CHAPTER 28

POWER CONTROL & MONITORING SYSTEMS - PCMS

BACKGROUND

28.1 Power Control and Monitoring systems are information systems that are provided at some Defence establishments. Their purpose is to perform centralised monitoring and control of the site electrical power system, and other functions as required.

SCOPE

28.2 This policy defines the technical and operational requirements for Power Control and Monitoring Systems at Defence establishments.

28.3 This policy describes the required operating philosophy of the system and includes requirements for:

a. Functional requirements;

b. Operating philosophy;

c. Operator interfaces;

d. Interfaces to other systems;

e. Control system hardware and software;

f. Communications networks.

g. Control room layouts;

h. Control cabinet layouts.

28.4 This policy provides guidance and technical material as necessary to define Defence performance requirements and standards to be applied; which are in addition to applicable statutory regulations and standards.

28.5 The content of standards, regulations and other references have not been repeated here unless relevant for context.

28.6 Where necessary a reference will be provided for the source of the information.

Requirement for a PCMS

28.7 This chapter does not prescribe the type of establishment that requires the implementation of a PCMS or the extent of the PCMS at an establishment.
28.8 The determination as to whether a PCMS is required and its extent shall be by assessment of the relevant issues, including but not limited to the following:

a. Existence and capacity of any centralised power generation (either Prime or Standby) with a Generator Control System that requires the ability to shed remote load;

b. Master planning requirements and possible staged implementation;

c. The feasibility and desirability of extending the PCMS to existing facilities at the establishment;

d. Operational requirements, such as the extent of operator interfaces (full SCADA system implementation or a simplified HMI)

e. Consequences of power supply interruption, and the need to manage load to prevent these from occurring, in terms of:

   (1) Loss of function;

   (2) Process disruption;

   (3) Recovery time.

f. Duration and frequency of power outages;

g. Ability of utility power supply or site emergency power supply to meet the site power requirements.

h. The presence of embedded generation, within the Defence facility able to export electricity back into the NSP network.

28.9 Notwithstanding the above, in the design of new (or modifications to) centralised generator plant, high voltage networks or distribution substations the presumption is that, at a minimum, facilities in support of a future PCMS shall be provided

PERFORMANCE OBJECTIVE

28.10 The objective of this policy is to:

a. Define what systems might be controlled and monitored from a PCMS and the interfaces to those systems;

b. Provide a consistent operator interface and method of operation across the Defence estate;

c. Allow effective use of Defence emergency power generation facilities by suitable load control; and,

d. Minimise the impact of single points of failure.
28.11 All materials and workmanship shall be of high standard and shall comply with the relevant regulations and standards and Australian Standards, or if such do not exist, with the relevant IEC or International (ISO) Standards.

28.12 Irrespective of any requirements shown in these documents, the installation as a whole shall comply with:

Table 28.1 - Standards

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS 60870.4</td>
<td>Telecommunications equipment and systems Part 4: Performance requirements.</td>
</tr>
<tr>
<td>AS 1049</td>
<td>Telecommunication cables – Insulation, sheath and jacket</td>
</tr>
<tr>
<td>AS 1243</td>
<td>Voltage Transformers for Measurement and Protection.</td>
</tr>
<tr>
<td>AS 1307</td>
<td>Surge arresters - Metal-oxide surge arresters without gaps for a.c. systems.</td>
</tr>
<tr>
<td>AS 1627</td>
<td>Metal finishing – Preparation and pre-treatment of surfaces.</td>
</tr>
<tr>
<td>AS 60044</td>
<td>Instrument transformer - Current transformers</td>
</tr>
<tr>
<td>AS 60529</td>
<td>Degrees of protection provided by enclosures for electrical equipment (IP Code)</td>
</tr>
<tr>
<td>AS 4029.2</td>
<td>Stationary batteries - Lead acid - Valve regulated sealed type</td>
</tr>
<tr>
<td>AS 4044</td>
<td>Battery chargers for stationary batteries - Type 2.</td>
</tr>
<tr>
<td>AS 4418.1</td>
<td>Supervisory control and data acquisition (SCADA) – Generic telecommunications interface and protocol - General</td>
</tr>
<tr>
<td>AS/NZS 61000</td>
<td>Electromagnetic Compatibility (series).</td>
</tr>
<tr>
<td>AS IEC 61131.1</td>
<td>Programmable controllers; Part 1 - General information</td>
</tr>
<tr>
<td>AS IEC 61131.2</td>
<td>Programmable controllers; Part 2 - Equipment requirements and tests</td>
</tr>
<tr>
<td>AS IEC 61131.3</td>
<td>Programmable controllers; Part 3 - Programming languages</td>
</tr>
<tr>
<td>AS/NZS 3000</td>
<td>Australian Wiring Rules</td>
</tr>
<tr>
<td>AZ/NZS 3013</td>
<td>Electrical Installations – Wiring Systems for Specific Applications.</td>
</tr>
<tr>
<td>AZ/NZS 3080</td>
<td>Telecommunications installations – Generic cabling for commercial premises</td>
</tr>
<tr>
<td>AS/ACIF S008</td>
<td>Requirements for authorised cabling products.</td>
</tr>
<tr>
<td>AS/ACIF S009</td>
<td>Installation requirements for customer cabling (Wiring Rules).</td>
</tr>
<tr>
<td>HB 100 (CJC 4)</td>
<td>Coordination of power and telecommunications - Manual for the establishment of safe work practices and the minimization of operational interference between power systems and paired cable telecommunications systems</td>
</tr>
<tr>
<td>HB 102 (CJC 6)</td>
<td>Coordination of power and telecommunications - Low Frequency Induction</td>
</tr>
</tbody>
</table>
DEFENCE REQUIREMENTS

Infrastructure Management (IM)

28.13 The installation as a whole shall comply with the requirements of the Defence Infrastructure Management (IM) policy and procedures relevant to the works being performed.

28.14 The Defence IM promulgates policy and procedures for the management of the Defence estate, including the procurement of capital facilities. The IM is the prime reference document for all infrastructure activities and processes.

28.15 The provisions of the IM are mandatory.

Defence Communications Cabling

28.16 All Defence communications cabling infrastructure shall comply with the requirements of the Defence Communications Cabling Standard and other Defence standards referenced therein.

Manual of Fire Protection Engineering

28.17 The MFPE is the primary policy document when determining fire safety requirements for Defence facilities and its provisions are mandatory.

SYSTEM CONFIGURATION

28.18 Generally PCMS shall be a distributed control system with two main components:

   a. A distributed control system consisting of remote input/output devices (such as PLCs) or Remote Terminal Units (RTU). This is termed the PCMS Process Network (PN).

   b. A Supervisory Control and Data Acquisition (SCADA) system that monitors and provides a user interface into the PCMS Process Network.

28.19 The PCMS Process Network shall be capable of autonomous operation when communications to the PCMS SCADA are unavailable. No automatic control shall be implemented in the PCMS SCADA.

28.20 The PCMS SCADA:

   a. Allows configuration of the PCMS PN control functions;

   b. Allows manual control of some PCMS PN control functions;

   c. Monitors, stores and trends data from the PCMS PN and other systems;
d. Provides an operator interface consisting of an Operator Terminal/s or Human Machine Interface (HMI).

**LEGACY SYSTEMS INTEGRATION**

28.21 Where a PCMS is to be implemented at a Defence site that previously had a form of load control that is not in accordance with the current Defence IM, the Designer shall give consideration to the following factors in determining whether to replace or integrate the new PCMS with the existing system:

a. Ability of the PCMS to manage the connected load within the capacity of the generator plant, if the existing load control system is not integrated or replaced;

b. Type and age of existing load control devices;

c. Functionality of the existing load control devices;

d. Where an existing load is not sheddable, the cost of implementing load shed control compared to the size of the load; and,

e. Extent (site coverage or amount of sheddable load compared to non-sheddable load) of the existing load control system.

**FUNCTIONAL REQUIREMENTS**

**Overview**

28.22 The Power Control and Monitoring System (PCMS) is a supervisory system for the control and monitoring of various systems associated with the electrical supply network at an establishment. These systems and the interfaces are described in detail thereafter, but can be summarised as follows:

a. LV load management in response to load shedding commands from other systems;

b. Control and monitoring of Local Emergency Generators across the establishment.

c. Monitoring of HV switchgear;

d. Monitoring of power flows in the HV network and distribution substations;

e. Monitoring of HV secondary equipment, such as battery chargers and protection equipment;

f. Monitoring of centralised power generation plant, e.g. CEPS or centralised frequency converters (such as 60 Hz);
g. Defence Operational Requirements, such as RAAF Base blackout systems; and

h. Other control and monitoring functions as required.

28.23 Note: All references below to a Central Emergency Power Station (CEPS) shall be read as a reference to any form of centralised power generation, capable of supporting multiple facility loads on a Defence site.

28.24 References to a Generator Control System (GCS) shall be read as a reference to the overall control system of this centralised power generation.

Low Voltage Load Management

28.25 The PCMS PN shall control low voltage load shedding devices in the distribution substations and elsewhere in response to load shedding commands issued to it by other systems external to the PCMS.

28.26 For example, where a CEPS is provided, the load shed strategy shall be implemented within the CEPS GCS for the purposes of:

a. Preventing overload of the operating generator sets;

b. Optimising the use of the available generator plant;

c. Providing maximum power supply availability to all buildings in a prioritised manner.

28.27 In this case, the GCS will generally issue commands to the PCMS to shed load groups. The PCMS shall then issue commands to the individual load shedding devices associated with those load groups.

28.28 Group load shed commands received from the GCS shall be implemented by the PCMS within one second of receipt of the command.

Local Emergency Generators

28.29 Local Emergency Generators (LEGs) are provided on Defence sites to support key Defence operational facilities and other facilities as identified by the Defence MIEE (refer Section 21.3 – LEG Justification). For each LEG the PCMS shall perform the following control and monitoring functions:

a. Remote monitoring, starting and stopping control of each LEG from the Operator Terminal;

b. Transfer the ‘LEG Run-on’ signal issued by the CEPS GCS to each LEG control system;

c. Provide software interlocks to prevent a LEG from being started in one location and stopped from another, eg a LEG manually started at the ATC/Tower shall keep running until commanded to stop from the ATC/Tower.
d. Where a LEG can be started and stopped from multiple (remote) locations and start signals have been issued from several locations, the LEG shall not stop until stop signals have been received from all locations that issued a call-to-start.

28.30 Mobile generators are not required to be controlled and monitored by the PCMS.

HV Switchgear

28.31 Where applicable to the PCMS implementation, the site HV network switchgear status shall be monitored by the PCMS for event and alarm logging and display. This shall include as appropriate:

- Open/Closed/Tripped status of HV switchgear;
- Other status signals available from the HV switchgear, such as the position of earthing switches or withdrawable CB truck position;
- Other status signals or analogue parameters available from the HV switchgear such as surge diverter failure or gas pressure alarms.

28.32 No control of any HV device shall be performed by the PCMS.

28.33 Where the HV system is provided with its own monitoring and control system, such as a Substation Automation System (SAS), the PCMS can obtain the status of the HV switchgear at high-level from that system. Otherwise, hard-wired status signals shall generally be used.

Power Flows in the HV Network and Distribution Substations

28.34 The Designer shall consider the metering of substation and HV network ring loads.

28.35 Metering at substations shall generally be limited to:

- Each HV circuit at primary substations and switching stations, such as ISS and CEPS.
- The total substation load measured on the LV side of each distribution substation.
- Each significant LV circuit out of a distribution substation LV switchboard.
- Monitoring of the substation and HV network ring loads shall include at a minimum the monitoring and (where applicable) calculation, and logging of the following values:
  1. Phase Voltages, instantaneous, minimum and maximum;
  2. Phase Current, instantaneous, minimum and maximum;
(3) Thermal Phase Current, instantaneous, minimum and maximum;
(4) Power Factor (Per Phase), instantaneous, minimum and maximum;
(5) Phase Total Harmonic Distortion, instantaneous and maximum;
(6) Kilowatts, instantaneous and total;
(7) kVA, instantaneous and total;

28.36 Where the HV system is provided with its own monitoring and control system, such as a Substation Automation System (SAS), the PCMS can obtain the metering data HV switchgear at high-level from that system. Otherwise, hard-wired comms signals shall generally be used.

HV Secondary Equipment

28.37 Where applicable to the PCMS implementation, the secondary equipment associated with the HV power network shall be monitored by the PCMS for:

   a. Event and alarm logging and display, and
   b. Analogue parameter logging and display.

28.38 Secondary equipment includes all support equipment associated with the HV system and includes to the extent to which they are available and appropriate:

   a. Substation Automation System (SAS) status;
   b. Protection relay faults, such as watchdog;
   c. The position of control switches, such as Local/Remote switches;
   d. Communications equipment faults;
   e. Battery chargers and DC system faults and available analogue values.
   f. Mechanical faults, such as ventilation systems and room temperature
   g. OLTC position and faults;
   h. Power transformer on-unit devices, such as buchholz and temperature indication,
   i. Fault indication signals from fault passage indicators and
   j. Other status signals or analogue parameters available from the HV secondary equipment.

28.39 Where the HV system is provided with its own monitoring and control system, such as a Substation Automation System (SAS), the PCMS can obtain the
status of the HV secondary equipment at high-level from that system. Otherwise, hard-wired status signals shall generally be used.

Centralised Power Generation Plant

28.40 Where applicable to the PCMS implementation, the centralised generation plant shall be monitored by the PCMS for:

a. Status, event and alarm logging and display, and
b. Analogue parameter logging and display.

28.41 The centralised generator plant includes the generators themselves and any support equipment associated with the power station, and includes to the extent that they are available and appropriate:

a. Prime movers, e.g. diesel engines or synchronous motors;
b. Alternators;
c. Fuel systems, including pumps and bulk tank levels;
d. Starting systems, such as battery chargers and air compressors;
e. Generator Control System (GCS) or Converter Control System (CCS) faults
f. The position of control switches, such as Start/Stop or Prime/Standby switches;
g. Communications equipment faults;
h. Battery chargers and DC system faults and available analogue values.
i. Mechanical faults, such as ventilation systems and room temperature, and
j. Other status signals or analogue parameters available from the plant.

28.42 PCMS shall generally obtain the status of the plant at high-level from the GCS/CCS.

28.43 No control of any centralised generator plant shall be performed by the PCMS.

Other Control and Monitoring - PCMS Systems

28.44 The Communications Network associated with the PCMS is critical to the operation of the PCMS. The state of network links shall be monitored and alarmed within the PCMS.
28.45 Additional information regarding the Communications Network may also be provided, e.g. UPS status, switch port status, etc.

Other Control and Monitoring - Defence Operational Requirements

28.46 Depending on the type and / or function of the Defence facility, certain specialised PCMS functionality may be required.

28.47 The Designer shall consider whether there is a requirement for this functionality through liaison with appropriate Defence personnel.

28.48 Northern RAAF Bases may require the provision of RAAF ‘Blackout’ functionality, the purpose of which is to blackout the Base in the case of an air raid. This shall take the form of a discrete input from the Base Command Post to be passed via the PCMS to each facility and substation as required, for the use by lighting systems.

28.49 The airfield lighting control system shall receive indication of the Blackout command as a request that requires manual confirmation from the Air Traffic Control tower prior to extinguishing any airfield lighting.

28.50 Generally, all external lighting will be connected to the Base Blackout system (refer Defence MIEE Section 13 – Artificial Lighting).

Other Engineering Services

28.51 Other systems may be present at Defence sites; commonality between these systems and the PCMS shall be limited to the use of a shared communications network.

28.52 These other systems may include:

a. Building Management System (BMS): A BMS is typically provided to individual buildings to control, monitor and manage building services including but not limited to air conditioning plant, hot water units, energy and water metering, and lighting.

   (1) The individual building management systems may be networked and connected to a site-wide management system for enhanced facilities management.

b. Regional Utility Management System (RUMS): The RUMS system is effectively an extension of the site-wide BMS to multiple sites for the purpose of energy accounting and load profiling. The implementation of this system is limited and has been largely superseded by other energy metering systems.

c. Energy Metering System: This is an entirely separate system from the above, focussed solely on energy metering on a facilities basis.
(1) Typically smart meters are installed at facility main switchboards or substation site main switchboards, and are provided with a cellular data modem to report to a centralised system.

OPERATIONAL PHILOSOPHY

Low Voltage Load Management

28.53 Low voltage load management shall be achieved using load shedding devices that are under the direct control of the PCMS.

28.54 Individual load shedding devices shall be allocated to load groups within the PCMS.

28.55 The PCMS shall provide both automatic and manual operational modes of load management control.

28.56 **Automatic control** shall disconnect and reconnect predefined prioritised load groups to achieve a fast and substantial load reduction in the case of a CEPS overload or underspeed, which threatens continued operation of the CEPS generator set(s), as determined by the Generator Control System.

   a. It will normally be the function of the Generator Control System to determine when and how many load groups are to be shed or reconnected.

28.57 **Manual control** shall be possible at all times. This shall occur from the Operator Terminal. It shall allow disconnection and reconnection of individual load shedding devices or load groups to optimise the use of generator capacity and provide maximum power supply availability for each facility according to its operational requirements.

   a. When manual control is selected, shed and reconnect commands shall be input by an Operator and the automatic control signal of that device/group shall be inhibited.

Load Group Allocation & Control

28.58 All discrete load shedding devices shall be allocated by operator pre-sets within the PCMS to one of ten load groups (Load Groups 1-10).

28.59 Each load group corresponds to a supply priority level, with facilities allocated to Load Group 1 considered to have a higher priority supply level relative to other facilities on the site.

28.60 Strong consideration shall be given to allocating the site load approximately equally among the ten load groups (i.e. 10% of site load per load group).

28.61 When a load shed signal for Load Group ‘X’ is initiated by the GCS, all loads allocated to Load Group ‘X’ shall be shed simultaneously.
28.62 When the Load Group ‘X’ shed signal is removed by the GCS, all building loads allocated to Load Group ‘X’ shall be reconnected simultaneously.

**Low Voltage Load Management [Automatic Control]**

28.63 Under automatic control operation of the Low Voltage Load Management systems is initiated by the CEPS GCS.

28.64 The automatic operation of the load shedding signals from the GCS and the interface with the PCMS are defined in MIEE Chapter 27.

**Low Voltage Load Management [Manual Control]**

28.65 Manual Load Control shall be provided on the level of both an individual load shedding device, and a Load Group basis.

28.66 Selection and operation of Manual Load Control shall be able to be made at several locations:

- **Table 28.2 – PCMS Manual Load Control Locations**

<table>
<thead>
<tr>
<th>Location</th>
<th>Manual Load Control Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCMS SCADA or HMI Operator Terminal</td>
<td>Selection and operation of manual control on an individual load shedding device basis and a load group basis.</td>
</tr>
<tr>
<td>CEPS Station Control Panel</td>
<td>Selection and operation of manual control on a load group basis only. No discrete load control available. (See MIEE Chapter 27)</td>
</tr>
<tr>
<td>Local to the load shedding device</td>
<td>Refer to the section on <strong>SCADA Requirements</strong> in this Chapter.</td>
</tr>
</tbody>
</table>

**Base Mode Change**

28.67 The load control function within the PCMS system shall be configured to allow two separate time-based operational modes i.e. Mode 1 and Mode 2.

28.68 Typically, these two operational modes may correspond to a ‘Day’ and ‘Night’ mode.

28.69 For each mode, the buildings may be allocated to different priority load groups.

28.70 The current mode for the PCMS shall be configurable based on a 24-hour 7-day time schedule.

28.71 The time schedule will be Operator configurable from the PCMS Operator Terminal at the primary PCMS Operator Interface location.
28.72 When transitioning between modes, load groups that are disconnected under the new mode shall be shed before load groups that are connected under the new mode are reconnected.

28.73 If a load group allocation does not change between modes, those loads shall not be disconnected during the mode change.

28.74 GCS load shedding requests issued during the mode change shall be implemented immediately.

28.75 If the GCS removes load group shed signals (i.e. load group reconnect) while a mode transition is being implemented, the reconnect action shall be delayed by an Operator configurable period (nominally 0-10 minutes) within the PCMS until the revised load configuration has been adopted.

Local Emergency Generators

28.76 The operation of the local emergency generators are defined in MIEE Chapter 21

28.77 LEGs shall be able to operate independently to the CEPS.

28.78 When the LEGs detect a local mains failure, it shall start and connect to the local load.

28.79 Where a local mains failure is a result of a utility mains failure, the following sequence shall occur:

   a. Local mains fail detected by the LEG control system.
   b. Utility mains fail detected by the GCS.
   c. The LEG starts and connects to the local load.
   d. The CEPS GCS sends a ‘LEG Run-on’ signal to the PCMS. The PCMS then issues this ‘LEG Run-on’ to all LEGs. This prevents them shutting down on (apparent) mains restore.
   e. The CEPS starts and connects to the HV network.
   f. The LEG detects local mains available (due to supply by CEPS).
   g. On restoration of utility mains supply the CEPS GCS removes the LEG Run-on signal and the LEG control system transfers the load back to the utility mains supply;

28.80 If the LEG fails, the PCMS shall receive an indication from the LEG control system, the load shall reconnect to the CEPS mains supply and the LEG Run-on signal to that particular LEG shall be removed.
Events and Alarms Strategy, Logging and Reporting

28.81 All changes shall be logged by the PCMS. Events shall be grouped into two categories:

a. **Events**: Events are generally defined as changes in status or actions taken.

   (1) Events do not require the attendance of maintenance personnel or operator acknowledgement.

   (2) All changes of status shall be logged regardless of who the imitator of the change was, for example, the opening and closing of switchgear.

   (3) Actions by the operator shall also be logged, including actions such as login, manual load shed initiation, cancelling or enabling trending / reporting, or inhibiting event inputs.

b. **Alarms**: Alarms are considered extraordinary events that require the attendance of maintenance personnel or operator acknowledgement.

   (1) All change of alarm status shall be logged, i.e. equipment going into and out of alarm state.

   (2) Alarms shall be classified as either HIGH or LOW priority.

   (3) HIGH level alarms shall require operator acknowledgement to be reset and, where the facility is provided, shall be transmitted to maintenance personnel via a paging or SMS system.

   (4) LOW level alarms shall reset automatically once the alarmed point returns to normal.

28.82 Events and alarms shall be recorded for all major items of the PCMS, including the following items at a minimum:

a. Controller;

b. Power supplies;

c. Batteries;

d. Load shed devices;

e. Communications; and,

f. Cabinet temperatures.
REDUNDANCY, FAULT TOLERANCE AND FAILURE MODES

Redundancy and Fault Tolerance

28.83 Redundancy provided to the PCMS shall be focussed on prevention of the failure of the entire system and not on individual equipment.

28.84 Therefore, only critical common systems, particularly those elements with higher failure rates, shall be duplicated.

28.85 In particular, duplicated DC supplies for centralised control system equipment shall be provided.

28.86 The PCMS shall be designed to be tolerant of faults, including alternate methods of operating the system in the event of component failure. Specifically, the failure of PCMS system equipment:

   a. Shall not result in loads being shed when mains supply is available; and,

   b. Shall not prevent the CEPS from connecting to the HV network and supplying the site.

PCMS Failure Modes of Operation

28.87 The PCMS shall be configured to operate for various failure scenarios that include failure of any part of the PCMS, communications equipment and mains supply.

28.88 Failure mode responses shall be incorporated into the PCMS system as summarised in Table 28.3, below:
Table 28.3 – PCMS Failure Modes of Operation [Load Shedding]

<table>
<thead>
<tr>
<th>Type of Failure</th>
<th>PCMS Load Shedding Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local PCMS PLC Failure</td>
<td>The connected configuration of each load shedding device shall remain unchanged. Local manual load shed controls shall remain enabled. Remote operation is not available.</td>
</tr>
<tr>
<td>Master PCMS PLC Failure</td>
<td>The connected configuration of each load shedding device shall remain unchanged. Local manual load shed controls shall remain enabled. Remote operation is not available.</td>
</tr>
<tr>
<td>Communications lost between Master PCMS PLC and local PCMS PLC</td>
<td>The connected configuration of each load shedding device shall remain unchanged. Local manual load shed controls shall remain enabled. Remote operation is not available.</td>
</tr>
<tr>
<td>Local PCMS DC Supply Failure</td>
<td>The connected configuration of each load shedding device shall remain unchanged. Local manual load shed controls shall remain enabled. If the PCMS DC supply is used by the load shedding device those functions might not be available. Remote operation is not available.</td>
</tr>
<tr>
<td>Local PCMS PLC Fails OR Communications is lost between CEPS PCMS PLC and the local PCMS PLC – AND – Subsequent PCMS DC Supply Failure.</td>
<td>The connected configuration of each load shedding device shall remain unchanged. Local manual load shed controls shall remain enabled. If the PCMS DC supply is used by the load shedding device those functions might not be available. Remote operation is not available.</td>
</tr>
<tr>
<td>Local PCMS PLC Fails OR Communications is lost between CEPS PCMS PLC and the local PCMS PLC – AND – Subsequent Utility Mains Supply Failure.</td>
<td>The connected configuration of each load shedding device shall remain unchanged. Local manual load shed controls shall remain enabled. Remote operation is not available.</td>
</tr>
<tr>
<td>Local PCMS PLC Fails OR Communications is lost between CEPS PCMS PLC and the local PCMS PLC – AND – Subsequent Mains Supply Failure – AND – Subsequent PCMS DC Supply Failure</td>
<td>The connected configuration of each load shedding device shall remain unchanged. Local manual load shed controls shall remain enabled. If the PCMS DC supply is used by the load shedding device those functions might not be available. Remote operation is not available.</td>
</tr>
<tr>
<td>Local PCMS PLC Fails OR Communications is lost between CEPS PCMS PLC and the local PCMS PLC – AND – Subsequent PCMS DC Supply Failure – AND – Subsequent Mains Supply Failure</td>
<td>The connected configuration of each load shedding device shall remain unchanged. Local manual load shed controls shall remain enabled. If the PCMS DC supply is used by the load shedding device those functions might not be available. Remote operation is not available.</td>
</tr>
<tr>
<td>Note: Remote operation denotes control signals are initiated from the GCS or PCMS Operator Terminal.</td>
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</tbody>
</table>
Table 28.4 – PCMS Failure Modes of Operation [LEGs Control]

<table>
<thead>
<tr>
<th>Type of Failure</th>
<th>PCMS LEGs Control Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local PCMS PLC Fails OR Communications is lost between CEPS PCMS PLC and the local PCMS PLC – AND – No subsequent mains failure</td>
<td>LEG is not required to start. Remote control and monitoring of LEG is not available.</td>
</tr>
<tr>
<td>Local PCMS PLC Fails OR Communications is lost between CEPS PCMS PLC and the local PCMS PLC – AND – Subsequent mains failure</td>
<td>LEG shall start on mains failure. Remote control and monitoring of LEG is not available. When CEPS starts and connects the LEGs will see this as a mains return and shutdown.</td>
</tr>
</tbody>
</table>

HARDWARE REQUIREMENTS

SCADA Server

28.89 The SCADA server shall consist of an industrial-rated PC with a RAID array (minimum RAID 1) for data storage. Storage shall be adequate to store at least five years of records.

28.90 For smaller installations, the server can be the same machine as the operator interface.

28.91 In larger installations the server shall be separate from the operator interface and be 19 inch rack mounted.

Data Storage, Backup and Archive Requirements

28.92 The SCADA server shall have backup facilities available (data cartridges or equivalent) for long term data archiving and software backup purposes.

28.93 The server shall have facilities for scheduled backup and archiving as well as manually-initiated and selected data backup.

28.94 The scheduled backup facilities shall be implemented such that required Operator interaction is limited to only replacing data cartridges once full.

28.95 Sufficient data cartridges should be supplied to support a minimum of five years of logged data.

PCMS Controller Requirements - General

28.96 The PCMS shall use industrial grade technology such as distributed expandable Programmable Logic Controllers (PLCs), inclusive of a processor with an integral Ethernet port, digital and analogue inputs and outputs, interfaces for electronic power meters, watchdog timer, real-time clock and all other facilities necessary for successful operation.
Controllers shall be suitable for use in the electrically noisy environment of an electrical substation and for the expected site conditions.

PCMS Controller Requirements - Inputs / Outputs

Hardware shall support 50% spare I/O points and 50% spare program memory at completion of commissioning of the system.

A minimum of 25% or 24DI / 24DO spare I/O (whichever is the greater) shall be installed at each Controller prior to hardware delivery to site.

PCMS Controller Requirements - Software

All custom software shall be in accordance with AS 4168.3 (IEC 61131).

At least one copy of all appropriate custom Controller software developed by the Contractor shall remain with the Department of Defence.

Generally, software licences shall be for the unlimited use by the Department of Defence for this site, however the following is the minimum required:

PLC Software:- Licensed for the relevant site (e.g. entire RAAF Base)

SCADA Software:- Licensed for the following sites:- Central (Emergency) Power Station, and - Maintenance Contractor Office.

Communications Network - General

The communications network provided for the use of the PCMS shall be either physically (standalone network) or logically (Virtual Local Area Network-VLAN) separated from other networks.

VLANs on classified Defence networks will only be possible if approval is provided by CIOG. Generally, the PCMS will cover a large geographic area of the Defence site, including areas where typical Defence networks would not otherwise be required.

The preferred approach shall be to provide a site wide engineering services network, dedicated to only engineering services network data (e.g. PCMS, site wide BMS, energy metering, etc), with each engineering service logically isolated via a VLAN.

Where there are limited remote PCMS controllers, covering only a restricted geographic area the Designer may consider proving single point-to-point links connecting each individual PCMS controller to the PCMS central controller.

The PCMS provides load shedding and reconnection functions that need to continue even when power to a particular facility has been shed. The design of the PCMS communications network shall consider continued availability of PCMS communications under load shedding. In particular the design shall consider the impact of an extended loss of power on active communications equipment in facilities that can be load shed.
Communications Network - Network Structure

28.110 The topology design shall generally follow the requirements of the Defence Communications Cabling Standard.

28.111 The preferred network topology is for a two-layer network of two meshed core nodes and several edge nodes, with each edge node connected to the two core nodes.

28.112 Generally, network nodes shall be interconnected with single mode optic fibre (SMOF). Refer to Figure 28.3 and Figure 28.4 for example network topologies.

28.113 Core and edge nodes shall be selected and geographically located to provide a 'balanced' network, meaning that if an edge node fails, only a proportionate amount of PCMS devices will not be able to communicate and will execute failure modes as described above.

   a. For example, if there are four edge nodes and one node fails, a maximum of approximately one-fourth of the PCMS devices shall lose connectivity.

28.114 When selecting network node locations, preference shall be given to facilities used for the Defence site electrical network, e.g. central generation facilities and HV switching stations, as these buildings will have a high reliability power supply relative to the remainder of the site facilities.
Communications Network - Network Performance Requirements

28.115 The network shall provide a minimum 10 Mb/s interface to each connected PLC.

28.116 The one-way latency of the network link from the PCMS Operator Terminal to any PCMS controller shall be less than one (1) second at all times, including during network topology changes if a redundant path fails.

28.117 Load shedding of an individual load group shall occur within one second from the time of initiation of the command at the CEPS GCS.

28.118 Load shedding of all load groups shall occur within two seconds from the time of initiation of the command at the CEPS GCS.

Communications Network - Power Supplies

28.119 PCMS and associated equipment shall be supplied from DC supplies where possible.

28.120 Equipment requiring AC supplies shall generally be powered from inverters connected to the DC supply.

28.121 The PCMS and associated equipment shall be powered from a circuit that is not sheddable by the PCMS.

28.122 DC systems shall be nominally 24 VDC, unearthed with earth fault detection. An earth fault shall initiate an alarm connected to the PCMS controller.

28.123 Minimum backup time for PCMS and associated equipment shall be:

a. SCADA server and operator interface: - 16 hours
b. Communications nodes:- 16 hours
c. PCMS Controllers:- 16 hours (At communications nodes and major HV substations)
d. PCMS Controllers:- 6 hours (Field)

28.124 Generally power supplies shall be derived as follows:

a. SCADA Server:

(1) Provide a separate duplicated power supply that complies with the requirements for protection power supplies contained in Chapter 26.

b. Primary Substations and Switching Stations

(1) PCMS power supply shall be derived from a separate circuit of the same DC supply as for the HV systems where this does not adversely impact on the autonomy time of that system.
(2) Otherwise provide a separate PCMS DC supply system.

(3) Provide any necessary voltage converters if the HV has a different DC voltage to 24 VDC.

c. Distribution Substations & Other Facilities

(1) Provide a separate 230V AC circuit on the distribution section, in the substation LV switchboard or building main switchboard to supply the PCMS DC supply system.

(2) This DC supply can be utilised to power the LV load shedding devices. The capacity of the DC system shall make allowance for this.

Locations / Enclosures - Operator Interface

28.125 The Primary Operator Interface should generally be located within the Control Room of the CEPS.

28.126 If a Secondary Operator Interface is provided, it should generally be located within the Maintenance Contractor Offices.

28.127 The location of the Primary Operator Interface shall be provided within the following facilities:

a. An office desk, suitable for a PC workstation, two 24" monitors and two colour printers;

b. An office chair;

c. Space for a 19" 45 RU for the Master PCMS Controller; and,

d. Space for a 19" 45 RU communications rack.

PCMS Enclosures

28.128 Equipment enclosures for the PCMS shall house the following equipment:

a. PLC equipment;

b. Termination panels for UTP copper and fibre cabling;

c. 24 VDC power supply and batteries;

d. Field cabling terminals.

28.129 Equipment enclosures installed within buildings shall be a standard catalogued item with a minimum degree of protection of IP51.

28.130 Enclosures shall generally not be installed outdoors unless the environment is suitable for the equipment enclosed.
a. In such circumstances, the enclosures shall be of stainless steel construction with a degree of protection of IP55 (minimum) complete with sun shade and rain hood.

b. The enclosure construction shall be modified as necessary to accommodate identified features and equipment.

28.131 Enclosures should be securely fixed in place, lockable and provided with adequate, vermin-proof ventilation.

Load Shedding Devices

28.132 Load shed devices shall be installed for each facility and shall be installed at locations to achieve functionality identified under the sections of FUNCTIONAL REQUIREMENTS and OPERATIONAL PHILOSOPHY in this Chapter.

28.133 The use of specific devices is not required; any device that can achieve the following requirements can be utilised.

Functionality

28.134 Load shed devices shall meet the following functionality:

a. The device shall open (i.e. shed) via a ‘pulsed’ 24 V DC signal and without 240 V AC being available;

b. The device shall close (i.e. reconnect) using a 240 V AC signal;

c. Where a protection device is used as a load shed device (e.g. a circuit breaker), the remote shed (or ‘trip’) must be distinguishable from a ‘fault’ trip.

d. Devices shall not allow remote resetting or closing after a fault trip;

e. Devices shall move to an ‘open’ state after receiving a remote shed signal without any external intervention;

f. Devices shall not change state on power supply failure, except in the case of the fault modes identified under the section of REDUNDANCY, FAULT TOLERANCE AND FAILURE MODES in this Chapter.

28.135 Local Control and Indication

a. Each device shall have an LOCAL/REMOTE switch at the device, it shall be monitored by the PCMS;

b. Local manual controls, shall consist of Open and Close pushbuttons, which shall only be enabled when the device is in the LOCAL position.

c. Illuminated indicators shall be provided to indicate the Open/Closed status.
d. Indicators and control switches shall consist of 22 mm dia oil-tight units.

28.136 Refer to Figure 28.1 and 28.2 for logic diagrams depicting the use of circuit breakers and latching contactors as load shed devices.

**Figure 28.1 – Motorised Circuit Breaker State Chart**

<table>
<thead>
<tr>
<th>Transition</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>CLOSE command received from local PCMS Controller or manually at device</td>
</tr>
<tr>
<td>1</td>
<td>SHED command received from local PCMS Controller or manually at device</td>
</tr>
<tr>
<td>2</td>
<td>Occurs automatically within circuit breaker; no external signal required.</td>
</tr>
<tr>
<td>3</td>
<td>Circuit breaker opened manually locally (transition not available from PCMS)</td>
</tr>
<tr>
<td>4</td>
<td>(Electrical) Fault Trip</td>
</tr>
<tr>
<td>5</td>
<td>Circuit breaker reset locally (manual reset, transition not available from PCMS)</td>
</tr>
<tr>
<td>6</td>
<td>Circuit breaker reset to CLOSE position</td>
</tr>
<tr>
<td>7</td>
<td>Circuit breaker reset to OPEN position</td>
</tr>
<tr>
<td>8</td>
<td>Circuit breaker reset to FAULT TRIP position</td>
</tr>
<tr>
<td>9</td>
<td>Circuit breaker failed to trip</td>
</tr>
<tr>
<td>10</td>
<td>Circuit breaker failed to reset automatically to open position</td>
</tr>
<tr>
<td>11</td>
<td>Circuit breaker failed to close</td>
</tr>
</tbody>
</table>
### Design Life

**28.137** Design life for the selected load-shedding device shall consider the capacity of the device to perform open-close cycles.

**28.138** For assessing design service life of devices, the following assumptions should be made:

- Load shed devices may be operated once per week for testing of the CEPS generators under site load;
- For northern sites (or sites that experience tropical wet / dry seasons), load shed devices may be operated once per day over a period of six months (e.g. wet season);
28.139 That is, load shed devices will be operated approximately 50 times/year generally and approximately 190 times/year for northern sites.

28.140 Using these assumptions, load shed devices should be selected for a minimum design life of 30 years.

28.141 When assessing design life, consideration shall be given to typical loads on the device. For example, if a hypothetical circuit breaker has a design service life expectation of 15,000 cycles at 50% load and 4,000 cycles at full load, it can be estimated that the design life will be between approximately 21 and 78 years. However, if this hypothetical circuit breaker can justifiably be expected to typically not be operated at full load, the design life is expected to be greater than 30 years and it would be acceptable for use as a load shed device.

Fault Protection

28.142 Any device selected as a load shed device shall be required to withstand the fault let-through capacity associated with the respective up-stream protective device.

Standardisation

28.143 When selecting a load shed device for a new facility within an existing site, strong consideration shall be given to standardising on common load shed devices for that site.

28.144 Where several new facilities are proposed within or at an existing site and where the existing load shed devices have been installed for several years, the use of common devices across the site shall not form a significant factor in selecting devices.

Cost

28.145 Consider the cost and space requirements for providing a combined protection and load shed device (e.g. circuit breaker) versus the use of separate devices (e.g. fuse switch and contactor).

Power Meters

28.146 Monitoring of power flows at the distribution substations and in the HV network shall include at a minimum, the monitoring and logging of the following values directly from the meter:

   a. Instantaneous Phase Voltage (per phase);
   b. Instantaneous Phase Current (per phase);
   c. Instantaneous Thermal Phase Current (per phase);
   d. Instantaneous Power Factor (per phase);
   e. Instantaneous Total Harmonic Distortion (per phase);
f. Instantaneous Kilowatts;
g. Instantaneous kVA; and,
h. Total Accumulated kWh (since last reset).

28.147 The following values shall be calculated within the PCMS controller, where these are not available within the meter:

a. Peak Phase Voltage (per phase, minimum and maximum);
b. Average Phase Voltage (instantaneous, minimum and maximum);
c. Peak Phase Current (per phase, maximum);
d. Average Phase Current (instantaneous and maximum);
e. Peak Thermal Phase Current (per phase, maximum);
f. Average Thermal Phase Current (instantaneous and maximum);
g. Peak Power Factor (per phase, minimum and maximum);
h. Average Power Factor (minimum and maximum);
i. Peak Total Harmonic Distortion (per phase, maximum);
j. Average Total Harmonic Distortion (instantaneous and maximum);
k. Peak kW (daily maximum);
l. Peak kVA (daily maximum);
m. Total Accumulated kWh for today;

28.148 The scan period of the meters by the local controller shall be user-configurable from 1 second to 1 hour but initially set at 10 seconds.

28.149 Data shall be transferred from the local controller to the master controller and Operator Interface for logging and recording at a user-configurable period of 10 seconds to 10 hours, but initially set at 10 minutes.

28.150 The value transferred from the local controller for each period shall be the average of the scanned values for that parameter during the interval calculated within the local controller.

28.151 Diagnostic information reported by the local controller about each meter is limited to communications error count and the current health status.

28.152 The Operator Interface shall be provided with a common reset facility to reset the minimum and maximum value registers at the local controller.
INTERFACES TO OTHER SYSTEMS

Local Emergency Generator Control and Monitoring Interface

28.153 The interface between each LEG control system and the local PCMS controller shall be a low level interface with discrete signals.

28.154 Specific signals that shall be provided to the PCMS from the LEG control system include the following:

- **Table 28.5 – PCMS Controller - LEG Control System Interface**

<table>
<thead>
<tr>
<th>Signal</th>
<th>Signal Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEG Start</td>
<td>Digital Output</td>
<td>Remote call-to-start LEG</td>
</tr>
<tr>
<td>LEG Stop</td>
<td>Digital Output</td>
<td>Remote call-to-stop LEG</td>
</tr>
<tr>
<td>CEPS Run-on</td>
<td>Digital Output</td>
<td>When this non-latching signal is present the LEG shall continue to run, whether or not is has detected the mains return.</td>
</tr>
<tr>
<td>LEG Healthy</td>
<td>Digital Input (non-latching)</td>
<td>When this non-latching signal is present, the LEG is healthy and available for use. Healthy = 1 Fault = 0</td>
</tr>
<tr>
<td>LEG Available</td>
<td>Digital Input</td>
<td>The generator is healthy and the control system is in the AUTO mode.</td>
</tr>
<tr>
<td>Local Mains Available</td>
<td>Digital Input (non-latching)</td>
<td>When this non-latching signal is present, the LEG is indicating that either CEPS or utility supply is available to supply the building.</td>
</tr>
<tr>
<td>Local Mains Connected</td>
<td>Digital Input (non-latching)</td>
<td>When this non-latching signal is present, the LEG is indicating that either CEPS or utility supply is supplying the building – i.e. the LEG is not supplying the building.</td>
</tr>
</tbody>
</table>

28.155 All LEGs on the site shall be able to operate independently of the PCMS or CEPS.

Start / Stop / CEPS Run-on Signals

28.156 Depending on generator control system requirements and the existing installation conditions at each LEG, the start, stop and run-on commands for each of the LEGs can be either a pulsed or a latching output.

28.157 Where a pulsed latching output is used, separate start and stop signals shall be required from the PCMS controller, with the stop signal taking precedence if both signals are present.
28.158 If a continuous output is used, only one signal shall be required from the
PCMS controller with the stop signal being high (1) and the start signal being low (0)
for fail-safe purposes.

28.159 The Designer shall also consider combining the CEPS Run-on signal with
the start signal.

28.160 Discrete inputs from each LEG defining its status shall be transferred to the
PCMS where the information shall be displayed on the PCMS Operator Interface.

28.161 A Stop signal can only be provided by the control location that issued the
Start signal; i.e. the LEG shall not stop if a Start signal is received from one location
and a Stop signal is received from an alternative location (except for local manual
controls).

High Voltage Network Status Monitoring

28.162 The interface between HV equipment and the local PCMS controller shall be
either:

   a. a low level interface with discrete signals., or

   b. a high-level interface to a Substation Automation System

28.163 Example signals that shall be provided to the PCMS from typical monitored
HV equipment include the following:

28.164 Equipment monitored may include:

- Table 28.6 – HV Network Monitoring

<table>
<thead>
<tr>
<th>HV Network Equipment</th>
<th>Monitoring Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substation Ring Main Units (RMUs)</td>
<td>The status of each switch in a ring main unit shall be monitored in the field for logging in the PCMS for OPEN, CLOSED and TRIPPED.</td>
</tr>
<tr>
<td>CEPS, Intake Switching Station (ISS) &amp;</td>
<td>The status/position of HV switches or circuit breakers installed on the ISS, PSS and CEPS switchboards shall be monitored in the field for logging / alarming in the PCMS for LOCAL/REMOTE, OPEN, CLOSED, TRIPPED and WITHDRAWN as appropriate.</td>
</tr>
<tr>
<td>Primary Switching Station (PSS) HV switchgear.</td>
<td></td>
</tr>
<tr>
<td>Power Factor Correction (PFC) Units</td>
<td>The status of the PFC Unit shall be monitored, for example the number of capacitor banks (stages) connected, unbalanced alarms and trips.</td>
</tr>
<tr>
<td>Switching Station Transformers</td>
<td>The status of substation transformers shall be monitored, for example over temperature, oil level, winding temperature.</td>
</tr>
<tr>
<td>Distribution Substation Transformers</td>
<td>The status of distribution substation transformers shall be monitored, for example over temperature and oil level.</td>
</tr>
<tr>
<td>Secondary Systems Supply</td>
<td>DC Supply system faults (high / low voltage, rectifier failure, battery test failure)</td>
</tr>
<tr>
<td>Tap Changers</td>
<td>Tap changer position, oil level alarm.</td>
</tr>
</tbody>
</table>
Generator Control System Interface

28.165 Provide both a low-level and high-level interface between the GCS and the PCMS.

Low Level Interface

28.166 The low-level interface shall consist of voltage-free contacts of the signals described in Table 28.7.

Table 28.7 – Transferred Signals from CEPS GCS to PCMS

<table>
<thead>
<tr>
<th>Signal</th>
<th>Signal Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load Shed Group 1</td>
<td>Shed / Connect</td>
</tr>
<tr>
<td>Load Shed Group 2</td>
<td>Shed / Connect</td>
</tr>
<tr>
<td>Load Shed Group 3</td>
<td>Shed / Connect</td>
</tr>
<tr>
<td>Load Shed Group 4</td>
<td>Shed / Connect</td>
</tr>
<tr>
<td>Load Shed Group 5</td>
<td>Shed / Connect</td>
</tr>
<tr>
<td>Load Shed Group 6</td>
<td>Shed / Connect</td>
</tr>
<tr>
<td>Load Shed Group 7</td>
<td>Shed / Connect</td>
</tr>
<tr>
<td>Load Shed Group 8</td>
<td>Shed / Connect</td>
</tr>
<tr>
<td>Load Shed Group 9</td>
<td>Shed / Connect</td>
</tr>
<tr>
<td>Load Shed Group 10</td>
<td>Shed / Connect</td>
</tr>
<tr>
<td>Load Shed Group 1</td>
<td>Auto/Man</td>
</tr>
<tr>
<td>Load Shed Group 2</td>
<td>Auto/Man</td>
</tr>
<tr>
<td>Load Shed Group 3</td>
<td>Auto/Man</td>
</tr>
<tr>
<td>Load Shed Group 4</td>
<td>Auto/Man</td>
</tr>
<tr>
<td>Load Shed Group 5</td>
<td>Auto/Man</td>
</tr>
<tr>
<td>Load Shed Group 6</td>
<td>Auto/Man</td>
</tr>
<tr>
<td>Load Shed Group 7</td>
<td>Auto/Man</td>
</tr>
<tr>
<td>Load Shed Group 8</td>
<td>Auto/Man</td>
</tr>
<tr>
<td>Load Shed Group 9</td>
<td>Auto/Man</td>
</tr>
<tr>
<td>Load Shed Group 10</td>
<td>Auto/Man</td>
</tr>
<tr>
<td>CEPS Run-on</td>
<td>CEPS supplying site, emergency generator to ignore local mains return</td>
</tr>
<tr>
<td>CEPS Operating</td>
<td>Any of the CEPS generators is running and connected</td>
</tr>
</tbody>
</table>

High Level Interface

28.167 The high-level interface shall be used primarily to monitor, trend and log the status and condition of CEPS plant, including generators, fuel and air systems. This includes both digital and analogue information.
28.168 The GCS shall pass all plant status, event, alarm and warning data via a read-only interface; the PCMS shall not be able to write to GCS registers or affect the operation of the GCS.

28.169 The high-level interface shall be configured with a firewall that prevents devices on the PCMS network from controlling or otherwise affecting the operation of the CEPS.

SCADA REQUIREMENTS

Operator Interface - Access Levels

28.170 The Operator Interface shall be provided with three (3) operator levels for the following functions:

a. Level 1 - Permit the Operator to view monitoring status screens of the PCMS;

b. Level 2 - Permit all Level 1 functions and access the control function of the PCMS, acknowledge alarms, other windowed applications or the Operating System;

c. Level 3 - Permit all Level 2 functions and in addition allow the Operator to access the Engineering configuration functions (i.e. PLC addresses and PLC programming) of the system.

28.171 Examples of functions available at each of the access levels are as follows:


c. PLC output number: Access Level 3.

d. Adding new or deleting existing facilities: Access Level 3.

e. Operational mode time scheduling: Access Level 2.

28.172 Access to restricted levels shall expire if the interface remains unused for a preset period.

28.173 Passwords shall not automatically expire.

28.174 An event shall be logged and stored on each Operator Interface when an Operator level is accessed.

28.175 Where a Secondary Operator Interface is provided at a location external to the CEPS, the Secondary Operator Interface shall be provided with monitoring, report generation and trending capability only, i.e. control of the load shedding system and the LEGs shall not be provided.
Operator Interface - SCADA Software

28.176 The PCMS Operator Interface, it shall include the following functions at a minimum:

a. A user-friendly operator interface for monitoring, control and system management purposes;

b. Display and / or control of all analogue and digital points. The maximum response time between an operator action or automatic control and confirmation that the action has taken place shall not exceed one second.

c. Configuration of individual controllers.

d. Alteration of parameter values, e.g. trending intervals, archive intervals, alarm/event inhibit.

e. Annunciation of alarms on both occurrence and alarm priority basis.

f. Alarm / event / operator action history collection for the generation of logs and customised reports.

g. Incorporate consequential alarm suppression whereby secondary alarms will not be raised from systems that have failed or are programmed to be off.

h. On-line generation of reports.

i. The ability to tag messages of at least 100 characters to any alarm to provide instruction to the operator for action to be taken.

j. A colour graphics interface package for the display of windows into all the systems controlled or monitored by the PCMS Controllers and the CEPS generation plant.

k. Include the capability for producing schematics of the systems and displaying dynamic data, in real time, at appropriate locations in the graphic.

l. Commandable points shall be uniquely identified and shall be directly addressable from the graphic display.

m. Synchronisation of all PCMS Controller real-time clocks with its own once daily.

28.177 All pages shall include clear and consistent navigation buttons for selection of each display function outlined.

28.178 Colours used in the SCADA Operator Interface shall generally conform to those listed in Table 28.81
Table 28.81 - Colour Used in PCMS SCADA Operator Interface

<table>
<thead>
<tr>
<th>Colour</th>
<th>Element / Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>• All cabling and connections</td>
</tr>
<tr>
<td></td>
<td>• Loss of communications/facility</td>
</tr>
<tr>
<td>Grey</td>
<td>• Disabled buttons</td>
</tr>
<tr>
<td></td>
<td>• Devices for which the status is not known, such as switches which are not monitored by the PCMS or points to which communication has been lost</td>
</tr>
<tr>
<td>Green</td>
<td>• Selected state, healthy on</td>
</tr>
<tr>
<td></td>
<td>• Safe status, such as open switches, conditions which are not in alarm</td>
</tr>
<tr>
<td></td>
<td>• Location of HV ring open points</td>
</tr>
<tr>
<td>Green/Grey Flashing</td>
<td>• Processing selection (if applicable)</td>
</tr>
<tr>
<td>Amber</td>
<td>• Alarm conditions</td>
</tr>
<tr>
<td></td>
<td>• Tripped status for switches</td>
</tr>
<tr>
<td></td>
<td>• De-energised substations</td>
</tr>
<tr>
<td></td>
<td>• Conditions preventing automatic operations of equipment such as control switches in the ‘Manual’ position or otherwise isolated</td>
</tr>
<tr>
<td></td>
<td>• Substations isolated by the operation of HV protection</td>
</tr>
<tr>
<td>Red</td>
<td>• Fault</td>
</tr>
<tr>
<td></td>
<td>• Danger status, such as closed switches</td>
</tr>
<tr>
<td>Blue</td>
<td>• Text for Auto / Manual</td>
</tr>
<tr>
<td></td>
<td>• Mode buttons that are currently in AUTO mode.</td>
</tr>
</tbody>
</table>
28.179 The SCADA system shall be configured as three streams (modules), which include:

a. Power Control and Monitoring System (PCMS)

b. Engineering Services

c. Central Emergency Power System (CEPS)

28.180 Several screens that are common to all the above modules include:

a. Main Menu

b. Logon

c. Events
d. Alarms

e. Trending

f. Reports

g. Administration Screen

Main Menu

28.181 The Main Menu shall provide links to each of the three modules.

- Power Control and Monitoring System (PCMS) Module
- Engineering Services Module
- Central Emergency Power Station (CEPS) Module

Logon Screen

28.182 Provide separate secure logon to each of the modules with multi-level access to different levels of each module.

28.183 Access to a module shall automatically expire if the interface remains unused for a preset period.

28.184 Passwords shall not automatically expire.

28.185 Logons, logoffs, alarm resets and control actions initiated while logged on shall be recorded in the event log.

Figure 28.6 – Logon Screen
Events

28.186 Refer to Section – Events and Alarms Organisation in this Chapter for details on what shall be displayed on this page.

Alarms

28.187 Refer to Section – Events and Alarms Organisation in this Chapter for details on what shall be displayed on this page.

Trending

28.188 Refer to Section - Trending in this Chapter for details on what shall be displayed on this page.

Reports

28.189 Refer to Section – Reporting in this Chapter for details on what shall be displayed on this page.

Administration Screen

28.190 Provide a screen that enables the Operator to add and delete users, and define their maximum access levels.

Power Control and Monitoring System (PCMS) Module

28.191 The PCMS module shall comprise the following typical SCADA screens:

HV Mimic Diagram

28.192 Display a mimic diagram of the HV supply system. The diagram shall be displayed on a single screen to provide a clear representation of all HV system elements, including the

a. CEPS,

b. Intake Switching Stations,

c. Primary Switching Stations, etc.

28.193 Selection of any HV system element buttons on the main HV screen shall link to individual power monitor screens for each of the locations.

28.194 The diagram shall incorporate dynamic elements providing a clear indication of HV switch position and metered load (Instantaneous Average Current) demand on each feeder at each intake switching station (ISSs) and primary switching station (PSSs) and each substation.

28.195 HV switchgear changes of state shall be logged.
28.196 Alarms shall be annunciated for:

a. HV switch or circuit breaker ‘tripped’ - HIGH level
b. HV switch or circuit breaker ‘out of service’ - LOW level

28.197 A detailed mimic diagram shall be provided displaying an individual distribution substation, intake switching station or primary switching station, with the power monitor window displayed on the left.

28.198 This window shall provide the details of, and readings from, the presently active power monitor.

28.199 The default power monitor is the substation power monitor. By clicking on an individual circuit box the values for that meter shall appear in the left window.

28.200 The status of the load shed device for each circuit shall be shown on the circuit line.

28.201 The status of the Auto / Manual switch for each load shed device and the SCADA Auto / Manual mode shall be shown as indicators directly above.

28.202 Clicking on a specific load shed device shall bring up a window which enables the SCADA mode for the device to be changed and the device to be manually operated.
Figure 28.8 – Substation Screen

Figure 28.9 – CEPS / ISS / PSS Screen
28.203 Graphical displays shall be provided for all electronic power meters for the following:

a. Display on page all meter interface system status information.

b. Status and details of communication links between the relevant PLC and power monitor.

c. Control MAXIMUM and MINIMUM meter register reset to zero.

d. Trend all real time and uploaded historical data in logical groups.

e. Display of trending graphs shall be selected from the ‘Power Monitor Selection & Trending’ page following selection of characteristics to be trended and time period of trend.

f. A graphical display is also to be provided to show all CEPS, PSSs, ISSs and substations as active buttons in a selection window.

g. Selection of characteristic and time period on each element will display a trending graph.

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**Figure 28.10 – Power Monitor Selection & Trending Screen**

![Power Monitor Selection & Trending Screen](image-url)
Load Shed Control Display – Figure 28.11

28.204 The PCMS Load Control Screen shall be configured as a list of all facilities on the Base as shown on the drawings on a scrolling screen, identified by:

a. Building Number.

b. Building Name.

c. Substation to which the facility is connected.

d. Load Group in Current Mode.

28.205 Functionality and features shall be provided on the Load Control Screen which includes:

a. Load group allocation (1 - 10) button, linked to a Load Group selection pop-up load group change box which shall allow re-allocation of a facility to another load group for either Mode 1 or Mode 2.

b. Load shed status feedback from load shed device.

c. Mode Selection button which enables / disables manual load shed buttons for control of individual buildings for each operational mode.

(1) In Auto mode load shedding shall be initiated by the CEPS GCS under its control of load groups.

d. Provision of manual control shed and connect buttons, accessible (enabled) only if the mode selection is set to manual.

(1) Confirmation pop-up boxes are to be provided to confirm intentional shed or connection of a facility.

e. Automatic (CEPS GCS) load control status for load group control is to be provided on the screen and displays the status of the load group (shed, connected or connect delay) for each of the Load Groups 1-10.

f. ‘CEPS Available Capacity’ is to be displayed on the screen to assist the Operator if manually reconnecting individual building loads from the PCMS SCADA system.

g. A button is to be provided for configuration of each Operational Mode (Mode 1 and Mode 2), using a 24 hour 7 day time schedule.

h. Facilities that do not have load shed control shall be provided with:

(1) Facility number.

(2) Facility name.

(3) ‘Greyed’ (disabled) inactive button indicating that the facility is not equipped with load shed control.
28.206 Provide features to enable single action printout of the list in the Load Group, Facility Number or substation number in ascending numerical order or Facility Name in Alphabetical Order.

- Figure 28.11 – Load Shed Control

Load Group Shed Control Display – Figure 28.12

28.207 The load group shed control screen shall display the status of all load groups, and load group control is to be provided only when the screen is enabled (GCS is in manual mode for that group) or the low level interface between the GCS and the PCMS is inoperative.

- Figure 28.12 – Load Group Shed Control
28.208 Additional facilities to be provided on this screen include:

a. ‘CEPS Available Capacity’ is displayed on the screen to assist the Operator if manually reconnecting load groups from the PCMS SCADA system.

b. Load group shed status.

c. Shed / Connect buttons for manual shedding and reconnection respectively of individual load groups.

d. Confirmation pop-up boxes are provided to confirm intentional shed of the load group.

**LEGS Screen – Figure 28.13**

28.209 Display a graphical diagram on a single page showing the status and enabling starting and stopping of each Local Emergency Generator Set (LEG) from the PCMS SCADA Operator Interface PC in the CEPS via on screen controls.

28.210 Note the LEGs are required to “run on” when the mains has failed and the CEPS is supplying the site.

28.211 LEGS control and monitoring changes of state shall be logged.

28.212 Alarms shall be provided for:

a. LEGS faults - HIGH level; and,

b. LEGS indications - LOW level.

![Figure 28.13 – LEGs Status & Control Screen](image-url)
PCMS Communications Network – Figure 28.14

28.213 The complete PCMS network communications status shall be displayed on a single display screen, to monitor the status of the communications between equipment.

28.214 HIGH level alarms shall be annunciated for PCMS Controller and/or communications failure in the PCMS network.

Engineering Services Module

28.215 The Engineering Services Module may be used to provide control and monitoring of selected site-wide services at the Defence base that do not have a SCADA or equivalent system and require alarming and event logging capabilities.

28.216 For example, these may include basic monitoring of frequency converters or pump stations.

Central Emergency Power Station (CEPS) Module

28.217 Where no SCADA system is provided for the CEPS Generator Control System (GCS), the CEPS module shall be provided to monitor the status of the Central Emergency Power Station including auxiliary support systems.

28.218 This module shall be interfaced to the CEPS Generator Control System (GCS) so that the SCADA is able to collect the required data, but is not able to control any aspect of CEPS operation.
28.219 A high level interface shall be provided between the GCS and PCMS SCADA system to facilitate transfer of signals and data to the PCMS SCADA CEPS module.

28.220 Graphical screens shall be provided for the following elements:

**CEPS Mimic Screen – Figure 28.15**

28.221 The CEPS Mimic screen shall display a mimic diagram of the CEPS Generator System.

28.222 Dynamic elements shall be incorporated to display the status of switchgear and instantaneous kW produced by individual generators.

28.223 Faults associated with the switchgear and the generators shall trigger a HIGH level alarm.

**Figure 28.15 – CEPS Mimic Screen**

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**Generator Status Screen – Figure 28.16**

28.224 The Generator Status screen shall display detailed status information regarding an individual generator, including various temperature readings, phase, voltage and kW information.

28.225 Faults associated with the generators shall trigger a HIGH level alarm.

28.226 Status messages, warnings and alarms specific to the particular generator shall also be displayed in the panel on this screen.
Auxiliary Systems

28.227 System mimic screens shall be provided to show status of major auxiliary systems including the fuel system and compressed air system that support operation of the CEPS.

Events and Alarms Organisation

28.228 The PCMS shall record the following for each event / alarm:

a. Time the event was registered at the PCMS Operator Terminal;

b. Time the event was registered at the relevant PLC (if applicable);

c. Facility Number;

d. Facility Name;

e. Event Description;

f. [For Alarms Only] Category of alarm; HIGH and LOW priority; and,

g. System (e.g. HV System, LV System, LEG, etc).

28.229 Inhibited alarms shall not be logged or transmitted; however, the PCMS shall record the event when alarms are inhibited or re-activated.
28.230 Depending on their status, alarms shall be displayed in a variety of standard colours.

28.231 High priority alarms that are:
   a. Active and unacknowledged shall be displayed in flashing red;
   b. Active and have been acknowledged shall be displayed in solid red;
   c. Inactive but have not been acknowledged shall be displayed in magenta.

28.232 Low priority alarms that are:
   a. Active and unacknowledged shall be displayed in flashing yellow;
   b. Active and have been acknowledged shall be displayed in solid yellow;
   c. Inactive but have not been acknowledged shall be displayed in green.

28.233 All events shall be displayed in white. Only an Operator with Level 2 or higher security access shall be able to acknowledge alarms.

28.234 Events and alarms shall be viewable in a sortable list and filtered based on the recorded element of the event / alarm.

28.235 All active and unacknowledged alarms shall be displayed on the standard alarm page in chronological order.

28.236 All alarms and events regardless of their status shall be displayed on the standard alarm summary page.

28.237 Both the alarm and alarm summary pages shall be accessible from every screen. The latest three alarms shall be displayed at the bottom of each screen.

28.238 Events and alarms shall be stored for a minimum of two years on the active system.

28.239 The system shall be supplied with sufficient backup media to store events and alarms for a minimum of five years.

Data Logging

28.240 Data logging implemented within the Operator Interface shall include both short- and long-term data and event logging.

28.241 Short-term data logging shall be logged at five-second intervals with data storage capacity of three months.

28.242 Long-term data logging shall be logged at 15-minute intervals and every 24 hour period with a data storage capacity of at least 12 months.

28.243 The short-term interval shall be configurable between a 1- and 60-second interval.
28.244 Every event shall be logged and time stamped. The event file shall have sufficient data storage capacity for four months.

28.245 Data logging and event recording shall be undertaken by the Primary Operator Interface.

28.246 In the event of its failure, the Secondary Operator Interface shall automatically take over this role.

28.247 Logged short-term data shall include the following analogue values read from the electronic power monitors:

   a. Instantaneous Phase Voltage (per phase);
   b. Instantaneous Average Voltage (across the 3 phases);
   c. Instantaneous Phase Current (per phase);
   d. Instantaneous Average Current (across the 3 phases);
   e. Instantaneous Average Thermal Current (across the 3 phases). If this parameter is not directly available from the power meter then it shall be calculated either by the local controller or the Operator Interface;
   f. Instantaneous Average Power Factor;
   g. Instantaneous Average Total Harmonic Distortion. If this parameter is not directly available from the power meter then it shall be calculated either by the local controller or the Operator Interface;
   h. Instantaneous Kilowatts;
   i. Instantaneous kVA; and,
   j. Instantaneous Total Accumulated kWh for today;

28.248 The average values for Voltage, Current, Thermal Current, Total Power Factor and Total Harmonic Distortion are the instantaneous average values read directly from each power monitor and should not be calculated by the PCMS Controllers or the Operator Interface.

28.249 The Instantaneous Total Daily Accumulated kWh value is the running total daily kWh value calculated by the PCMS Controllers.

28.250 Logged long-term data at 15-minute intervals shall include the following analogue values read from the electronic power monitors:

   a. Instantaneous Phase Voltage (per phase);
   b. Instantaneous Average Voltage (across the 3 phases);
   c. Instantaneous Phase Current (per phase);
d. Instantaneous Average Current (across the 3 phases);

(e) Instantaneous Average Thermal Current (across the 3 phases).

(1) If this parameter is not directly available from the power meter then it shall be calculated either by the local controller or the Operator Interface;

f. Instantaneous Average Power Factor;

g. Instantaneous Average Total Harmonic Distortion.

(1) If this parameter is not directly available from the power meter then it shall be calculated either by the local controller or the Operator Interface;

h. Instantaneous Kilowatts;

i. Instantaneous kVA; and,

j. Instantaneous Total Accumulated kWh for today;

28.251 The long-term data to be logged at 24 hour intervals shall include each of the following calculated analog values from each power monitor.

a. Daily Maximum kW;

b. Daily Maximum kVA; and,

c. Total Daily kWh.

28.252 The total daily kWh accumulation value shall be calculated by each PCMS Controller while the daily maximum value for kW and kVA are calculated by the SCADA system.

Trending

28.253 Trending of real time and historical data shall be available for the information collected by the power monitors.

28.254 Provision shall be made for up to eight trendable instantaneous characteristics to be displayed on each trend page; including information such as

a. Phase Voltages, Average (across 3 phases) voltage,

b. Phase Currents, Average (across 3 phases) Phase Current, Average (across 3 phases)

c. Thermal Current,

d. Average 3 Phase Power Factor,

e. Average 3 Phase total harmonic distortion,
f. total kW,
g. total kVA and
h. total kWh.

28.255 Options for the time span of the real time trends displayed shall include
   a. current day (00:00:00 to 23:59:59),
   b. current week (Sunday to Saturday) and
   c. current month (1st to 31st).

28.256 Time spans for the trends for the historical data shall include
   a. last day,
   b. last week, and
   c. last month options.

28.257 Each trend screen shall have a cursor that can be used to display the trend readings at for the selected time.

28.258 Provision shall be made for the operator to zoom in and out to view the trend in the necessary detail or a particular time period can also be selected.
28.259 A generalised user-definable trend page using the Operator Interface’s standard trend configuration setup shall also be provided allowing the operator to select a variety of up to eight trends from any substation power monitor variables for viewing on the same page.

**Reporting**

28.260 The report system to be implemented on the PCMS Operator Interface shall consist of selectable

- Daily,
- Weekly,
- Monthly (on a selectable date) and
- Yearly (on a selectable date) reports.

28.261 Reports shall be generated at midnight on the relevant day.

28.262 A blank user configurable report template shall also be included, which shall allow the Operator to select and assign different tag names and build their own reports.

28.263 Each report generated shall be stored in a Microsoft Excel file format and shall be stored on the Primary Operator Interface.

28.264 The reports to be generated shall include:

- System access to Levels 2 and 3, including user and the control actions taken.
- Energy consumption (kWh per period) by facility.
- Electrical Demands (maximum kVA per period).
- Alarms: The alarm, including the
  - (1) time of occurrence,
  - (2) the time of reset and
  - (3) the time the condition was corrected.
- Exceptions Report: Conditions which are outside the expected, such as:
  - (1) Alarms or events which are inhibited
  - (2) Auto / Manual switches which are in the Manual position
  - (3) Load shedding which is switched to the Manual mode at the Operator Interface
(4) Maximum demands that exceed the transformer capacity.

28.265 The system shall provide the facility to generate user-defined reports based on the following trigger mechanisms:

   a. Time / Date.
   b. On selected events.
   c. Manually initiated by the Operator.

28.266 User-defined reports shall enable the inclusion of all of the following:

   a. Selected data from the event log for any area, system, point type, absolute time window, time window relative to the present time and previous number of events, or any combination of these criteria.
   b. Selected data from the trend logs as for event log data.
   c. Facility load shed groups.

28.267 All reports shall include a header and footer that provide a description of the report, consecutive page numbers and the date printed.

EXECUTION, TESTING, COMMISSIONING AND HANDOVER

Execution

28.268 The PCMS Designer shall consider the following factors when designing a PCMS system:

   a. Rating plates and labels to all items of equipment and wiring;
   b. Fire safety;
   c. Master keying;
   d. Standardisation;
   e. Interchangeability;
   f. Corrosion protection;
   g. Ensure that any special tools shall be supplied; and,
   h. Minimise interruptions to electrical supply.

Inspection and Test Plans (ITPs)

28.269 The PCMS Designer shall prepare ITPs detailing the commissioning procedure to be applied to test and validate the control system.
28.270 ITPs shall be prepared for validation of all control and monitoring functions between the Operator Interface and each PCMS Controller location.

**Factory Acceptance Testing (FAT)**

28.271 All software shall be proven by simulation and factory testing to conform to the functional requirements before installation on site.

28.272 This includes testing of the Operator Interface and individual PCMS Controllers.

**Site Acceptance Testing (SAT)**

28.273 Site Acceptance Testing (SAT) shall be required to fully test the functionality of the PCMS, including all possible failure conditions, and demonstrate the correct performance and integration with all associated equipment and subsystems.

28.274 The SAT shall be terminated if defects and discrepancies are identified.

28.275 Recom mencement of the SAT (from the beginning) shall only occur after the outstanding items have been rectified and fully tested.

**Spare Parts**

28.276 At each site spare parts shall be provided for the PCMS.

28.277 The spare parts shall comprise as a minimum

a. one spare PCMS Controller processor,

b. four of each type of I/O module,

c. one of each type of PCMS Controller power supply and

d. sufficient consumable items (printer ink cartridges, printer paper, etc) for average operation of the system for a minimum of three years.

28.278 The spare hardware and consumables are to be labelled and boxed for long-term storage.

**TRAINING AND DOCUMENTATION**

**User / Maintenance Training**

28.279 The PCMS Designer shall ensure that sufficient training on the operation and routing maintenance of all installed equipment is provided for, including the provision of all manuals, videos and notes.

28.280 Each system shall be fully demonstrated covering all aspects of

a. use,
b. programming and operation of the plant and equipment and
c. of maintenance procedures,
d. and shall be run after all commissioning tests have been completed.

28.281 Training shall be run at two levels:
   a. (1) Operator / Maintenance and
   b. (2) Engineer Training.

28.282 Operator Training shall include all aspects of the operation of the system as specifically configured for the site including:
   a. Custom built displays and controls;
   b. Operator Interface software package;
   c. All trend, report and log configuration and output;
   d. Login;
   e. Navigate through the system;
   f. Acknowledge alarms;
   g. Select alarmed screens;
   h. Display or print variables using pre-configured reports or trends;
   i. Printer control;
   j. Set point adjustment;
   k. Manual system control;
   l. Undertake periodic backup to disk;
   m. Report, trend and graphics configuration;
   n. Report event or time of day triggering; and,
   o. Other spreadsheet, database and programming related exercises.

28.283 Engineer Training shall include all other aspects of system operation including:
   a. All software backup and loading
   b. Control software modification
   c. Configuration of the Operator Workstation
d. Hardware fault finding down to circuit board or module level

As-Constructed Documentation / Drawings

28.284 Detailed drawings shall be prepared covering the whole of the PCMS.

28.285 Generally, drawings shall be

a. of A3 size,

b. include a drawing scale and

c. shall be prepared to a professional standard in accordance with the relevant Australian, IEC or International (ISO) Standards.

28.286 Drawings shall include sufficient Manufacturers’ detail or serial number of all plant / equipment to facilitate the ordering of replacement parts.

28.287 Drawings of assemblies of mechanical and electrical plant / machines shall include, at a minimum:

a. Overall dimensions and mass (including the mass of the heaviest lift for maintenance;

b. Finished sizes and tolerances of all wearing parts;

c. Terminal point details;

d. Expansion limits;

e. Lubrication points;

f. Minimum clearances;

g. Welding preparation and procedures;

h. Where plant or plant items subject to pressure and temperatures higher than ambient:

(1) Design pressures and temperatures;

(2) Working pressures and temperatures;

(3) Test pressures and temperatures;

i. Insets, where necessary, to ensure every item of the assembly is clearly shown;

j. All points of support;

k. All points of attachment of the plant to piping, conduits or other items supplied by others; and,
28.288 Electrical schematics shall be drafted in accordance with AS / NZS 1102 and shall include, at a minimum:

   a. Ammeter scales and current transformer ratios;
   b. Circuit breaker and fuse current ratings;
   c. Ratings of capacitors, resistors and any other electrical devices;
   d. A short name description of each relay, timer or control device to describe its operation;
   e. A cross-reference system that indicates where each contact for a relay or timer is located. The system may include sheet and line numbers;
   f. Switchboard drawings including layouts and construction details and panel wiring diagrams;
   g. Single line diagrams;
   h. Items shall be designated as per AS 3702;
   i. All field wiring diagrams;
   j. Overall system diagrams of communication systems, showing terminal strip allocation.
   k. Cable types and system components; and
   l. Block cabling diagrams with detail frame allocation and terminals.

28.289 Once works are completed on site, final copies of the drawings as amended during construction shall remain on site.

Operation & Maintenance Manuals

28.290 The Operation & Maintenance Manuals shall be compiled by people experienced in the maintenance and operation of equipment and systems installed, and with editorial ability.

28.291 Include referenced documentation or technical sections where required in the operation and maintenance manuals.

28.292 The Manuals shall generally be

   a. A4 size,
   b. loose leaf in commercial quality ring binders with hard covers,
   c. indexed,
d. divided and
e. titled.

28.293 Fold drawings to A4 size using a ‘Z’-fold and insert them in the binders such that they be unfolded without being detached from the rings.

28.294 Include

a. three electronic copies of the manuals on DVD(s) with the text in Microsoft Word 2003 format (.doc),
b. as-installed drawings in both AutoCAD 2004 (.dwg) and Adobe Acrobat (.PDF, ISO 32000-1:2008) format, and
c. copies of all PCMS Controller and Operator Interface software, including any custom software.

Contents

28.295 The Manuals shall include the following information at a minimum:

a. Drawings and technical data;
b. Names, addresses, and telephone and facsimile numbers of principal consultant, sub-consultants, contractor, subcontractors and names of responsible parties;
c. Equipment descriptions, including manufacturer and supplier details and catalogue list numbers;
d. Operation procedures with manufacturers' technical literature as appropriate;
e. Installation description;
f. Technical description of the systems installed, written to ensure that the maintenance personnel fully understand the scope and facilities provided. Identify function, normal operating characteristics, and limiting conditions;
g. Technical description of the mode of operation of the systems installed;
h. Maintenance procedures including preventative maintenance frequency and procedures for trouble-shooting, repair and re-assembly, cleaning and alignment; and,
i. Manufacturers' warranties.
Software Documentation

28.296 The Manuals shall include a separate section for software documentation for the systems provided, including the following:

a. A full description of the control system software operation.

b. A full description of the hardware configuration, user memory size, memory used, firmware version, hardware versions

c. Manufacturers’ documentation and original disks for all operating system, diagnostic, driver, programming and operator interface software.

d. Description of Operation of the User Interface in each location.

e. Support documents including logic charts for all custom or job specific software.

f. High quality laser printed source code listing with full explanatory comments for all custom or job specific software.

g. Source code listings for all custom or job specific software on CDs.

h. A fully labelled set of backup disks.

i. All software documentation and removable media copies including dates, version and serial numbers are to be listed in the Operation and Maintenance Manuals.