CANADIAN LIGHT SOURCE
ELECTRICAL DESIGN CRITERIA

CLS DESIGN NOTE – 8.1.16.1 Rev. 1

Date: 2006-10-20

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Revision History

Revision	Date	Description	Author
A	2000-08-15	Original Draft	Harbans Aulakh
B	2000-10-20	Issued for Comments	Harbans Aulakh
O	2001-02-05	Original Issue	Harbans Aulakh
0A	2004-Jan-13	Updated to reflect present practice	Neil Johnson
0B	2006-10-20	Additional updates including comments from Wade Dolton and Neil Hovdestad	Neil Johnson
1	2006-10-20	Issued for use	Neil Johnson

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1.0 PURPOSE

The purpose of these design criteria is to provide the basis for developing the detail design of the electrical services and associated systems for the Canadian Light Source project by establishing general considerations, recommended practices and specific precautions based on referenced standards and industry practices.

This document is intended to be used for the design of equipment that shall be installed after this document's date of approval. It is not intended that existing systems be modified to meet these specifications.

The design criteria document shall be used as a continuing document and shall be kept current throughout the life of the project.

The design criteria shall contain the salient design goals for accomplishing complete system design. As system descriptions are developed producing greater detail for the system, the applicable portion shall be referenced by the design criteria to avoid duplication.

2.0 INTRODUCTION

The design, selection and sizing of electrical equipment is affected by many factors and installation conditions such as ambient temperature, altitude, load, demand factors, percent loss of equipment life under short time emergency overload conditions, voltage regulation, short circuit capacities, the ability to start large motors, load characteristics, client standards, and relevant codes and standards.

The electrical system shall be economically designed for continuous and reliable service, safety to personnel and equipment, ease of maintenance and operation, minimum power losses, mechanical protection of equipment, interchangeability of equipment, and addition of future loads.

Voltage insulation levels, interrupting capacities, continuous current capacities, circuit protective devices, and mechanical strengths shall be selected and co-coordinated in accordance with the recommendations of IEEE, EEMAC, CSA, ICEA, and ANSI. Calculations shall be made to ensure all equipment is suitable for the duty required.

System protective devices (relays, fuses, breaker trip units, etc.,) shall be selected and co-coordinated to ensure that the interrupter nearest the point of short circuit (or high overload) shall open first and minimize disturbances on the rest of the system.

Flexibility of the system, investment and operational costs together with load concentration shall also be considered in the electrical design.

The electrical distribution system shall be designed and installed to meet the power and grounding requirements of the electronic load equipment.

3.0 CODES AND STANDARDS

The latest editions of the applicable codes and standards of the following organizations shall be used as guidelines in the design of electrical systems and equipment; and where required by law, such systems and equipment shall conform to applicable standards.

- CSA - Canadian Standards Association

- CEC - Canadian Electrical Code
- SES - Saskatchewan Electrical Amendments
- EEMAC - Electrical and Electronics Manufacturers Association of Canada
- IEEE - Institute of Electrical and Electronics Engineers
- ULC - Underwriters Laboratories of Canada (where applicable)
- IES - Illuminating Engineering Society
- ICEA - Insulated Cable Engineers Association
- CACO – Canadian Accredited Certified Organization
- FM – Facilities Management (U of S)

This document is in addition to the above requirements. When a discrepancy occurs, the most stringent requirement shall have priority.

The local Technical Safety Services Branch Inspector or Client's representative shall generally be present during the construction phase to ensure compliance with the Canadian Electrical Code and Saskatchewan Supplement.

4.0 DESIGN DOCUMENTS

CLS has an Employer's License, which allows CLS electricians to perform most work of electrical installation without submitting drawings, obtaining permits, or inspection. For major installation designs (as defined in the Electrical Inspection Act) and for work done by contractors all plans and specifications shall be sent to Technical Safety Services Branch of the Department of Industry and Labor, Province of Saskatchewan, for review during the design stage.

Where applicable, electrical design documents shall include but not be limited to the following documents:

4.1 ROOM DATA SHEETS

Room data sheets using the CLS form shall be prepared and approved before detailed design begins.

4.2 PROCESS AND INSTRUMENTATION DIAGRAMS

For automated systems, process and instrumentation diagrams (P&ID) shall show interconnection, interlock, and control of equipment in a single line format

4.3 KEY PLOT PLAN

Plot plans shall show all underground and overhead cable and conductor runs, and the location and identification of all major electrical equipment.

4.4 SINGLE LINE DIAGRAMS

System single line diagrams shall include all major electrical equipment. Single line diagrams shall show power distribution starting at the CLS substation and ending either at the equipment being supplied, or at a power distribution panel. This information will require multiple drawings.

The following technical information shall be included in system single line diagrams:

- System phase rotation (phase sequence)
- Equipment names, ratings, and device identification numbers
- Protective relay description covering device numbers, make/model, locations, and intended function of relays
- Types of meters and transducers with specified ranges
- Power transformer and instrument transformer connection (delta-wye, wye-wye, etc) and grounding requirements, including polarity markings for instrument transformers
- Continuous current ratings of power circuit breakers, or motor starters, and their numbering and cubicle location numbers in switchgear assemblies and motor starter assemblies
- Isolated phase bus and/or nonsegregated phase bus continuous current ratings
- Power cable sizes, types, and cable number.
- Current ratios of current transformers and polarities and voltage ratios of potential transformers
- “Local” and/or “remote” control points of an electrically operated circuit breaker; the associated control switch, selector switch, and meter; and their respective location.
- Setting of all protective relays, fuses, and other devices.

4.5 PANEL SCHEDULES

Panel schedules shall show breaker sizes and equipment number or description for power distribution panels.

4.6 EQUIPMENT LAYOUT DRAWINGS

Equipment layout drawings shall show all electrical equipment and racks with:

- Elevations of racks with sections views, enlarged plans and details when required for clarification.
- Plan views showing location of electrical equipment such as transformers, switchgear, MCCs, power distribution panels, local push buttons/selector switches etc. with identification numbers.
- Underground conduits, duct banks and surface trenches layout.
- Cable tray and conduit layout including support details, wall and floor openings, fire-proofing/fire stops details.
- Dimensions to the centre line of horizontal tray and bottom (side rail) for vertical tray.
- Location and type of tray fittings
- Tray numbers.
- Tray grounding and installation of covers where required.

4.7 LIGHTING LAYOUT DRAWINGS

Lighting layout drawings showing:

- Plans showing locations of lighting fixtures (normal, emergency, security)
- Switch locations
- Panel and circuit number

4.8 RECEPTACLE LAYOUT DRAWINGS

Receptacle layout drawings showing:

- Convenience outlet locations
- Panel and circuit number supplying the receptacle

4.9 GROUNDING LAYOUT DRAWINGS

Grounding layout drawings showing

- Overall grounding drawings
- grounding details
- lightning protection.

4.10 SCHEMATIC DIAGRAMS

Most schematic diagrams are based on the functions defined by the single line and P&ID diagrams. Therefore, these diagrams shall be fully understood before the design of the schematic diagram begins.

Schematic diagrams shall be prepared to show:

- All interconnections between power sources, apparatus, and device elements of a particular system or equipment
- Internal wiring diagrams
- Cable and terminal numbers and types
- Wire colors or numbers in multiconductor cables. Colors are specified in CLS document 7.4.39.14 Cable Specification for Class 2 Circuits. When possible color order and wire number order in cable should be in same sequence as pin or terminal number at termination.
- Annunciator and PLC and/or DCS inputs and outputs, interlocks, spare contacts etc.
- All interlocks with other systems in a manner which fully indicates the circuit function and operation
- Any special requirements such as conductor shielding or separation from other circuits
- Contacts and devices shall be shown in the de-energized (off the shelf) condition.

4.11 FIRE DETECTION AND ALARM SYSTEM DRAWINGS

CLS uses a Class A fire detection system. Separate conduits shall be used for outgoing and return portions of the loop.

Isolator modules shall be used to separate loops to a maximum segment size of 15 modules or devices. New installations should limit segment size to 10 modules or devices to allow for expansion.

All fire alarm drawings shall be reviewed by an external engineering firm prior to construction.

All drawings shall be submitted to CNSC through the CLS Health, Safety, and Environment department.

Fire Detection and Alarm System Drawings shall be prepared to show:

- Layout drawings indicating zones, initiating devices (detector type/pull-station), control modules, isolation modules, audible/visual signal devices (horn/strobe) and associated conduit runs and sizes. All devices labeled by loop and device or module number.
- Sprinkler layout drawings showing sprinkler and piping location and size. Calculations proving adequate water flow may be on the drawing or in a separate document.
- Block diagrams and/or riser diagrams showing each loop, the order of components within loop and cable numbers.
- Field wiring diagrams indicating physical location of all components which make-up the fire alarm system, complete with associated conduit runs and sizes.

All rooms with ceilings shall have fire detection installed and spaced according to manufacturer's recommendations, NFPA standard 72, CAN/ULC-S524, and CEC Part 22 Sec. 32.

The fire alarm system is a Notifier AM2020 panel.

Notifier 6424A Projected beam detectors are used for the upper (roof) level of the building.

Notifier FDX-551RA Rate of rise with fixed temperature alarm detectors are used in high radiation areas such as beamlines up to the end of the first optical enclosure, and areas with the potential for smoke during normal operation such as electrical, electronic, and mechanical workshops.

Notifier FSI-851A Ionization detectors are normally used in other areas unless there is a specific reason not to.

VESDA LaserPLUS detectors are used in the relief air handling units, storage ring, booster ring, and sub-basement.

4.12 COMPUTER NETWORK SYSTEM DRAWINGS

Computer network system drawings shall be prepared to show:

- Plan view of Ethernet RJ45 receptacle locations and number. Note that the number indicates where the receptacle is fed from.

4.13 HAZARDOUS LOCATION DRAWINGS

Hazardous location drawings shall be prepared to show:

- The limits of all hazardous areas clearly identified in accordance with the CEC.
- The class, division and group of each hazard shall also be specified.

4.14 MANUFACTURER'S DRAWINGS

Manufacturer's drawings shall be provided showing:

- Manufacturer's drawings for major items of electrical equipment.

4.15 CABLES DATABASE

The CLS Cables Database shall be updated either while drawings are being produced internally or from a list provided by an outside agency. The following information is required:

- assigned cable number
- cable type
- termination locations
- other status information that may be relevant.

4.16 LOAD LIST (LOAD-EQUIPMENT SCHEDULE)

A Load list shall be prepared providing the following information:

- equipment identification
- equipment location
- rated voltage and rated power
- normal power demand
- normal power factor at actual demand
- equipment requiring UPS
- equipment requiring standby power supply during outage of normal power

4.17 DESIGN NOTES

Design notes shall be prepared and shall provide the following information

- Short circuit calculations
- Voltage drop calculations
- Cable sizing calculations

4.18 ELECTRICAL SPECIFICATIONS AND EQUIPMENT DATA SHEETS

The following electrical specifications shall support the electrical design:

- General Electrical Specification (design criteria)
- High Voltage Switchgear
- Recording and indicating metering
- High Voltage Power Transformer
- Low Voltage Switchgear
- Low Voltage Motor Control Center
- Low voltage switchboards
- High Voltage Power Cable
- Medium Voltage Power Cable
- Low Voltage Power and Control Cable
- Low Voltage Induction Motors 300 kW and less
- Station Battery and Battery Charger
- Uninterruptible Power Supply System

- Emergency generator
- Electrical installation

4.19 AS-BUILT DOCUMENTS

Fully indexed, "As-Built" documentation shall be provided containing

- Single line diagrams,
- Equipment specifications
- Vendor data sheets and maintenance procedures
- Settings of all protective relays & devices
- Incorporation of all field changes
- Any additional information that may be beneficial during construction.
- As-built markups shall be prepared during equipment installation

5.0 AMBIENT CONDITIONS

Project specific ambient conditions shall be followed in the design and selection of equipment and materials.

The equipment and materials shall be designed to operate under the following conditions:

- Altitude: 584 meters above sea level
- Maximum Temperatures: 40°C
- Minimum Temperatures: Outdoor -40°C
  Indoor 15°C
- Relative Humidity: Indoor 25-60%
  Outdoor 10-100%
- Unusual Conditions: Magnetic, radio frequency,
  Gamma, X-ray, and neutron radiation

Effective ambient temperature inside a non-ventilated equipment enclosure exposed to the sun shall be considered as 51°C due to combined effects of a 40°C ambient outside the enclosure, 8°C rise from solar radiation, and an assumed 3°C rise caused by an internal heater or other heat-producing device.

Records show that the line voltage may exhibit instantaneous (< ½ cycle) fluctuations of ± 1.5 % and gradual variations of ± 10 %. Brownout conditions lasting several seconds involving instantaneous drops and restorations of 10 % are also observed.

6.0 DESIGN PHILOSOPHY

6.1 UTILITY REQUIREMENTS

The power requirements for the facilities are as follows:

- Present demand load of 3.75 MVA
- Present connected capacity of 14 MVA

- Future additional loads should not require additional substation transformers or switchgear

The 25 kV feed to the transformers has a maximum three phase short circuit current of 10 kA.

6.2 AC POWER SUPPLY

Power supply to the CLS facilities should be provided by two independent sources (different incoming distribution lines). The minimum capacity of each supply feeder shall be sufficient to supply 120% of the maximum operating load for non-transformer loads plus 100% of the sum of the full-load maximum site ratings of the connected transformers. This has not been implemented yet.

Power supply interface with the CLS facilities is at the 25 kV bus of the main switchgear (primary selective). It is intended that the 25 kV bus be double ended, connected via a normally open tie-switch that may be manually closed upon loss of one feeder. All feeders from main switchgear to the CLS facilities shall be radial.

General building loads (such as lighting, heating, ventilation, air conditioning, process cooling equipment, the old SAL facility and the booster) and electronic load equipment (storage ring power supplies, beam lines, etc.) shall be supplied from separate switchgears respectively. The switchgear for general building loads shall be designated “convenience power switchgear” and switchgear for electronic load equipment shall be called “clean power switchgear”.

Beamline equipment supplied from clean power switchgear shall be powered through dedicated feeder cable circuits consisting of phase conductors, neutral conductor (where applicable) and insulated equipment grounding conductor(s) in effectively grounded and bonded metallic conduit, raceway or cable assemblies.

Where shared feeder cable circuits or busway (with taps) are used to serve electronic load equipment, a separately derived source (such as an isolation transformer or other power conditioner) shall be specified for each tap serving electronic load equipment.

Each beamline shall have separate dry-type shielded transformers (typically 30 kVA) for clean and convenience power.

Clean and convenience power shall be supplied to the hutches. Two sub-Panels are to be installed down at the beamline and shall be fed from two panels on the top of the storage ring.

For any voltage drop exceeding 25% for ½ second, the facilities shall require a new start up. An automatic re-acceleration of motors or a restart of equipment shall not be provided.

7.0 SYSTEM VOLTAGE AND FREQUENCY

Where possible, power to the electronic load equipment shall be provided at higher voltage (600Y/347V) instead at the actual equipment utilization voltage (208 Y/120V) to achieve the following benefits.

Lower system impedance to provide a more stable source with better voltage regulation and to minimize voltage distortion due to the non-linear load currents.

Step-down transformers (and other power enhancement devices) located close to the electronic load equipment to minimize the buildup of common mode voltages. Delta-connected transformer primaries trap balanced triplen harmonic currents generated on the secondary side by non-linear electronic load equipment that helps to reduce distortion of the voltage waveform at 600 V level as well as helps to attenuate disturbances originating at the 600 V systems.

Distribute power at lower currents resulting in lower heat losses in feeders and decreased material and labor costs associated with installing long feeder circuits.

The alternating current frequency for power system shall be 60 Hertz. Nominal system voltage and the respective grounding shall be as per the following table.

Nominal Voltage	Phase	Configuration	Grounding
25000	Three	Three Wire	Solidly Grounded
600Y/347	Three	Four Wire	Solidly Grounded
600	Three	Three Wire	Solidly Grounded
480Y/277	Three	Four Wire	Solidly Grounded
480	Three	Three Wire	Solidly Grounded
208Y/120	Three	Four Wire	Solidly Grounded
120	Single	Two Wire	Solidly Grounded

The nominal system voltage requirements do not apply to dedicated (captive) transformers in specialty applications such as supplying special electronic equipment and submersible pump motors.

7.1 STEADY-STATE UTILIZATION VOLTAGE LEVELS

7.1.1 Existing Facilities (SAL/Linac)

Low Voltage Switchgear	480 V
Low Voltage Distribution panels	480 V
	208 V
	120 V
Low Voltage Motors	460 V
	208 V
	115 V
Main (substation) MCC trip	120 V

7.1.2 New Facilities

HV Switchgear	25 kV
Low Voltage MCCs or switchracks	600 V
Low Voltage Distribution Panels	600 V
	347 V
	208 V
	120 V
Substation switchgear trip coils	125 V DC
MCC shunt trip voltage	24 VDC
Motors greater than 3 kW	600 V
Motors less than 3 kW	208 V
Fractional horsepower motors may be	115 V

Three-phase power should be specified for all motors, with the exception of small fractional horsepower motors.

The table below shows recommended maximum currents at different voltage levels. If the load would exceed the maximum current alternative designs, using higher voltage or additional phases should be considered.

60 Hz AC Load Connections

RMS voltage (V +/- 10 %)	Single or Three Phase	Maximum RMS current (A)	Notes
120	Single	20	Power distribution to subpanels 100 A
208	Single	20	
208	Three	30	Power distribution to subpanels 100 A
347	Single	20	Lighting – circuits may be combined and use three phase breakers
480	Three		Old SAL building Old power supplies on storage ring
600	Three		CLS building additions

8.0 INSULATION CO-ORDINATION

The objective of insulation co-ordination is to achieve an optimum economic balance between investment in the surge protective system and investment in the apparatus insulation required to withstand surges.

The insulation co-ordination shall be achieved by properly selecting:

- Surge arrester ratings, class and location.
- Line-to-ground and line-to-line minimum clearances.
- Equipment Basic Insulation Level (BIL) and Basic Switching Level (BSL).
- Creepage distance requirements.

All MCC cabinets shall include surge protection (Siemens Sentron TPS typical). Surge arrester selection and application shall be in accordance with ANSI/IEEE Std C62.11 "IEEE standard for Metal-Oxide Surge Arrester for AC Power Circuits" and ANSI/IEEE Std C62.22 "IEEE Guide for the Application of Metal-Oxide Arresters for Alternating-Current Systems"

Insulation levels of 25 KV power cables shall be specified based on fault clearing time for the system voltage being used and as described below:

100% insulation level shall be used where relay protection is such that ground faults shall be cleared as rapidly as possible, but in any case, within one minute of occurrence. Usually, these are solidly grounded systems.

133% insulation level shall be used where fault-clearing time is not within the one-minute criterion but offering adequate assurance that the fault shall be cleared within one hour. Usually, these are ungrounded systems. The 133% insulation level is the most common and is recommended for delta ungrounded systems

Insulation levels (BILs) shall be as follows:

25 kV Load Interrupter Switchgear (existing switchgear supplied by U of S)	125 kV
25 kV/600 V Transformer Primary Windings	150 kV
25 kV/600 V Transformer Secondary Windings	50 kV
25 kV Power Cables	28 kV
600/347 V Power Cables	1 kV
208/120 V Power Cables	600 V

9.0 MINIMUM BUS RATINGS

25 kV Load Interrupter Switchgear (existing switchgear supplied by U of S)	600 A
600 Volts MCCs fed directly from 25 kV/600 V transformer	2500 A
600 Volt MCCs with no future expansion	800 A
600 Volt MCCs if load requires or future expansion anticipated	1600 A
600 V MCCs minimum bus bracing	65,000 A

10.0 NAMEPLATE VOLTAGE RATINGS OF STANDARD INDUCTION MOTORS

Nominal System Voltage	Nameplate Voltage
Single-phase motors	
120	115
Three-phase motors	
208	200
480	460
600	575

11.0 PROVISION FOR FUTURE EXPANSION

Any increase in capacity should be achieved through the installation of additional equipment as opposed to replacement with larger sizes.

All switchgear (low, medium and high voltage) and operator control panels shall be manufactured and installed to permit future additional cubicles to be easily added to the lineup.

12.0 SPARE CAPACITIES

For transformers, the initial (actual calculated) running load shall not exceed 80 percent of the self cooled (OA) rating with the maximum rating used for sizing the cabling or bus duct.

Main breakers and buses shall be sized to allow use of the transformer's maximum capacity for transformers 1000 kVA and larger.

A reserve allowance of 50% (exclusive of future expansions) shall be allowed for main distribution floor space requirements

Future space for breakers and MCCs shall be specified as a percentage of the installed equipment or a number of certain sizes. Since fully equipped spares are expensive, spaces equipped with necessary hardware are more economical to provide. A minimum of one spare space should be provided in switchgear and 20% spare space should be provided in MCCs.

The bus shall be sized to allow for 20% more loads. MCCs shall be purchased and arranged so that additional sections can be added to the lineup.

Initial designs shall not fill or load power distribution panels more than 70%.

13.0 ISOLATION PHILOSOPHY

All medium voltage (347 V and higher) packaged equipment shall have a lockable local disconnect capability.

All power feeders shall be isolated by breakers and/or switches in the switchgear/MCC/switchboard/distribution panel.

14.0 LOAD CLASSIFICATION

The loads shall be categorized as continuous and non-continuous loads based on CEC.

Demand factors shall be applied to motors that are known to operate at less than full load or when the load is cyclical or intermittent to provide the most economical system.

Motor loads shall be calculated based on expected duty cycle... Spare pumps shall be added to the load list as a zero load (0.5 for each paired pump). Cyclical loads such as sump pumps shall be applied a reduced demand factor (0.3-0.7). Intermittent loads such as cranes shall have a demand factor based on the percent of the time they are used (0. 1-0.25).

Lighting loads shall be calculated with a 100% demand factor.

Welding loads shall be calculated with a 100% demand factor.

Critical loads or loads requiring a high degree of availability shall be supplied by a UPS system and/or a standby generator capable of automatically supplying the required power within 60 seconds after a power failure.

15.0 DESIGN FACTORS

The network shall be designed such that any piece of electrical equipment can safely be taken out of service for maintenance purposes.

Available fault levels within the electrical system shall be sufficient to start and operate any electrical load without disrupting operation of other equipment.

Voltage drop on a feeder bus during starting is not to exceed 5% (10% for large motors with infrequent starts). Appropriate measures like capacitor assisted starting, reduced voltage starting, soft start and transformer on-load tap changers shall be selected so as not to exceed voltage drops.

Motors greater than 20 kW shall be provided with solid-state soft-start starters.

Motors in excess of 40 kW shall be provided with local power factor correction.

Where motor anti-condensation heaters are utilized, the control circuit shall be designed for automatic operation of heaters whenever the motor is off and, in the case of medium voltage motors, when the switchgear is in the racked-out position.

Transformer impedance shall be selected to limit short-circuit currents to values within the ratings of the connected equipment and to optimize voltage regulation.

Emergency shutdown of equipment, if required, shall be possible irrespective of any PLC/microprocessor failure.

Emergency stop pushbuttons shall include mechanical latching when pressed.

16.0 PROTECTIVE DEVICES

Protective devices shall be provided for the electrical system to permit isolation of faulted or overloaded equipment and cables as quickly as possible to minimize equipment damage and limit the extent of system outages. Protective devices shall be sized for the maximum available fault currents. Major components such as the HV switchgear and large transformers shall be provided with back-up protection (e.g. Fuses at Preston Ave. substation).

Current sensing relays shall be of the draw out case type to permit testing and calibration without disruption of the current transformer secondary circuit.

The over current protective devices for electronic load equipment located in switchboards and panel boards shall be true RMS type.

To avoid damage to electronic load equipment due to single-phasing, electronic phase-failure or voltage unbalance relays should be considered in addition to fuses or circuit breakers.

Time and instantaneous phase and ground over-current tripping shall be provided for incoming feeder breaker in MCC panels.

Instantaneous phase over-current tripping requires selectivity, which can be achieved if the instantaneous trip setting is 140% of the peak let-through current of the largest anticipated fuse, and that fuse is current limiting at the fault level of the system where it is located.

Overcurrent protection for primary feeders to main HV-MV power transformers shall consist of fuses in each phase.

The main breaker on MCCs fed from the 25 kV/600 V transformers shall have provision for remote shunt trip to disconnect MCC from substation.

MCC fed motors shall have breaker-protected combination starters.

17.0 ALLOWABLE STEADY-STATE VOLTAGE DROPS

17.1 AC VOLTAGE DROPS

Voltage drop on cables shall be considered with respect to the allowable limits for equipment and motors.

17.2 25000 VOLTS CIRCUITS

- Maximum 1% between 25 kV switchgear and primary of 25 kV/600 volt power transformers

17.3 600 VOLTS MAIN CIRCUITS

- Maximum 2% between secondary of 25 kV/600 volt power transformers and 600 volt MCC or switchrack providing the maximum total voltage drop from the transformer secondary to the branch circuit does not exceed 5%.

17.4 600 VOLTS FEEDER CIRCUITS

- Maximum 3% between 600 Volt MCC or 600 Volt switchrack and motor terminals, distribution centres, panel boards or transformers that supply lighting, instrumentation, or other low voltage equipment providing the maximum total voltage drop for the main feeder and branch circuit does not exceed 5%.

17.5 MOTOR BRANCH CIRCUITS

Maximum 3% providing the maximum total voltage drop for the main feeder and branch circuit does not exceed 5%.

Maximum 10% at full-voltage locked rotor current (including total voltage drop in sub-feeder if any) for motors. The 10% limit may be relaxed only if all motors and other equipment that will be subjected to this drop have manufacturer's rating allowing more than 10% drop. Then the minimum rated drop (highest minimum rated voltage) can be allowed.

17.6 BRANCH CIRCUITS SUPPLYING LIGHTING, INSTRUMENTATION, OR OTHER LOW VOLTAGE REQUIREMENTS

- Maximum 3% between transformer secondary terminals and the most distant fixture or outlet (or single user) providing the maximum total voltage drop for the main feeder and branch circuit does not exceed 5%.
- Maximum 3% for general feeders (3% maximum of nominal bus rating at full feeder load current) providing the maximum total voltage drop for the main feeder and branch circuit does not exceed 5%.
- Maximum 1% for feeders from distribution transformers to 120/208 V distribution panels (maximum 1% of transformer nominal secondary voltage at full transformer secondary load current) providing the maximum total voltage drop for the main feeder and branch circuit does not exceed 5%.

17.7 DC VOLTAGE DROPS

- Maximum total voltage drop for main, feeder, and branch circuits shall not exceed 5%.
- The maximum voltage drop in branch circuits shall not exceed 2%.

18.0 WORKING CLEARANCES FOR SUBSTATION EQUIPMENT

Unless greater clearances are specified by CEC, the following minimum clearances shall be maintained:

- A minimum working clearance of 2 meters on all sides.

- A minimum working clearance of 3 meters on sides of equipment having doors or access panels that can be opened to expose live parts and/or required for normal maintenance and/or operations.
- The intent of above requirements can be met by gate(s), which can be opened to provide the required clearance.
- A minimum clearance of 1.1 meter between pad-mounted equipment and fences or walls installed to protect the equipment from unauthorized access.

18.1 OUTDOOR-PAD-MOUNTED EQUIPMENT

- Equipment shall be placed on a level concrete pad, the top of which shall be elevated a minimum of 100mm above natural grade.

19.0 CONTROL CIRCUITS

19.1 SWITCHGEAR CONTROL POWER

A dedicated and reliable source of control power shall be provided for all switchgear and all main MCC breakers fed directly from the 25 kV/600 V transformers to trip the switches and circuit breakers remotely.

A common control power source may be used for multiple switchgear and MCC assemblies.

In AC controlled power systems, the control power transformer shall be on supply side of the supply circuit breakers, to permit electrical closing of all breakers served by the transformer or source.

Battery capacity at minimum design ambient temperature shall be capable of supplying switchgear normal loads (relays, pilot lights) for eight hours with the charger off and then permit tripping all breakers and switches.

Automatic chargers shall be provided for batteries. Chargers shall be of the solid-state type, capable of rated output with input voltage tolerance of ±10% and input frequency tolerance of ±5%.

Chargers for batteries shall be current limited for initial recharge, with automatic change to adjustable controlled voltage for end-of-charge, and shall have a floating/equalizing function.

Charger output shall be equal to the battery continuous load plus 30 to 35% of the battery eight-hour discharge rate. Charger shall have a DC voltmeter and ammeter.

A distribution panel shall be provided for each control battery. The panel shall provide two pole circuit breakers or fused disconnect switches for each switchgear control circuit being supplied.

Alarms shall be provided for AC and for DC under voltage and ground fault conditions in the switchgear control power system.

19.2 MOTOR CONTROL CIRCUITS

All motors shall have a lockable disconnect located near the motor.

Fractional Horsepower motors may be controlled by a manual motor starter switch or similar device.

All motor control centers shall be specified as class 1 type B with type 1 enclosures.

Motors controlled by a combination starter should have a selector switch. The switch shall have three maintained position labeled HAND-OFF-AUTO, and shall provide the following operations:

- HAND: Motor shall start if interlocks indicate it is safe to do so.
- OFF: Motor is stopped and cannot be restarted automatically or manually.
- AUTO: Motor is under control of the automatic device, subject to interlocks.

Time delay shall be provided when changing speed on two speed controllers or when reversing rotation on reversing controllers. This shall apply to air fin exchangers, cooling tower fans or similar equipment. For two speed controllers, time delay shall be allowed between fast and slow speeds, and for reversing controllers time delay shall be allowed when switching between forward and reverse, or vice versa. This may not be necessary on small fractional horsepower motors.

20.0 METERING

Full-featured, revenue metering approved digital power metering to monitor and record all basic power quantities including the following shall be provided in each incoming line to the main switchgear.

- Harmonic Analysis
- Transient Capture
- Waveform Recording
- Voltage Sag and Swell

Basic-featured digital power metering to monitor all common electrical parameters shall be provided in each main transformer secondary feeder.

All units shall be networked via Ethernet TCP/IP communication with embedded Modbus protocol to CLS's EPICS monitoring and control system.

21.0 ALARMS

Alarm states shall be monitored in the CLS control room.

Transformers rated 500 kVA and larger shall be provided with an alarm as follows:

- A two-stage alarm shall be actuated by contacts in the liquid temperature thermometer and shall give abnormal indication whenever the transformer reaches its maximum self-cooled operating temperature, as indicated by the thermometer. The setting shall be 90°C for alarm and 105°C for trip.
- A single-stage alarm for each transformer with 2-float Buchholtz relay (or equivalent), to be actuated by slow gas accumulation.
- A single-stage trip to be actuated by rapid pressure rise.
- A single-stage liquid level trip to be activated on low liquid level.

Switchgear control power alarms shall be provided as follows:

- High battery voltage
- Low battery voltage

- Loss of battery voltage on any circuit

Motor alarms shall be provided as per project requirements.

Motor winding high temperature alarms when required shall be set to operate when the normal or anticipated motor load is exceeded and before the overload relay setting is reached.

22.0 GROUNDING SYSTEM

The grounding system of the facilities shall be based on grounding specification 16390, IEEE Std 141, Recommended Practice for Electric Power Distribution in Industrial Plants and IEEE Std 1100, Powering and Grounding Electronic Equipment.

Substation grounding shall be based on IEEE Std. 80, Guide for Safety in Substation Grounding so that maximum tolerable step and touch potentials are not exceeded.

The grounding system shall be designed such that it adequately provides protection against potential hazards associated with rise in voltage and sparks caused by electrical faults, lightning discharges and accumulation of static charges.

The grounding system shall ensure safety to personnel in relation to touch and step voltages and protect equipment against damage associated with rise of potential.

A grounding system consisting of a grid of network of medium-hard drawn bare copper conductors shall be provided.

Ground grid conductors shall be sized to withstand maximum expected future fault current for 0.5 seconds.

The system shall be designed to limit the overall resistance to earth to two (2) Ohms or less, measured during the dry season.

Electrical equipment, building steel, and metal components likely to become energized under abnormal conditions shall be effectively grounded by direct or indirect connection to the main ground grid.

Columns and beams not directly connected to the grounding system shall be considered to be effectively grounded if they can be traced to a grounded column through a series of metal-to-metal connections. Conductive coatings at the connections shall be considered as an adequate and effective ground path.

A clean ground shall be arranged in a tree topology to avoid potential ground loops. A 4/0 green insulated ground shall be brought from the exterior ground grid and routed through the cable tray above the storage ring. Connections to the clean ground shall be made with green insulated cables. The connection shall be insulated with electrical tape or other suitable means.

An isolated clean ground shall be made available made available for beamlines and some sensitive laboratory applications. A Startco PPI-600V parallel path isolator (or equivalent) shall be used to isolate the ground before the X0 point on the beamline clean 600/208 transformer.

An isolated ground bus shall be provided in breaker panels using the clean ground.

Orange isolated ground receptacles shall be used to indicate clean ground outlets.

A Startco SE-502 ground-fault ground-continuity detector (or equivalent) shall be used in conjunction with the parallel path isolator to detect connections between the isolated ground and regular ground which could cause ground loops. The status of the detector shall be monitored by the facility control system.

23.0 LIGHTING

23.1 GENERAL

Illumination levels shall be in accordance with the Canada Occupational Health and Safety Regulations.

Lights in hallways and stairways should be supplied from more than one circuit, with successive fixtures using different circuits. Lights in rooms should be supplied from more than one circuit. If a breaker trips there will still be some light.

Main facility (high-bay) lighting shall be controlled by a time clock and hand-off-auto selector switches in conjunction with a contactor.

Lighting for control rooms, instrument boards and other similar installations shall be designed to illuminate vertical-board-mounted equipment and details without glare.

Interior lighting shall be switched with local switches throughout.

The main control room should have a luminous ceiling that shall have provision for dimming by dimmer control.

Emergency lighting required for egress from buildings shall be provided by an emergency generator or by local battery packs.

Where practical, general purpose distribution panels shall be located in corridors so that service and inspection can be done without interfering with the occupants.

In main areas, the circuits shall be on a staggered basis so that if a single branch circuit breaker shall trip any given area shall not be in total darkness.

Security lighting shall be provided for the fenced areas, building entrances, outside storage areas, parking areas and other specified areas.

Lighting shall enable personnel to safely exit enclosed areas following the loss of electric power and lighting circuits.

Electromagnetic contactors shall be used to switch all outdoor lighting fixtures from a central location.

23.2 LIGHTING FIXTURES

Standard lighting fixtures shall be metal halide or fluorescent.

In general, suitable rapid start fluorescent fixtures with plastic lens diffusers shall be used in low ceiling indoor areas requiring high illumination levels such as labs and offices. Metal halide lighting shall be used to illuminate large areas such as the main experimental floor.

Metal Halide fixtures when used shall have constant wattage high power factor ballasts and color-corrected lamps.

Fluorescent fixtures shall utilize T8 lamps with 3500° K temperature and CRI of 80 or better. Quiet ballasts (sound rated class A) shall be used.

Lighting for beamline hutches has typically been with 2 foot 2 Bulb T8 32W fixtures since they fit in with the ceiling layout better.

An emergency light with battery pack shall be installed in each hutch.

Lighting within the beamline hutches shall be 100 foot-candles and switched (unless there is a request for dimming)

24.0 RECEPTACLES

All offices shall be provided at least with two duplex receptacles adjacent to each desk location with a minimum of two duplex receptacles on each wall.

Lobbies and corridors shall be provided with sufficient number of outlets to require no more than a 15 metre cord for power-driven housekeeping machines. One of these outlets shall be provided near each caretaker's office and these outlets shall be on separate circuits than outlets in user spaces.

Duplex receptacles shall be provided in the mechanical duct systems at filter locations and near mechanical units in the ceiling spaces and crawl spaces where frequent maintenance will occur.

Receptacles shall be provided, as required, to supply electrical equipment not supplied by permanent wiring and to serve portable electrical devices.

General use receptacles shall be single-phase AC and shall have a separate contact for connection to the grounding pole in the plug. Ground contacts in plugs and receptacles shall be arranged so that the grounding circuit is made first and broken last.

General use receptacle ratings shall be 120 volt, 15 ampere.

One circuit shall supply not more than six single or duplex outlets.

Outdoor outlets shall meet the following:

- Outlets shall be located within 5 m of the equipment to be serviced and about 1 m above grade or platform.
- These shall be protected by ground fault circuit interrupters.
- Plug shall have shrouded contacts so that contacts remain enclosed until circuit is broken.
- Arcs resulting from breaking loads shall be contained. Plug and receptacle shall incorporate arc-quenching design of the main contacts, with means of delaying full withdrawal until extinction is complete.
- Receptacles shall be equipped with a weatherproof flap to cover outlet when it is not in use.

To ensure a reliable, low resistance connection, all wiring terminations to receptacles shall be by screw-compression wiring contacts. Push-in wiring contacts shall not be accepted.

25.0 RACEWAY SYSTEM

The layout shall be designed to avoid obstructing survey monument locations.

25.1 CABLE TRAY

For power and distribution ladder tray should be specified.

Cable tray and accessories shall be rigid steel, hot-dipped galvanized, CSA Standard load classification E. Where less load capacity is required and future expansion is not anticipated (such as individual beamline dedicated installations) this can be reduced to classification D.

Covers shall be used for cable trays on the floor where the area will also be used as a walkway.

If covers are used, the weight of the cover shall be taken into account and added to cable tray loading. For outdoor applications, wind and snow loading shall be added to the weight of the cables, thereby reducing cable tray load capacities.

The maximum cross-sectional loading area of the trays shall be as per the following table:

Type of Installation	Maximum Percent Fill
Cable Tray (trough or ladder type)	
Power cables only (76 mm deep tray)	40
Power and control cables combined	40
Control and electronics cables only	40
Wireway	20
Conduits and Ducts	
One cable	53
Two cables	31
Three or more cables	40

Cable tray supports shall be field located by the installation contractor and placed at intervals not exceeding 6 metres measured along the tray centerlines and also in accordance with standard details.

Cable trays must be supported either from overhead or adjacent structural members. Closer supporting may be required for outdoor installations, vertical installations, and installations where more than one level of tray share the same supports. Extra consideration must be given to the strength of the support elements (beam clamps, anchor bolts, hanger rods, etc.) used to support vertical stacks and long vertical runs of cable tray.

Shallow 6"x1.7" Cable trays should be run along the walls inside the hutches for controls cables, as these will not normally be installed in conduit.

Generally a 600mm wide x 6" high cable tray has been run above the hutches for the entire length of the beamline.

Trays containing power cables only shall be limited to 76 mm deep.

Where possible, cable entries to electrical power sources (i.e., switchgear, MCC) shall be from above to simplify tray systems.

Overhead trays should be located so that the lowest part of the cable tray support assembly is at least 2.1 metres above floors to maintain minimum headroom requirements.

Cable trays should not be routed through areas where there is potential for accumulation of oil or other combustible materials on the cables. If cable trays must be routed through these areas, the cable trays shall be provided with tray covers designed to minimize the amount of such material reaching the cables.

Trays should not be located near heat sources (burner fronts, steam piping, heat exchangers, etc.) unless cables are adequately derated and suitable for the higher ambient temperatures. If this is not practical or possible, a protective heat barrier shall be installed.

Circuits in cable spreading areas shall be limited to those performing control and instrument functions and power distribution for equipment in the area.

Where routed through cable spreading areas, power circuits shall be installed in conduits or be armoured cable.

Each section of cable tray shall be connected to adjacent sections using splice plates or approved coupling device and located within ¼ of the span from the supports.

Standard fittings shall be limited to 45 and 90 degrees. Special, 30° and 60° or custom fittings shall be used only when required to satisfy special requirements.

The choice of radius for tray fittings shall be a minimum of 8 times the diameter of the largest nonshielded cable or 12 times the diameter of the largest shielded cable to be installed, whichever is larger. A minimum variety of radii shall be used.

In general, the recommended minimum vertical clearance between cable trays is 300 mm, measured from the bottom of the upper tray to the top of the lower tray. At least 300 mm clearance shall be maintained between the top of trays and beams, piping, etc., to facilitate installation of cables in the tray.

Two or more horizontal trays located adjacent to each other shall not be located against a wall, unless the vertical clearance above the trays is increased to 813 mm.

The cable tray system shall be electrically continuous. All trays containing power circuits shall be provided with a continuous 4/0 ground conductor installed in the entire length of the tray system. To allow potential sharing with power circuits, cable trays intended for control circuits should also be provided with a continuous 4/0 ground conductor. This ground must be connected to the station ground grid at locations indicated on the grounding drawings. Cable trays shall be grounded at intervals not exceeding 15 m.

Effective fire stops shall be provided for cable entries into equipment. All penetrations through walls for cable trays especially into cable spreading rooms and all vertical penetrations through floors shall also be provided with fire stops.

Where trays extend vertically through concrete floors and platforms, curbs or other suitable means shall be provided to prevent water flow through the floor or platform opening.

Cable trays shall not be loaded initially to greater than 80% of their load capacity. Deflections shall not exceed EEMAC standards.

Since the lengths vary between manufacturers, the tray layout shall be flexible enough to be installed using standard components from any acceptable supplier.

Wiring for each personnel safety system shall be separate from all other wiring and enclosed in conduits or be armoured cable and shall be clearly identified.

26.0 RACEWAYS

Raceways should be Wiremold 5500 series. Generally three channel raceway is used. These shall be installed at the power drops within the hutches. along the beamline tray support poles and along the walls in the desk/lab areas. It shall be installed vertically for the power drops in the hutches (or on the beamline poles) and horizontally in the desk/lab areas. Horizontal runs shall be installed at an elevation of 1100mm to the bottom from the floor.

When multichannel raceways are used the following order, as applicable, shall be followed:

- Horizontal runs – From top down Control, Clean Power, Convenience Power.
- Vertical runs – From left to right Control, Clean Power, Convenience Power.

27.0 CONDUITS

All cables with a voltage of >300V must be in conduit.

All AC power runs shall be in conduit or armoured cable.

Hot-dipped galvanized EMT conduit shall be specified where conduit installation is required except as noted below:

- Rigid galvanized steel with bonded 40 mil PVC coating for corrosive atmosphere.
- Liquid-tight, PVC jacketed, flexible conduit for all equipment that might be subject to vibrations.

- Schedule 40 PVC pipe sleeves for buried cables.

Minimum size of conduit shall be 21 mm for exposed runs and 27 mm for embedded installations.

Conduit runs for high voltage cables such as ion pumps and vacuum pumps shall be limited to the equivalent of two 90° bends between pull boxes.

Conduits shall be maintained one-diameter spacing to minimize conductor derating.

The sleeve size selected for a conduit penetration shall be large enough to permit the conduit coupling to pass through the sleeve. There shall also be adequate space to install sealing material. Approximately 13 mm (1/2 inch) of space is normally sufficient for insulating material.

If the conduit size is not known at the time, the designer shall size the sleeve for the largest conduit size that may be required.

Flexible conduit must be provided wherever conduit runs bridge expansion or vibration isolation joint or are attached to two independently supported structures.

Conduits installed outdoors or in high humidity areas where water might enter or condense inside the conduit shall be routed into the bottom of enclosures. Where conduits must enter the top of enclosures in such areas, conduit seals with drain holes shall be provided.

Where required rigid steel, hot-dipped galvanized conduits and associated hardware shall be used to reduce damage of conductor insulation due to radiation.

A separate -ground conductor shall be installed inside all conduit runs..

28.0 DUCT BANKS AND BURIED CONDUITS

The underground duct banks shall be schedule 40 PVC sized 50 mm through 150 mm encased in concrete and/or direct buried. A minimum spacing of 50 mm shall be maintained between the ducts.

Below grade conduits must meet the same requirements as provided above grade conduit in addition to the following:

- Manholes and handholds must be provided to permit pulling cables within their allowable pulling tensions.
- The raceways must be sloped for drainage of water from the ducts towards manholes provided with a sump pit.

To avoid the possibility of cables jamming in a conduit or duct during installation, it is recommended that for three single conductors (nontriplexed) the maximum percent of cable fill be less than 30%.

Conduits installed below grade and required to be encased in concrete shall be encased by not less than 76 mm of concrete, shall be buried not less than 610 mm below the finished grade elevations, and shall be sloped to provide drainage of water. A means for drainage of water from the low point of conduits must be provided.

To avoid corrosion of its threads, conduit exiting a concrete encasement and extended to equipment shall not be terminated flush with a coupling at the concrete surfaces. An exception is in locations where conduits extending beyond the concrete encasement might be damaged during construction.

29.0 POWER FACTOR CORRECTION

Improvements in power factor may be desired for financial reasons (to lower utility costs associated with power factor penalties) or operational reasons (to lower system losses, increase system reserve capacity, or improve voltage conditions).

Power factor capacitors, if specified, shall be added as necessary to minimize the electrical kVA power demand. Larger, higher voltage capacitor banks are generally more economical than capacitor units installed with individual motors.

Extreme caution shall be used when applying capacitors to ensure that they do not cause resonance conditions that can magnify harmonic levels and cause excessive voltage distortion.

Load harmonic profiles shall be calculated or estimated (current harmonic profile estimated from typical individual pieces of electronic load equipment based upon experience or data supplied by the OEM).

30.0 HEAT TRACING (FREEZE PROTECTION)

Electrical heat tracing (freeze protection) shall be provided for water-filled piping and instrument sensing lines routed outdoors that are subject to freezing. Water lines shall be designed to maintain flow, where practical. Lines not normally self-draining or drained during normal shutdown shall be freeze-protected. Self-draining lines include such services as drains and discharges to sumps and sump pump discharges to grade. Electrical heat tracing shall be the self-regulating type, wherever possible, and shall be provided with necessary power distribution equipment.

31.0 LIGHTNING PROTECTION

A lightning protection system shall be provided to protect facilities from damage due to lightning stroke or discharge.

The lightning protection system shall be an active attraction system designed to attract the lightning strike to a preferred point through an air terminal and to convey the energy safely to ground.

The lightning protection system shall include the following components:

- An enhanced active air terminal of the type designed to minimize corona emissions and optimise streamer inception at a predetermined time.
- An insulated low impedance down-conductor to conduct the energy to ground safely and effectively.
- A 6 metre copper-clad steel ground rod c/w access ground well and chemical electrodes filled with conductive electrolytes to provide better grounding conductivity (if required to reduce grounding resistance to acceptable level).
- A lightning event counter.

The air terminal shall be insulated from the protected structure under all conditions. The mast shall be adequately rated for wind shear loading and guy wires shall be provided as appropriate to local environmental conditions.

The down-conductor shall consist a plastic filler (to increase effective diameter of core conductor), main copper conductor, semiconducting stress control layer, polyethylene high voltage insulation, semiconducting stress control layer, copper tape screen and electrically conductive plastic sheath. Insulation breakdown ratings between main conductor and copper tape shall be no less than 200 kV based on 1/50 μs wave shape as defined in ANSI C62.41.

The lightning event counter shall have an electronic register that activates one count for every discharge where the peak current exceeds 1500 A. The test wave shape shall be the 8/20 μs standard as defined by ANSI C62.41. The lightning event counter shall be suitable for outdoor installation in –40°C to + 40°C temperature and installed in EEMAC 4 enclosure.

32.0 EQUIPMENT SELECTION ANDSIZING

All equipment supplied shall bear one of the certification marks listed in Appendix D. Evidence of such approval shall be presented to the Owner, prior to acceptance of the equipment from the factory.

Equipment and materials selected for the CLS project shall reflect the expected life span of 25 years and operating and environmental conditions to be experienced.

Maximum operating loads shall be used in calculations for sizing electrical power supply, distribution equipment and power cables. Maximum operating load is the maximum demand including known future demand. In new installations a minimum of 20% shall be included for future demand.

CLS standard distribution panels, transformers, motor starters, etc are made by Siemens.

32.1 HV SWITCHGEAR

HV switchgear shall be outdoor, metal-enclosed, load interrupter and dead-front structures grouped together for centralized control.

Spare circuit breaker and/or interrupter switch cubicles shall be fully equipped for future addition of circuit breakers and/or interrupter switches without further modification to the assembly.

32.2 POWER TRANSFORMERS

The main transformers shall be outdoor, oil-immersed type, 3-phase delta connected primary and wye connected solidly grounded secondary with externally operated no-load full capacity tap changers on the high voltage winding and metal oxide lightning arresters on the low voltage side.

Dual temperature rise transformers shall be specified to limit initial maximum load below 80% of site-rated self-cooled rating of the transformer. This shall allow for load growth or changes from the time of purchase to project completion. For self-cooled transformers, an assessment shall be made to determine if the load data are preliminary or firm. If preliminary, a 20 percent margin shall be provided for potential load growth between transformer procurement and project completion. If client or contract commitments require a specific margin at project completion, this shall be accounted for. Demand load factors, if not specifically known, shall generally be 80 percent for 600 V loads.

Ambient temperatures affect load capacities of transformers. Transformers are rated for 30 C average over 24 hrs, 40 C maximum. Standard transformers have a 55 degree C rise, but dual rated 55/65 C transformers shall be specified, for 12 ½% extra margin to account for harmonics if data is not available.

The short circuit capacities of power systems can be controlled, within limits, by the proper selection of transformer impedance. For example, the standard impedances for a 1000 kVA, 25 kV/600 Volt transformers are 5.75% and 8%. Large transformers have a range of impedance usually at no additional cost within standard ranges and at added cost outside those ranges.

Transformer impedance is selected to optimize voltage regulation and short circuit duty. A transformer's impedance shall be increased to allow for lower bus and breaker ratings, or decreased to start a large motor if cost premium can be justified.

Power transformers for outdoor locations shall be oil immersed sealed tank construction.

Transformers for indoor locations, supplying general service type loads such as shops or office buildings, shall be as follows:

- For clean above grade locations, ventilated dry type.
- For dirty or below grade locations, hermetically sealed dry type.

Dry type transformers shall be equipped with over-voltage protection when connected to systems above 600 Volts.

For liquid filled transformers; the type of liquid preservation system shall be specified.

Enclosed terminals and connections are required for all power transformers.

Power transformers without on-load tap changing shall have four 2.5% full capacity taps for de-energized operation. Taps shall be arranged to have an adjustment both up and down so that rated voltage may be obtained at the secondary terminals when normal primary voltage is applied. For average conditions, an arrangement of two taps above and two taps below rated primary voltage is suitable.

Fault pressure relaying shall be furnished on transformers larger than 1000 kVA where it is possible to trip primary breaker or controller.

Transformers should be specified with manufacturer's standard impedance except when other values are required to meet voltage drop limitations or cost saving by the use of switchgear with lower interrupting rating.

600V/208V power transformers shall include an electrostatic shield between the primary and secondary windings.

To minimize voltage waveform distortion due to non-linear electronic load equipment and to improve voltage regulation of the transformer, dry-type isolation transformers shall be specified with an impedance range of 3-5% as calculated at the nominal line frequency. The impedance shall not exceed 6% in any case.

The transformer neutral bus shall be rated at 200% of the secondary full load ampere rating to accommodate the large neutral currents resulting from triplen harmonics and phase imbalance.

For calculating K-factor, harmonic profiles of load currents shall be measured and recorded at main transformers serving the load rather than at individual loads downstream locations, to avoid the tendency of calculating a higher than necessary K-factor.

If the load K-factor is not known at the time, a K-factor of 20 shall be specified. In any case, the K-factor shall not be less than 13.

Derating of conventional transformers (if required) shall be in accordance with IEEE Standard C57.10.

32.3 CIRCUIT BREAKERS

Circuit breakers shall be sized to safely break the circuit under all cases of overload and fault conditions.

600 Volts power circuit breakers are rated at 100% of their long time rating. It is recommended that when sizing a new breaker's feeder it be sized for 100% of the breaker setting and the initial load be limited to 80%.

Circuit breakers, switches and contactors whose load side terminals can be energized when in the position from a source outside their own switchgear or control center assembly shall be identified by a legible nameplate mounted on the front of their compartment.

Circuit breakers feeding electronic load equipment shall be either thermal-magnetic trip unit type or electronic trip unit type with true-RMS and peak sensing.

32.4 CABLES

Feeders to buses and power transformers above 600 volts shall be sized to withstand short circuit thermal stress without damage to the feeders. The maximum short circuit level of the supply and clearing time of the feeder protective device shall be used to determine this condition. Cable at 600 V and below, and feeders to motors above 600 V, shall not be increased in size because of short circuit duty.

Power cables shall be rated for 90°C continuous conductor temperature, 130°C emergency overload temperature, and 250°C short-circuit temperature. A cable rated at these conditions can withstand 90°C continuously as well as emergency overload of 130°C for 100 hours in any given 12 months and not more than 500 hours for the entire life of the cable. The 250°C short-circuit rating is the temperature of the conductor during a one second ground fault.

Cable ampacities shall be based on the rated conductor temperature using the applicable tables and derating factors from the CEC. Cables should be sized with 50% derating to reduce the requirement for maintained spacing. Where the CEC does not cover a specific application, such as with certain duct bank configurations, the IEEE/ICEA tables and associated methods of derating cables shall be used. Required ampacities shall be based on the following loading criteria:

- Transformer feeders — 125 percent of maximum transformer rating
- Motor feeders — 125 percent of motor full load current
- Feeders to load centers and MCCs — 100 percent of full load current plus 25 percent of the largest connected load current
- Other individual loads feeders — 125 percent of rated full load current

Minimum acceptable conductor size shall be as follows:

- 4.0 mm^2 for power (#12 AWG)
- 6.0 mm^2 for clean power (#10 AWG)
- 2.5 mm^2 for control (#14 AWG)
- 1.0 mm^2 for Class 2 systems (#18 AWG)
- 4.0 mm^2 for lighting (#12 AWG)
- 1.0 mm^2 for instrumentation (#18 AWG)

Clean power often uses only one phase, so a separate neutral is required for each circuit. The requirement for derating happens sooner, so larger conductors are specified as standard practice.

To provide a low impedance, high frequency bonding path plus electrostatic and electromagnetic shielding between the enclosed circuit conductors and other nearby conductors, cables shall be specified with armour (Teck 90) sheath (the construction of metal-clad cable causes all circuit conductors to be tightly bundled together there by reducing the intensity of the magnetic field and self inductance leading to a lower voltage drop).

Power cable construction shall be as described below:

- Insulation – T90, XLPE or PVC for 0 to 1,000 volts and EPR or XLPE for 1,000 volts to 35,000 volts
- Shielding – Overall shield for 25 kV power cables.
- Overall jacket – PVC, sun and ozone resistant, flame retardant.

All cables utilizing #4/0 AWG and smaller conductors shall be multi-conductor-jacketed cables. For conductors larger than #4/0 AWG, either three parallel conductors or triplex cable shall be specified.

Stranding provides flexibility to the cable needed to pull, bend and terminate it. Cables shall be specified as Class B stranding. If extra flexibility is needed, Class C stranding shall be considered.

All conductors #1/0 AWG and larger shall be specified with uncoated conductors to take advantage of cost savings, lower conductor resistance and lower cable weight.

Uncoated conductors whose ends (at the termination points) are exposed to the atmosphere form copper-oxides. Since for small size wires (#16 AWG and smaller) this corrosion may be detrimental, these sizes shall be specified as coated conductors.

Cable bending radii shall not be less than that recommended by the manufacturer or the CEC.

In vertically stacked trays, power distribution cable trays should be above control cable trays.

Complete separation of control cable from power cable is the preferred practice. If they share a cable tray, a divider shall be installed to keep them separate.

When practicable, medium-voltage switchgear cubicles and load center stacks and breakers shall be arranged to permit the cables to enter and exit the tray system in the same sequence, thereby minimizing crossovers.

Outdoor cables shall be waterproof armored type (Teck or liquid tight conduit).

All cables with a voltage of >300V must be in conduit.

All AC power must be in conduit or Teck90 Cable.

Cables for Class 2 circuits shall follow the guidelines in CLS document 7.4.39.14 Cable Specification for Class 2 Circuits.

32.5 CONDUIT

Conduit junction box covers shall be colour coded as described in CLS form 8.11.16.3 CLSI Colour Codes for Conduit Junction Boxes.

Conduits carrying high voltage (>750V) conductors shall be limited to a maximum fill of 20%.

For conduit containing high voltage conductors a protective, non-conductive insert shall be placed at LB corners. This is to protect the cables as they bend around the corner of the LB.

An overall conduit "single line" shall define the conduit runs for the beamline. A main cable tray shall run the length of the beamline above the hutches.

For inside and outside the hutch walls, a layout showing the physical bends of the conduits and other equipment along the wall shall be drawn.

Where EMT Conduits are to cross a vibration isolation joint or for general vibration isolation, Liquid tight flex conduit shall be used.

For beamline enclosures the maximum conduit size through the chicanes shall be 27 mm. The chicanes can accommodate 5 22 mm conduits or 4 27 mm conduits. A detail shall be included in the drawings for 27 mm conduit since it requires an LB through the chicane. 22 mm conduit shall be a continuous bend through the chicane.

32.6 RECEPTACLES

Receptacle colours shall be coded to the type of power being supplied:

Ivory or Black Convenience power

Orange Clean power with isolated ground

Brown Clean power with conventional ground

Red Generator or UPS backup power

Clean power receptacles should be installed inside the hutches and in any beamline work/lab/desk areas. Convenience power receptacles shall also be installed on the outside of the hutches and on the roof of the hutches. At a typical location for each of clean and convenience power there should be:

- - Two 120V, 15A 1P Circuits 5-15R
- - One 208V, 20A 1P (2Phases) Circuit L6-20R
- - One 208V, 30A 3P Circuits L21-30R (only for Convenience Power)

Specific purpose receptacles must be labelled as to the equipment that they shall supply as well as the circuit that they are fed from.

A duplex RJ45 Ethernet jack shall be installed at each desk and at equipment requiring Ethernet access.

32.7 EQUIPMENT RACKS

Each equipment rack shall be powered on its own circuit(s). Racks connected together should be on the same phase. Clean power racks shall be electrically isolated from the floor and any trays/conduits/other racks fed with convenience4 power. The isolated ground shall bond the rack.

The rack designations and locations of equipment where conduit must be run are designed by the Controls Group. There shall be main racks along the beamline for the beamline controls. There shall also be racks on the top of the storage ring for the front end section of the beamline. This front end section extends into the beamline, so there may be some electrical wiring that goes back to the racks on the top of the storage ring. (Fast Valve CCGs or the ACIS System Conduits for example)

Vacuum equipment such as Ion pumps and cold cathode gauges shall be in a convenience power rack.

Titanium Sublimation Pump Tray Cables shall be run inside conduit from the chicane opening to the pump. They shall be in tray from the rack to the chicane.

32.8 ACIS SYSTEM

Locations for the Hutch ACIS Lockup and Powered Door Controls shall be designed by CLS Controls group. Conduits shall be appropriately sized.

33.0 STANDBY (EMERGENCY) GENERATOR

Standby generator intended for use with electronic load equipment shall be specified to meet IEEE Standard 446 requirements.

Standby generator systems generally have much higher impedance than the utility system and therefore, voltage waveform distortion typically increases when loads are fed by the standby generator power. Standby generator when supplying non-linear loads shall be specified to have the following characteristics to minimize adverse interactions:

- Isochronous electronic governor to regulate frequency. These governors typically maintain frequency regulation within 0.25% of the setting as opposed to approximately 3% for mechanical governors.
- Permanent magnet excitation system or filtering means to isolate the voltage regulator power circuit from the distorted waveform.
- Generator with ⅔ pitch stator winding design to minimize third harmonic waveform distortion.
- Low subtransient reactance to minimize voltage waveform distortion.

34.0 REFERENCES

CLS form 8.11.16.3 CLSI Colour Codes for Conduit Junction Boxes

CLS document 7.4.39.14 Cable Specification for Class 2 Circuits

Appendix A Certification Marks

This table was extracted from “The Canadian Electrical Code (Saskatchewan Amendments) Regulations, 2002 Interpretations and Bulletins.” The latest version can be found at http://www.saskpower.com/services/cecr_sk/bulletins/item14.shtml.

Item 14 Acceptable Certification Marks For Canada

These are acceptable certification marks for the Province of Saskatchewan at the time of printing. To confirm the latest list, contact SaskPower Electrical Inspections at 306-566-2500.

Canadian Standards Association

Entela

Intertek Testing Services

Met Laboratories Inc. (Met)

OMNI Environmental Services Inc.

Underwriter's Laboratories Inc. (UL)

Underwriter's Laboratories of Canada (ULC)

TUV Rheinland of North America

TUV Product Service (A Division of TUV America Ltd.)