Subordinate Menus	√	
2.2.2.3-10	Control Options Distinct from Menu Branching	√	
2.2.2.3-11	Return to General Menu	√	
2.2.2.3-12	Use of Broad, Shallow Menu Structures	√	
2.2.2.3-13	Minimizing Menu Choices In the Middle of a Menu Structure	√	
2.2.2.3-14	Direct Selection of Submenus	X	We use short navigation paths, so direct selection of submenus is not necessary.
2.2.2.4	Menu Bars	Title	

Req. #	Requirement Title	CLS Compliance	
2.2.2.4-1	Systematic Organization of Items on Menu Bar	√	
2.2.2.4-2	Category Labels on Menu Bar	√	
2.2.2.4-3	Height of Menu Bar	√	
2.2.2.5	Selection of Menu Options	Title	
2.2.2.5-1	Menu Selection by Keyed Entry	√	
2.2.2.5-2	Standard Area for Code Entry	√	
2.2.2.5-3	Stacking Menu Selections	√	
2.2.2.5-4	Bypassing Menu Selection with Command Entry	√	
2.2.2.5-5	Menu Selection by Pointing	√	
2.2.2.5-6	Acknowledgement of Menu Selection	√	
2.2.2.5-7	Non-Selection of Conflicting Menu Items	√	
2.2.2.5-8	Non-Selectable Menu Items	√	
2.2.2.5-9	Separate Selection and Activation Actions	V√	Compliant except for touch screens which don't have a separate select and enter action.
2.2.2.5-10	Large Pointing Area for Option Selection		
2.2.2.5-11	Selection of ON/OFF Items	√	
2.2.2.5-12	Indicating Selected Menu Items	√	
2.2.2.5-13	Indicating Selectable Area	√	
2.2.2.5-14	Indicating Completion of Selection	√	
2.2.2.6	Wording and Coding Menu Options	Title	
2.2.2.6-1	Menu Options Worded as Commands	√	
2.2.2.6-2	Option Wording Consistent with Command Language	√	
2.2.2.6-3	Consistent Coding of Menu Options	√	
2.2.2.6-4	Key Coded Menu Selection	√	
2.2.2.6-5	Menu Color	√	
2.2.2.6-6	Letter Codes for Menu Selection	√	
2.2.2.6-7	Highlighting When Cursor Passes Over Items	√	
2.2.2.6-8	ON/OFF Menu Items	X	Not compatible with our current development tools.
2.2.2.6-9	Indication of Active Menu Selection	√	
2.2.5	**Forms**	**Title**	
2.2.5-1	Form Filling for Command Entry	√	
2.2.5-2	Defaults for Command Entry	√	
2.2.5-3	Consistent Format for Command Forms	√	
2.2.5-4	Forms for Information Entry	√	
2.2.5-5	Grouping Data Fields	√	
2.2.5-6	Combined Entry of Related Data	V√	For devices, each entry is atomic and processed individually.
2.2.5-7	Data Fields Label	√	
2.2.5-8	Minimal Use of Delimiters	√	
2.2.5-9	Standard Delimiter Character	√	
2.2.5-10	Flexible Interrupt	√	
2.2.5-11	Deferring Input of Information		
2.2.5-12	Use of Tabular Displays	√	

Req. #	Requirement Title	CLS Compliance	
2.2.5-13	Distinctive Label Formats	√	
2.2.5-14	Aiding Entry of Duplicated Data	√	
2.2.5-15	Tabbing of Advance to Subsequent Fields	√	
2.2.5-16	Direct Pointing Devices for Selecting Fields	√	
2.2.5-17	Row Scanning Cues	√	
2.2.5-18	Providing Default Information	√	
2.3	**Cursors**	**Title**	
2.3.1	Appearance	Title	
2.3.1-1	Distinctive Cursor	√	
2.3.1-2	Display of Cursor	√	
2.3.1-3	Non-Distracting Design	√	
2.3.1-4	Stable Cursor	√	
2.3.1-5	Initial Cursor Placement	√	
2.3.1-6	Consistent HOME Position	√	
2.3.1-7	Automatic Return of Cursor	√	
2.3.2	Controls	Title	
2.3.2-1	Cursor Control - General	√	Provided by O/S
2.3.2-2	Compatible Control of Cursor Movement	√	
2.3.2-3	Easy Cursor Positioning	√	
2.3.2-4	Consistent Positioning	√	
2.3.2-5	Cursor Control Key Functions	√	
2.3.2-6	Cursor Control at Keyboard	√	
2.3.2-7	Location of Cursor Control Keys	√	
2.3.3	Movement	Title	
2.3.3-1	Cursor Movement	√	
2.3.3-2	Responsive Cursor Control	√	
2.3.3-3	Precise Pointing	√	
2.3.3-4	Selectable Rate Aiding	√	
2.3.3-5	User Selectable Speed	√	
2.3.3-6	Variable Step Size	√	
2.3.3-7	Easy Cursor Movement to Data Fields	√	
2.3.3-8	Explicit Activation	√	
2.3.3-9	Display Format Protection	√	
2.3.3-10	Free Cursor Movement	√	
2.3.3-11	Proportional Spacing	√	
2.3.3-12	Cursor Movement by Units of Text	√	
2.3.3-13	Data Entry Independent of Cursor Placement	√	
2.3.4	Multiple Cursors	Title	
2.3.4-1	Minimal Use of Multiple Cursors	√	
2.3.4-2	Multi Monitor/Multi Controller Cursor Characteristics	√	
2.3.4-3	Distinctive Multiple Cursors	√	
2.3.4-4	Compatible Control of Multiple Cursors	√	
2.3.4-5	Distinctive Control of Multiple Cursors	√	

Req. #	Requirement Title	CLS Compliance	
2.3.4-6	Multiple Pointing Cursor Control Devices	√	
2.3.4-7	Unique Shapes	√	
2.3.5	Pointing Cursors	Title	
2.3.5-1	Pointing Cursor Visibility	√	
2.3.5-2	Pointing Cursor Blink	√	
2.3.5-3	Pointing Cursor Image Quality	√	
2.3.5-4	Pointing Cursor Design	√	
2.3.5-5	Pointing Cursor Size Constancy	√	
2.3.5-6	Pointing Cursor Movement	√	
2.3.6	Text Entry Cursors	Title	
2.3.6-1	Text Entry Cursor Visibility	√	
2.3.6-2	Identification of Text Entry Cursor	√	
2.3.6-3	Text Entry Cursor Blink	√	
2.3.6-4	Nonobscuring Text Entry Cursor	√	
2.3.6-5	Number of Text Entry Cursors	√	
2.3.6-6	Text Entry Cursor Size	√	
2.3.7	Multiple Display Devices	Title	
2.3.7-1	Cursor Motion Across Contiguous Similar Displays	√	
2.3.7-2	Cursor Motion Across Physically Separated Dissimilar Displays	√	
2.4	**System Response**	**Title**	
2.4.1	Prompts	Title	
2.4.1-1	Prompting User Entries	√	
2.4.1-2	Prompting Address Entry	√	
2.4.1-3	Standard Symbol for Prompting Entry	√	
2.4.1-4	Prompting Command Correction	A√	Instead feedback values are displayed and input values are restricted to permissible ranges are
2.4.1-5	Prompting Field Length	√	
2.4.1-6	Data Format Cuing in Labels	√	
2.4.1-7	User-Requested Prompts	n/a	Interfaces are GUI driven, not command line driven.
2.4.1-8	Prompting Data Entry	√	
2.4.1-9	Graphic Display of Control Prompting	√	
2.4.2	Feedback	Title	
2.4.2-1	Feedback During Data Entry	√	
2.4.2-2	Feedback for Completion of Data Entry	A√	Instead, screen is updated with feedback data in place of confirmation message.
2.4.2-3	Feedback for Repetitive Data Entries	√	
2.4.3	System Response Time	Title	
2.4.3-1	Response Time Appropriate to Transaction	√	

Req. #	Requirement Title	CLS Compliance	
2.4.3-2	Response Time Appropriate to Tasks	√	
2.4.3-3	Display Average System Response Time	n/a	Not affected by number of users.
2.4.3-4	Response Time Consistent with Requirements	√	
2.4.3-5	Processing Delay	√	
2.4.3-6	Indicating Completion of Processing	√	
2.4.3-7	Response Time Induced Keyboard Lockout	n/a	Applications have keyboard buffer and multi threading.
2.4.3-8	Keyboard Restoration	n/a	No keyboard lockout.
2.4.3-9	Variability of Response Time	√	
2.4.3-10	Maximum System Response Times	√	
2.5	**Managing Displays**	**Title**	
2.5.1	Display Selection and Navigation	Title	
2.5.1.1	Orientation Features	Title	
2.5.1.1-1	Organization of the Display Network	√	
2.5.1.1-2	Cues to Display Network Structure	√	
2.5.1.1-3	Overview of Display Network	X√	To be added to documentation
2.5.1.1-4	Perceptual Landmarks	√	
2.5.1.1-5	Location Cues	√	
2.5.1.1-6	Directional Cues	√	
2.5.1.1-7	Scales, axes, and grids	√	
2.5.1.1-8	Display Page Titles and Identification Codes	√	
2.5.1.1-9	Orientation Coding	√	
2.5.1.1-10	Display Overlap	√	
2.5.1.1-11	Explicit Indication of Context	√	
2.5.1.1-12	Understanding Successive Views	√	
2.5.1.2	Retrieval Features	Title	
2.5.1.2-1	Flexibility in Display System Interaction	√	Provided where appropriate.
2.5.1.2-2	Minimal Navigation Path Distance	√	
2.5.1.2-3	Short Navigational Distances in Hierarchies	√	
2.5.1.2-4	Relatedness of Successive Views	√	
2.5.1.2-5	Time to Complete Navigation	√	
2.5.1.2-6	Detection of Navigation Targets	√	
2.5.1.2-7	Lateral Moves in a Hierarchy	√	
2.5.1.2-8	Simultaneous Display of Related Items	√	
2.5.1.2-9	Support for 'Top-Down' Strategies for Navigating Hierarchies	√	
2.5.1.2-10	Support for 'Bottom-Up' Strategies for Navigating Hierarchies	√	
2.5.1.2-11	Representation of Distance	√	
2.5.1.2-12	Distortion-Based Orientation	√	
2.5.1.2-13	Visually Identifying Hypertext Links	√	
2.5.1.2-14	Typographically Identifying Hypertext Links	√	
2.5.1.2-15	Indentifying Hypertext Links by Cursor Coding	√	
2.5.1.2-16	Evaluating Hypertext Links	√	
2.5.1.2-17	Navigating Individual Hypertext Nodes	√	
2.5.1.2-18	Backtracking Capabilities in Hypertext Interfaces	√	

Req. #	Requirement Title	CLS Compliance	
2.5.1.2-19	Multiple Hypertext Navigation Methods	√	
2.5.1.3	Navigation Features for Large Display Pages	Title	
2.5.1.3-1	Integrating Information within Large Display Pages	√	
2.5.1.3-2	Consistent Framing for Pan and Zoom	√	
2.5.1.3-3	Selecting the Center for Zoom and Pan Operations	√	
2.5.1.3-4	Default Configuration for Zoom, Pan and Scroll	√	
2.5.1.3-5	Size Compensation for Zoom	√	
2.5.1.3-6	Minimize Scrolling Demands	√	
2.5.1.3-7	Column Width of Scrolled Text	√	
2.5.2	Windows	Title	
2.5.2-1	Window Identification	√	
2.5.2-2	Window Selection and Display	√	KDE
2.5.2-3	Displaying Multiple Windows	√	KDE
2.5.2-4	Managing Open Windows	√	KDE
2.5.2-5	Window Demarcation	√	KDE
2.5.2-6	Distinction Between Window Types	√	KDE
2.5.2-7	Active Windows Priority	√	KDE
2.5.2-8	Caution and Warning Window Priority	√	
2.5.2-9	Default Window Size	√	
2.5.2-10	Minimum Height for Text Windows	√	
2.5.2-11	Minimum Width for Text Windows	√	
2.5.2-12	Consistent Window Control	√	
2.5.2-13	Window Control Functions	√	
2.5.2-14	Consistent Control Within Windows	√	
2.5.2-15	Window Opening Methods	√	
2.5.2-16	Closing Windows	√	
2.5.2-17	Easy Shifting Among Windows	√	
2.5.2-18	Activating a Previously Opened Window	√	
2.5.2-19	Activation of Window Cursor	√	
2.5.2-20	Multi-Modal Window Designation	√	
2.5.2-21	Movable Windows	√	
2.5.2-22	Window Position	√	
2.5.2-23	Smooth Window Movement	√	
2.5.2-24	Indicate Active Window	√	
2.5.2-25	Update of Hidden Windows	√	
2.5.2-26	Alerting User to Information Availability	X√	Alarms for Facility app need to be coded.
2.5.2-27	Window Activates Upon Opening	√	KDE
2.5.2-28	Varying Window Size	√	KDE
2.5.2-29	Accessibility to Partially Removed Windows	√	KDE
2.5.2-30	Scrollable Windows	√	EDM
2.5.2-31	User Control of Automatic Update	√	Indirectly provided through screen capture
2.5.2-32	Multiple Views	√	
2.5.2-33	Minimize Needs for Window Manipulation	√	

Req. #	Requirement Title	CLS Compliance	
2.5.2-34	Obscured Critical Information	√	Procedural controls are in place to keep critical information on separate displays.
2.5.2-35	Positioning Critical Windows	√	Procedural controls are in place to keep critical information on separate displays.
2.5.2-36	Default Window Location	√	
2.5.2-37	Temporarily Obscured Display Data	√	
2.5.2-38	Obscuring the Active Window	√	
2.5.2-39	Number of Allowable Open Windows	X	Operational experience indicates this is not an issue.
2.5.2-40	Suppression of Window Objects	√	
2.5.2-41	Separate Menu Bars for Applications	√	
2.5.2-42	Conveying the Relationship Between Window, Icon and Action	√	
2.5.2-43	Labeling Windows	√	
2.5.2-44	Closing Main Window and Subordinate Objects	√	
2.5.2-45	Matching Selection Items and Window Labels	√	
2.5.2-46	Indication of All Open Windows	√	
2.5.2-47	Window Automation Coordinated with Tasks	√	
2.5.3	Display Control	Title	
2.5.3-1	Display Control	A√	Instead screen layouts are reviewed with users as part of requirements and commissioning activities.
2.5.3-2	Display of Control Options	√	
2.5.3-3	Zooming for Display Expansion	A√	Instead screen layouts are reviewed with users as part of requirements and commissioning activities.
2.5.3-4	Functional Labeling for Display Framing	√	
2.5.3-5	Easy Paging	√	
2.5.3-6	Show Changing Scale	√	
2.5.3-7	Show Overview Position of Visible Section	√	
2.5.3-8	Return to Normal Display Coverage	√	
2.5.4	Display Update/Freeze	Title	
2.5.4-1	Data Updated as Available	√	
2.5.4-2	Readability of Changing Data	√	
2.5.4-3	Visual Integration of Changing Graphics	√	
2.5.4-4	Refresh Rate for Free-drawn Graphics	√	
2.5.4-5	Display Freeze	A√	Users use screen capture.
2.5.4-6	Labelling Display Freeze	A√	Users note on screen capture.
2.5.4-7	Signaling Changes to Frozen Data	n/a	No freeze capability
2.5.4-8	Resuming Update After Display Freeze	n/a	No freeze capability
2.5.5	Display Suppression	Title	
2.5.5-1	Temporary Suppression of Displayed Data	√	Minimize windows
2.5.5-2	Labeling of Display Suppression	√	
2.5.5-3	Signaling Changes to Suppressed Data	X	Users do not suppress important

Req. #	Requirement Title	CLS Compliance	
			displays
2.5.5-4	Resuming Display of Suppressed Data	√	
2.5.5-5	Dedicated Function Key	√	
2.5.6	Scrolling and Paging	Title	
2.5.6-1	Continuous Text Data	√	
2.5.6-2	Consistent Orientation	√	
2.5.6-3	Panning with Free Cursor Movement	√	
2.5.6-4	Framing Applied to All Data	√	
2.5.6-5	Paging Controls	√	
2.5.6-6	Horizontal Scrolling	√	
2.5.6-7	Appropriate Scrolling/Paging Structures	√	
2.5.6-8	Common Display Structure	√	
2.5.6-9	Scrolling/Paging Techniques	X	Only provided by mouse
2.5.6-10	One Structure for Vertical, One for Horizontal Movement	√	
2.5.6-11	Labeling Scrolling Function	√	
2.5.6-12	Evident Direction of Paging	√	
2.5.6-13	Paging in One or Multiple Page Increments	√	
2.5.6-14	Discrete Paging	√	
2.5.6-15	Indicate Absolute and Relative Positions to User	√	
2.5.6-16	Graphic Indication of Scroll Position	√	
2.5.6-17	Scroll by Line or Display Unit	√	
2.5.6-18	Display Window	√	
2.5.6-19	Parameters Refer to Data not Window	√	
2.5.7	Automated Actions	Title	
2.5.7-1	Anticipation of Automated Interface Management Actions	√	
2.5.7-2	Observability of Automated Interface Management Actions	√	
2.5.7-3	Distracting Automated Interface Management Actions	√	
2.6	**Managing Information**	**Title**	
2.6.1	Editing Documents	Title	
2.6.1-1	Natural Units of Text	√	
2.6.1-2	Text Displayed as Printed	√	
2.6.1-3	Format Control by User	√	
2.6.1-4	Establishing Predefined Formats	√	
2.6.1-5	Storing User-Defined Formats	√	
2.6.1-6	Consistent Word Spacing	√	
2.6.1-7	Hyphenation by Users	√	
2.6.1-8	Changing Physical Characteristics of Text	√	
2.6.1-9	Tabs	√	
2.6.1-10	Tab Control	√	
2.6.1-11	Margins	√	
2.6.1-12	Automatic Line Break	√	
2.6.1-13	Automatic Pagination Aids	√	
2.6.1-14	User Control of Pagination	√	

Req. #	Requirement Title	CLS Compliance	
2.6.1-15	Controlling Integrity of Text Units	√	
2.6.1-16	Protecting Text During Page Overruns	√	
2.6.1-17	Head- and Foot-of File	√	
2.6.1-18	Inserting	√	
2.6.1-19	String Search	√	
2.6.1-20	Multiple Methods of Searching	√	
2.6.1-21	Search for Line Numbers	√	
2.6.1-22	Upper and Lower Case Equivalent in Search	√	
2.6.1-23	Specifying Case in Search	√	
2.6.1-24	Global Search and Replace	√	
2.6.1-25	Case in Global Search and Replace	√	
2.6.1-26	Moving Text	√	
2.6.1-27	Pasting Text into a Graphical File and Vice Versa	√	
2.6.1-28	Cutting Graphical Objects and Areas of Graphical Displays	√	
2.6.1-29	Viewing Text Prior to Pasting	√	
2.6.1-30	Placing Cut Text in Compatible Files	√	
2.6.1-31	Placement of Pasted Text	√	
2.6.1-32	Pasting the Same Text More than Once	√	
2.6.1-33	Cutting Without a Gap in the Text	√	
2.6.1-34	Storing Frequently Used Text	√	
2.6.1-35	Vertical Scrolling When Selecting Text	√	
2.6.1-36	Non-Contiguous Blocks of Text	√	
2.6.2	Saving Files	Title	
2.6.2-1	Saving to a Data File	√	
2.6.2-2	Exit with Save	√	
2.6.2-3	Exiting a File	√	
2.6.2-4	Distinct Commands for Exit With and Without Save	√	
2.6.2-5	Protection Against Exiting a File Without Saving	√	
2.6.2-6	Recovery of Replaced File	√	
2.6.2-7	Automatic Saving of a File	√	
2.6.2-8	Automatic Backup	√	
2.6.2-9	Access of Modified Information After Exit Without Save	√	
2.6.3	Temporary Editing Buffer	Title	
2.6.3-1	Automatic Placement of Cut Data in Buffer	√	
2.6.3-2	Contents of Temporary Buffer	√	
2.6.3-3	Default Conditions of Buffer	√	
2.6.3-4	Access to Contents of Temporary Buffer	√	
2.6.4	Excerpt File	Title	
2.6.4-1	Accessing Information Across Applications	√	
2.6.4-2	Excerpt File	√	
2.6.4-3	Integrating Data	√	
2.6.4-4	Copying Excerpt File	√	
2.6.4-5	Saving Excerpt File	√	

Req. #	Requirement Title	CLS Compliance	
2.7	**User Assistance**	**Title**	
2.7.1	General	Title	
2.7.1-1	Standard Display Location	√	
2.7.1-2	Consistent Format for System Messages	√	
2.7.1-3	Familiar Wording	√	
2.7.1-4	Concise Wording of System Messages	√	
2.7.1-5	Speaking Directly to Users	√	
2.7.1-6	Only Necessary Information Displayed	√	
2.7.1-7	Anthropomorphism	√	
2.7.1-8	User Control of Automated Guidance/Help	n/a	Covered by operator training document: Operator Task Description and Validation Plan CLS Plan 0.12.1.1 Rev. 4
2.7.1-9	Content of Online Help	n/a	Covered by operator training document: Operator Task Description and Validation Plan CLS Plan 0.12.1.1 Rev. 4
2.7.1-10	Display of Online Help	√	
2.7.1-11	Interaction Styles	n/a	Covered by operator training document: Operator Task Description and Validation Plan CLS Plan 0.12.1.1 Rev. 4
2.7.2	Advisory Messages	Title	
2.7.2-1	Distinctive and Consistent Advisory Messages	√	
2.7.2-2	Redundant Display	√	
2.7.2-3	Informing Users of Potential Data Loss	√	
2.7.2-4	Time-consuming processes	√	
2.7.3	Error Messages	Title	
2.7.3-1	Informative Error Messages	√	
2.7.3-2	Task-Oriented Error Messages	√	
2.7.3-3	Neutral Wording for Error Messages	√	
2.7.3-4	Non-Disruptive Error Messages	√	
2.7.3-5	Invalid Action	√	
2.7.3-6	Advisory Error Messages	√	
2.7.3-7	Displaying Erroneous Entries	√	
2.7.3-8	Cursor Placement Following Error	√	
2.7.3-9	Indicating Repeated Errors	X	Operational experience indicates this is not needed.
2.7.3-10	Errors in Stacked Commands	√	
2.7.3-11	Multilevel Error Messages	X	Users are trained to contact domain experts
2.7.3-12	Cautionary Messages	√	
2.7.3-13	Multiple Error Messages	√	
2.7.3-14	Error Message Placement	√	
2.7.3-15	Documenting Error Messages	X	Operational experience indicates this is not needed.

Req. #	Requirement Title	CLS Compliance	
2.7.4	Validating User Input	Title	
2.7.4-1	Automatic Data Validation	√	
2.7.4-2	Validation	√	
2.7.4-3	Stroke-By-Stroke Echo	√	
2.7.4-4	System Validation	A√	Instead, out-of-range data is rejected
2.7.4-5	Data Verification by User Review	√	
2.7.4-6	Cross Validation of Related Data	A√	Instead, out-of-range data is rejected
2.7.4-7	Displaying Default Values	√	
2.7.4-8	Non-Disruptive Error Messages	A√	Instead, fields are restricted to valid data, invalid data is rejected
2.7.4-9	Timely Validation of Sequential Transactions	√	
2.7.4-10	Optional Item-by-Item Validation	n/a	Apps have atomic data entry
2.7.4-11	Deferral of Required Data Entry	n/a	Apps have atomic data entry
2.7.4-12	Reminder of Deferred Entry	n/a	Apps have atomic data entry
2.7.4-13	User Validation	√	
2.7.5	Confirming Entries	Title	
2.7.5-1	User Confirmation of Destructive Entries	X	Covered by user training
2.7.5-2	Informing Users of Potential Information Loss	√	
2.7.5-3	Preventing Data Loss at Logoff	√	
2.7.5-4	Displaying Data to be Changed	√	
2.7.6	Protecting Data	Title	
2.7.6-1	Protection from Computer Failure	√	
2.7.6-2	Protection from Interrupts	√	
2.7.6-3	Protection from Data Change	√	
2.7.6-4	Explicit Action to Select Desctructive Modes	√	
2.7.6-5	Safe Defaults	√	
2.7.6-6	Protecting Physical Controls	√	
2.7.6-7	Disabling Unneeded Controls	√	
2.7.6-8	Distinctive File Names	√	
2.7.6-9	Feedback for Mode Selection	√	
2.7.6-10	Protection from Interference by Other Users	√	
2.7.6-11	Segregating Real from Simulated Data	√	
2.7.6-12	Data Entry/Change Transaction Records	X√	We need to review areas that need to be improved
2.7.7	Correcting Information/Command Entries	Title	
2.7.7-1	Acknowledging Corrections	√	
2.7.7-2	UNDO to Reverse Control Actions	A√	Instead for machine setup and configuation apps, there is an ability to save and restore configs.
2.7.7-3	User Review and Editing of Entries	√	
2.7.7-4	Immediate Error Correction	√	
2.7.7-5	Editing Entries After Error Detection	√	
2.7.7-6	Explicit Entry of Corrections	√	
2.7.7-7	Automated Correction Aid	X	Nature of app
2.7.7-8	Flexible BACKUP for Error Correction	√	

Req. #	Requirement Title	CLS Compliance	
2.7.7-9	Errors in Stacked Commands	√	
2.7.7-10	Partial Execution of Stacked Commands	√	
2.7.7-11	Replacing Erroneous Commands	√	
2.7.7-12	Correcting Command Entry Errors	√	
2.7.8	User Guidance/Help	Title	
2.7.8-1	On-Line Guidance	X√	Details being added to CLS wiki
2.7.8-2	Access to Guidance	X√	Details being added to CLS wiki
2.7.8-3	HELP Request	X√	Details being added to CLS wiki
2.7.8-4	HELP Guidance	X√	Details being added to CLS wiki
2.7.8-5	Synonyms for Standard Terminology	X√	Details being added to CLS wiki
2.7.8-6	Context-Sensitive HELP	X√	Details being added to CLS wiki
2.7.8-7	Clarifying HELP Requests	X√	Details being added to CLS wiki
2.7.8-8	Multilevel HELP	X√	Details being added to CLS wiki
2.7.8-9	Browsing HELP	X√	Details being added to CLS wiki
2.7.8-10	Return from HELP	X√	Details being added to CLS wiki
2.7.8-11	Hardcopy Procedures	X√	Details being added to CLS wiki
2.7.8-12	Computer Systems Procedures	X√	Details being added to CLS wiki
2.7.8-13	Display Indices	X√	Details being added to CLS wiki
2.8	**Interface Flexibility**	**Title**	
2.8-1	Appropriate Use of HSI Flexibility Features	√	
2.8-2	Design for User Requirements	√	
2.8-3	Scope of Flexibility	√	
2.8-4	Limits of Flexibility	√	
2.8-5	Default Configuration and HSI Flexibility Features	√	
2.8-6	Changes to Display Characteristics	√	
2.8-7	User Expertise and HSI Flexibility Features	√	