



Assets Delivery Group
| Engineering

DESIGN STANDARD DS 28

Water and Wastewater Treatment Plants - Electrical

VERSION 1
REVISION 7

JANUARY 2018

FOREWORD

The intent of Design Standards is to specify requirements that assure effective design and delivery of fit for purpose Water Corporation infrastructure assets for best whole-of-life value with least risk to Corporation service standards and safety. Design standards are also intended to promote uniformity of approach by asset designers, drafters and constructors to the design, construction, commissioning and delivery of water infrastructure and to the compatibility of new infrastructure with existing like infrastructure.

Design Standards draw on the asset design, management and field operational experience gained and documented by the Corporation and by the water industry generally over time. They are intended for application by Corporation staff, designers, constructors and land developers to the planning, design, construction and commissioning of Corporation infrastructure including water services provided by land developers for takeover by the Corporation.

Nothing in this Design Standard diminishes the responsibility of designers and constructors for applying the requirements of WA OSH Regulations 1996 (Division 12, Construction Industry – consultation on hazards and safety management) to the delivery of Corporation assets. Information on these statutory requirements may be viewed at the following web site location:

https://www.slp.wa.gov.au/legislation/statutes.nsf/law_s4665.html

Enquiries relating to the technical content of a Design Standard should be directed to the Senior Principal Engineer, Electrical Engineering, Electrical Design Standards, Engineering. Future Design Standard changes, if any, will be issued to registered Design Standard users as and when published.

Head of Engineering

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REVISION STATUS

The revision status of this standard is shown section by section below. It is important to note that the latest revisions including additions, deletions and changes to this version of the standard are also identified by the use of a vertical line in the left hand margin, adjacent to the revised section.

REVISION STATUS						
SECT.	VER./REV.	DATE	PAGES REVISED	REVISION DESCRIPTION (Section, Clause, Sub-Clause)	RVWD.	APRV.
1	0/0	23.05.05	All	New Version	CW	AAK
1	1/3	30.08.11	14-15	1.1, 1.3, 1.4, 1.6, 1.7 revised	NHJ	AAK
1	1/4	30.06.12		1.4 revised ((EXAMPLE))	NHJ	SE
1	1/7	10.01.18		1.4, 1.5, 1.8 revised	NHJ	MSP

2	0/0	23.05.05	All	New Version	CW	AAK
2	1/3	30.08.11	17	2.1, 2.2 revised	NHJ	AAK
2	1/6	31.05.17	20, 21	2.4.4 removed, 2.5.2 revised	NHJ	MSP
2	2/7	10.01.18		2.2, 2.4.4 revised	NHJ	MSP

3	0/0	23.05.05	All	New Version	CW	AAK
3	1/0	30.06.06	22	3.2.1, 3.2.2 revised	NHJ	AAK
3	1/0	30.06.06	24	3.3.5 revised	NHJ	AAK
3	1/2	02.06.09	23	3.4.2 revised	NHJ	AAK
3	1/3	30.08.11	28, 34	3.6.4, 3.9.2	NHJ	AAK
3	1/5	30.07.13	34	3.9.2 revised	NHJ	MH
3	2/7	10.01.17		3.3.1, 3.3.2, 3.3.5, 3.6.4 revised 3.3.5 new 3.10 new (previously 3.3.5)	NHJ	MSP

4	0/0	23.05.05	All	New Version	CW	AAK
4	1/1	30.04.07	35	4.1, 4.2 revised	NHJ	AAK
4	2/7	10.01.17		4.3 new	NHJ	MSP

5	0/0	23.05.05	All	New Version	CW	AAK
5	1/2	02.06.09	34	5.2 revised	NHJ	AAK
5	1/3	30.08.11	39	5.1, 5.2	NHJ	AAK

6	0/0	23.05.05	All	New Version	CW	AAK
6	1/1	30.04.07	37	6.1, 6.2 revised	NHJ	AAK

7	0/0	23.05.05	All	New Version	CW	AAK
7	1/1	30.04.07	38	7.1, 7.2 revised	NHJ	AAK

8	0/0	23.05.05	All	New Version	CW	AAK
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9	0/0	23.05.05	All	New Version	CW	AAK
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REVISION STATUS						
SECT.	VER./REV.	DATE	PAGES REVISED	REVISION DESCRIPTION (Section, Clause, Sub-Clause)	RVWD.	APRV.
10	0/0	23.05.05	All	New Version	CW	AAK
10	1/1	30.04.07	39	10.1,10.3,10.4 included	NHJ	AAK
10	1/2	02.06.09	39, 40	10.2, 10.3, 10.9 revised	NHJ	AAK
10	1/3	30.08.11	44	10.4, 10.5, 10.6, 10.7 revised	NHJ	AAK
10	1/6	31.05.17	43, 44	10.8 revised, 10.9 removed	NHJ	MSP
10	2/7	10.01.18		10.2, 10.3, 10.4 revised 10.9, 10.10 new	NHJ	MSP

11	0/0	23.05.05	All	New Version	CW	AAK
11	1/3	30.08.11	46	11.3, 11.5 revised	NHJ	AAK
11	2/7	10.01.17		11.1 revised	NHJ	MSP

12	0/0	23.05.05	All	New Version	CW	AAK
12	1/6	31.05.15	46	Heading changed	NHJ	MSP

13	0/0	23.05.05	All	New Version	CW	AAK
13	1/2	02.06.09	43	13.1, 13.2, 13.3 revised	NHJ	AAK
13	1/5	30.07.13	49	13.5 revised	NHJ	MH

14	0/0	23.05.05	All	New Version	CW	AAK
14	1/3	30.08.11	51	14.3 revised	NHJ	AAK
14	2/7	10.01.18		14.4 revised	NHJ	MSP

15	0/0	23.05.05	All	New Version	CW	AAK
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16	0/0	23.05.05	All	New Version	CW	AAK
16	1/6	31.05.17	56 - 59	New	NHJ	MSP
16	2/7	10.01.18		16.1.4 revised 16.3 new	NHJ	MSP

17	0/0	23.05.05	All	New Version	CW	AAK
17	1/6	31.05.17	60 - 61	New	NHJ	MSP
17	2/7	10.01.18		17.1.2, 17.1.3, 17.2, 17.3 revised	NHJ	MSP

18	0/0	23.05.05	All	New Version	CW	AAK
18	1/2	02.06.09	55, 56, 60	18.2.1.1, 18.4.2 revised	NHJ	AAK
18	1/3	30.08.11	61 – 63	18.1.2.7, 18.2.1.1, 18.2.3 revised	NHJ	AAK
18	1/6	31.05.17	61	Moved into Appendix, Sec 1	NHJ	MSP

19	0/0	23.05.05	All	New Version	CW	AAK
19	1/6	31.05.17	62 - 72	Moved into Appendix 1 Sec2 and revised; Sec 2.4.3 new	NHJ	MSP

20	0/0	23.05.05	All	New Version	CW	AAK
20	1/6	31.05.17	73 - 81	Moved into Appendix 1 Sec3 and revised	NHJ	MSP

21	0/0	23.05.05	All	New Version	CW	AAK
21	1/3	30.08.11	89	21.6.1 revised	NHJ	AAK
21	1/6	31.05.17	82 - 85	Moved into Appendix 1 Sec4 and revised	NHJ	MSP

22	0/0	23.05.05	All	New Version	CW	AAK
22	1/0	30.06.06	80	22.1 revised	NHJ	AAK
22	1/6	31.05.17	86 - 93	Moved into Appendix 1 Sec5 and revised	NHJ	MSP

23	0/0	23.05.05	All	New Version	CW	AAK
23	1/6	31.05.17	94 - 95	Moved into Appendix 1 Sec6 and revised	NHJ	MSP

24	0/0	23.05.05	All	New Version	CW	AAK
24	1/6	31.05.17	96 - 100	Moved into Appendix 1 Sec7 and revised	NHJ	MSP

25	1/6	31.05.17	101 - 102	Moved into Appendix 1 Sec8 and revised	NHJ	MSP
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App 1	2/7	10.01.18		2.2.1.1, 3.2.2, 3.3.2, 4.1.1, 4.3, 5.5, 6.4.2, 6.6, 7.2.1, 7.2.2, 7.3.1, 7.3.2, 7.4.2, 7.4.3, 7.5.1, 7.5.2, 8.1.2, 8.1.3, 8.3, 8.4, 8.5, 8.6 revised	NHJ	MSP
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Water and Wastewater Treatment Plants - Electrical

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1 INTRODUCTION

1.1 Purpose

The Water Corporation has adopted a policy of out sourcing most of the electrical engineering and electrical detail design associated with the procurement of its assets. The resulting assets need to be in accordance with the Corporation's operational needs and standard practices. This design standard (i.e. Electrical Design Standard DS28) sets out design standards and engineering practice which shall be followed in respect to the design and specification of electrical parts of major and minor treatment works being acquired by the Corporation. This design manual does not address all of the issues which will need to be addressed by the Designer in respect to a particular treatment works.

It is the Water Corporation's objective that its assets will be designed so that these have a minimum long term cost and are convenient to operate and maintain. In respect to matters not covered specifically in this manual, the Designer shall aim his/her designs and specifications at achieving this objective.

This design standard is intended for the guidance of electrical system designers. It is not intended as a type specification for equipment or installation work and shall not be quoted in specifications (including drawings) for the purpose of purchasing electrical equipment or electrical installations except as part of the prime specification for a major design and construct contract.

1.2 Scope

This design standard covers in detail aspects of electrical design which are particular to water and wastewater treatment plants. It provides cross references to other Corporation design standards in respect to those electrical design aspects which are common to both treatment plants and pump stations.

1.3 Use of Type Specifications and Corporation Standard Designs

The Type Specifications in the DS26 series cover many of the items of equipment commonly used in Treatment Plants. The Designer shall use the DS26 Type Specifications for the purchase of equipment where applicable. Where an applicable Type Specification does not exist, the Designer shall prepare an appropriate specification based on this design standard (i.e. Electrical Design Standard DS28).

The Corporation has prepared standard circuit designs and standard PLC logic designs and these are included in Corporation drawing sets FS00 and FS01. The Designer shall make use of these standard designs wherever practical.

1.4 References

Reference should be made also to the following associated design standards:

DS 20	Design Process for Electrical Works
DS 21	Major Pump Stations - Electrical
DS 22	Ancillary Plant and Minor Pump Stations - Electrical
DS 23	Pipeline AC Interference and Substation Earthing
DS 24	Electrical Drafting
DS 25	Electronic Instrumentation
DS 26	Type Specifications – Electrical

DS 29	Arc Flash Hazard Assessment of Switchgear Assemblies
FS00	Water Corporation Electrical Standard Drawings FS00 Series
MN01	Water Corporation Electrical Standard Drawings - Small Pump Stations - MN01 planset Series
HA-ST-02	EEHA Hazardous Area Classification Manual
HA-ST-03	EEHA Selection and Installation Manual
HA-ST-04	EEHA Competency Manual

1.5 Definitions

Asset Manager:	the Corporation officer responsible for the operation of the asset being acquired
Corporation:	the Water Corporation (of Western Australia)
Designer:	the consulting engineer carrying out the electrical design
Design Manager:	the Corporation officer appointed to manage the project design process
Network Operator:	the supply authority controlling the operation of the electrical supply network
Small Treatment Plants:	site having an installed duty transformer capacity rated at ≤ 315 kVA
Medium Treatment Plants:	site having an installed duty transformer capacity rated at > 315 kVA and ≤ 2 MVA
Major Treatment Plants:	site having an installed duty transformer capacity rated at > 2 MVA
Senior Principal Engineer:	Senior Principal Engineer, Electrical Engineering, Electrical Standards Section, Engineering Branch, Water Corporation

1.6 Standards

- (a) Electrical installations shall be designed in accordance with the latest edition of AS 3000 and except where specified otherwise in this design standard, treatment plant electrical design shall be carried out in accordance with the latest edition of all other relevant Australian Standards. In the absence of relevant Australian Standards, relevant international, other national, or industry standards shall be followed.
- (b) Except where a concession is obtained from Energy Safety, electrical design shall be in accordance with the W.A. Electrical Requirements Manual (WAER) produced by the Energy Safety Division (EnergySafety) of the Department of Consumer & Employment Protection.
- (c) Except where a concession is obtained from the Supply Authority, the electrical design of all installations to be connected to the Supply Authority system shall be designed in accordance with their requirements. Such requirements include the Western Australian Distribution Connection Manual and the Technical Rules for the South West Interconnected Network published by Western Power.
- (d) All electrical equipment which incorporates electronic switching or electronic measuring circuits shall be specified to be in accordance with the European standards IEC 61000-6-4 and

IEC 61000.6.2 for Electromagnetic Emissions and Immunity respectively. In addition all such equipment shall be specified to have been approved by the Australian Communications Authority in respect to Electromagnetic Compatibility.

- (e) Electrical installations shall be designed in accordance with the requirements of the Water Corporation's HA-ST-03: EEHA Selection and Installation Manual.

1.7 Electrical Safety

Electrical installations shall be designed to facilitate the safe operation and maintenance of electrical plant.

In respect to High Voltage equipment, mechanically and/or key interlocked isolating switches, earthing switches and access doors shall be employed wherever practical so as to prevent access to live conductors. In instances where interlocking is not practical, High Voltage isolating and earthing switches and access doors shall be fitted with the Water Corporation's EL1 series locks.

In respect to Low Voltage equipment, mechanically and/or key interlocked isolating switches and access doors shall be employed so as to prevent access to live conductors wherever it is practical and economical to do so. Where the latter is not the case, doors providing access to live conductors shall be fitted with the Water Corporation's EL2 equivalent series locks (Bilock).

All electrical equipment shall be adequately rated for the electrical fault level at the site so as to prevent injury to personnel in the event of a major electrical fault.

1.8 Mandatory Requirements

In general the requirements of this standard are mandatory. If there are special circumstances which would justify deviation from this standard, the matter shall be referred to the Senior Principal Engineer for his consideration. No deviation from the requirements of this standard shall be made without the written approval of the Senior Principal Engineer.

It is a requirement of the Corporation that the following QA systems be applied by electrical equipment manufacturers and electrical installers.

1.9 Quality Assurance

Suppliers of major electrical equipment (such as transformers, motors, variable speed controllers, switchgear, switchboards, instrumentation system) shall supply only equipment from a manufacturer who has in place a Quality Management System certified by an accredited third party to AS/NZS 9001:2000, or an approved equivalent.

1.10 Installers

Installers of major electrical equipment (such as transformers, motors, variable speed controllers, switchgear, switchboards, instrumentation system) shall have in place a Quality Management System certified by an accredited third party to AS/NZS 9001:2000 (excluding clause 7.3 Design & Development), or an approved equivalent.

1.11 Acceptance Tests

In tender documents in which acceptance tests are specified, the cost of providing works tests (including associated test certificates) and site tests (including associated test certificates) shall be shown as separate items in the Bill of Quantities so that it can be verified that sufficient funds have

been allowed to carry out such testing and it is clear that works tests and site tests are separable and critical deliverables.

2 BASIS OF DESIGN

2.1 General

The design of the treatment plant shall be carried out in accordance with:

- (a) The Corporation's Design Process for Electrical Works (DS20),
- (b) This Design Standard (DS28), and
- (c) The Corporation's design brief.

The Corporation's Design Standards set out the general standards and practices to be followed for all projects. However in the course of design of a particular treatment plant design data are accumulated, decisions are made and guidelines are developed which are specific to that treatment plant and which are not necessarily covered in detail in the Design Standards.

Such decisions shall be recorded, reviewed and incorporated into the project design management system as described hereunder.

2.2 Basis of Design Document

As an initial task the Designer shall develop a Basis of Design Document which shall record the design information which is specific to the particular treatment plant and shall keep this document up to date as a reference document for reviewers, detail design staff and designers from other disciplines. The Basis of Design Document shall form the basis for the preparation of the Concept Design Report and the Engineering Summary Report required under Corporation's Design Process for Electrical Works (DS20).

Since the electrical, instrumentation and control engineering design associated with treatment plants must proceed to some extent in conjunction with the process design, it is recognised that not all information may be available and not all design decisions may have been made at this early stage.

Consequently, in order to maintain adequate control of the design, it is important that the Designer maintain the Basis of Design as a living document for the duration of the design as specified above.

The Basis of Design Document shall be submitted to the Design Manager for approval at the first draft stage and following each major revision.

For major projects the electrical, control and instrumentation Basis of Design may form part of an overall project Basis of Design document.

The Basis of Design Document shall include the following items:

- (a) A brief outline of the scope of work,
- (b) Specific definitions and abbreviations,
- (c) Specific details of site conditions, including environmental conditions, isokeraunic level and details of any specific constraints,
- (d) Details of power supply to the site (source, voltage, fault levels, etc.) and estimates of power demand,

- (e) Decisions regarding locations and types of transformers, cabling, switchgear, switchboards, earthing systems, types and voltages of motors and variable speed controllers,
- (f) Process control system architecture and hardware, data communication methods and field instrument types,
- (g) Decisions regarding classification of hazardous areas and types of hazardous area equipment to be used (in accordance with the requirements of HA-ST-02: EEHA Hazardous Area Classification Manual and HA-ST-03: EEHA Selection and Installation Manual),
- (h) Decisions regarding lighting, paging, communication, fire and security systems,
- (i) Details of any departures or exemptions from the Corporation's Design Standards that have been approved by the Senior Principal Engineer and
- (j) Decisions arising from discussions with operators, maintenance staff and other stakeholders.

2.3 Environmental Conditions

The electrical engineering design shall be based on green field site environmental conditions determined as follows:

- (a) Maximum ambient temperature - the maximum monthly average daily maximum outside temperature for the site as published by the Commonwealth Bureau of Meteorology,
- (b) Maximum humidity - the maximum monthly average index of humidity for the site as published by the Commonwealth Bureau of Meteorology,
- (c) Isokeraunic Level - as shown for the site on the Average Thunder Day Map published by the Commonwealth Bureau of Meteorology,
- (d) Corrosion Environment - the ISO environmental corrosion category for the site as defined in AS/NZS 2312,
- (e) Airborne dust pollution level - severe, moderate, or low as determined for the site bearing in mind proposed operations and future developments,
- (f) Altitude - site mean height above sea level.

Except for air conditioned spaces, the environmental conditions at the various locations around the treatment plant will be more severe than the values determined above and shall be estimated on the basis of the above values depending on the particular location.

In wastewater treatment plants particular attention shall be paid to equipment to be located in areas in which traces of hydrogen sulphide (H_2S) gas may be present.

Within buildings, sun loading and heat losses from energy conversion equipment (including switchgear) will raise the local temperature above outside shade ambient temperature. In such cases ventilation or air conditioning shall be provided to ensure that internal room temperatures do not exceed 45°C.

Air filtering may be required to reduce to acceptable values the levels of airborne contaminants including poisonous and/or corrosive gases. If such is the case, filters shall be arranged to facilitate convenient maintenance.

2.4 P&ID's and Equipment Lists

The Designer's first task shall be to review the initial conceptual P&ID and in conjunction with the process, chemical and mechanical designers to develop and expand the P&ID details. From these the Designer, in conjunction with the mechanical designer, shall prepare the following lists on which the electrical engineering design shall be based. As a minimum the lists shall include the details in sections 2.4.1 to 2.4.4 below. Additional information shall be included as necessary to ensure that the equipment selected is appropriate to the specific process requirements and environmental conditions.

2.4.1 Mechanical Equipment List

Preparation of the mechanical equipment list is primarily the responsibility of the mechanical Designer. However the electrical Designer shall ensure that the list contains at least the following information and that equipment is correctly numbered in accordance with this Design Standard:

- (a) Plant area
- (b) Unique equipment number
- (c) Equipment name and description
- (d) Date and revision details

And for electrically-driven equipment:

- (e) Supply voltage
- (f) Rated load (kW)
- (g) Actual load (kW)
- (h) Duty (continuous, intermittent, standby)
- (i) Starter type, and whether fixed or variable speed

2.4.2 Valve List

Preparation of the valve list is the responsibility of the hydraulic, process or mechanical designer. However the electrical Designer shall ensure that the list contains at least the following information and that equipment is correctly numbered in accordance with this Design Standard:

- (a) Plant area
- (b) Unique valve number
- (c) Valve name and description
- (d) Fluid
- (e) Valve size and type
- (f) Actuator details (if applicable)
- (g) Position transmitter and position switch details (if applicable)
- (h) Date and revision details

2.4.3 Electrical Equipment List

The Designer shall develop the electrical equipment list from the mechanical equipment and valve lists, with the addition of non-mechanical equipment such as lighting and small power, UPS's, transformers, switchboards, distribution boards and the like. The list shall contain at least the following information:

- (a) Plant area
- (b) Unique equipment number
- (c) Equipment name and description
- (d) Supply voltage and no. of phases
- (e) Rated load (kW)
- (f) Actual load (kW)
- (g) Duty (continuous, intermittent, standby)
- (h) Starter type (if applicable)
- (i) Number of PLC inputs and outputs required
- (j) Switchboard from which supplied

The designer shall use the electrical load list as a basis for estimating loads and maximum demands for each switchboard and for the treatment plant as a whole. (This can be done conveniently by creating the electrical load list as a database or spreadsheet with automatic calculation of load subtotals and totals, taking power factor into account.)

2.4.4 Maintenance of Lists

The Designer shall ensure that all lists are kept up to date throughout the project up to completion of commissioning. This requires implementation of strict project controls and close liaison between designers of all disciplines; serious problems may arise if uncontrolled changes are allowed to occur.

On a major project maintenance of lists may be a significant task

2.5 Equipment Numbering Systems

2.5.1 Mechanical and Electrical Equipment Numbering

Mechanical and electrical equipment numbers shall be allocated according to Section 4 of the Corporation's "DS80 WCX Manual". The general format for equipment numbers is CC{C} aannn, where:

- (a) CC{C}, the equipment type code, represents two or three letters selected from Section 4 of the DS80 WCX Manual which identify the type of equipment;
- (b) aa represents the two-digit process area number from Section 4 of the DS80 WCX Manual;
- (c) nnn is a sequential 3-digit equipment number. For new plants the equipment numbers should start from 001 in each process area.

For example, "PU 15002" might be the second raw water pump in area 15 (raw water pump station). "BS 22001" might be the first bar screen at the inlet works of a wastewater treatment plant.

As a general rule each sequential 3-digit equipment number shall be used only once within each process area; for example the number "CP 15002" shall not be used for an air compressor in a raw water pump station if one of the raw water pumps has already been numbered "PU 15002".

The exceptions to this rule are:

- (i) Motors shall be numbered as for their driven equipment. For example, "MV 15002" is the variable-speed motor associated with raw water pump "PU 15002".
- (ii) Variable speed controllers and local control stations shall be numbered as for their associated motors.

Where there is more than one motor associated with an item of equipment (such as a blower drive motor with an electrically-driven lube oil pump), the ancillary motors shall be identified with the suffix A, B, C etc. For example MF 42004A could be the drive for a lube oil pump associated with blower motor MF 42004.

2.5.2 Existing Treatment Plants

Guidelines for work on existing treatment plants are given in section 17.

3 ELECTRICITY SUPPLY

3.1 Energy Supply Agreement

For major treatment plants, the Corporation may wish to consider purchase of energy from an electrical power supplier other than the local Network Operator. Negotiations in this respect will be carried out by the Corporation itself. However to assist the Corporation in this regard, the Designer shall carry out preliminary assessments of:

- (a) Expected maximum demand power requirements stage by stage,
- (b) Expected load versus time of day profile including an assessment of any power export from embedded generation, and
- (c) Date by which power supply is expected to be required.

3.2 Connection to Electrical Supply Network

3.2.1 Incoming Supply Arrangements

- (a) Electrical supply from a Network operator's network directly to treatment plant installations having a maximum power demand of not greater than 315 kVA may be taken at Low Voltage with the Network Operator metering being at Low Voltage and the associated transformers and primary side High Voltage switchgear being Network Operator owned.
- (b) Electrical supply from a Network Operator's network direct to treatment plant installations having a maximum power demand of greater than 315 kVA shall be taken at High Voltage with the Network Operator metering being at High Voltage and the associated transformers and primary side High Voltage switchgear being Corporation owned.

Sole use transformers owned by the Network Operator shall not be used if the treatment plant maximum power demand is greater than 315 kVA.

In country areas where the supply to the treatment plant site is via High Voltage overhead lines, the Network Operator metering unit may be aerial type external to the treatment plant site depending on Network Operator preference. Otherwise the Corporation's main High Voltage switchboard shall incorporate the Network operator's metering unit and one or two Network operator isolating switches, the latter depending on whether one or two Network Operator incoming cables are to be provided.

The Corporations main incoming High Voltage switchboard shall be of the indoor type located in a separate dust free switch room or in a proprietary weatherproof and dust free kiosk enclosure.

3.2.2 Initial Connection Enquiries

Early in the design process following an agreement for the supply of electrical energy the Designer shall reach an understanding with the Network Operator as to the likely conditions of connection to the electrical supply network. Initial information to be provided to the Network Operator shall include;

- (a) Expected maximum demand power requirements,

- (b) Expected load versus time of day profile including an assessment of any power export from embedded generation,
- (c) Whether sole use transformer is required (only if supply ≤ 315 kVA),
- (d) Required supply voltage,
- (e) Maximum motor size
- (f) Types of drives,
- (g) Size and type of any expected embedded generation, and
- (h) Date by which power supply is expected to be required.

3.2.3 Information Required Initially from Network Operator

In making the initial submission to the Network Operator, the Designer shall request the following information:

- (a) The minimum and maximum fault levels at the site,
- (b) The minimum and maximum source impedances at the site,
- (c) Any required variations from the Network Operator's published Specific Requirements (including power factor requirements),
- (d) Any required special protection requirements,
- (e) Details of the available tariff options,
- (f) The location and type of Network Operator's metering unit,
- (g) The date connection could be made to the electrical supply network,
- (h) The cost of connection.

3.3 Incoming High Voltage Electricity Supply

3.3.1 Point of Attachment

Generally for major treatment plants the incoming supply to the site will be at 22 kV or 33 kV and thus higher than can be used directly for drives within the treatment plant. Often a major treatment plant will have load spread over a relatively large area so that it will be desirable to distribute power over the site at the supply voltage. In such cases it will be necessary to use step down transformer substations at various locations within the treatment plant complex. Nevertheless the Corporation's point of attachment to the incoming electrical supply distribution network will be at the location where the supply enters the site and the High Voltage distribution system on the load side of that point will be the Corporation's responsibility.

3.3.2 Metering and Incoming Isolators

- (a) The Network Operator's metering will be at the incoming supply voltage and may consist of either an external pole mounted metering unit (i.e. potential and current transformers) or may be an internally mounted metering unit. If an internally mounted metering unit is to be used, the Network Operator's metering unit and line side isolating switch shall be mounted integral with the primary supply voltage switchboard.
- (b) For critical or major treatment plants two feeders from the incoming electrical supply distribution network should be obtained if this is possible. If two feeders are provided, each feeder shall be connected to the switchboard via separate Network Operator controlled isolators connected in parallel to the line side of the Network Operator's metering unit. If a second incoming feeder is not available initially space shall be provided for the addition of a second incoming isolator on the line side of the Network Operator's metering unit.
- (c) Metering data shall be fed into the Plant Control System (PCS). As a minimum, the following data shall be provided:
 - Instantaneous power consumption
 - Instantaneous kVA
 - Tariff

3.3.3 Surge Protection

- (a) Suitably rated surge diverters shall be installed so as to provide overvoltage protection to the incoming High Voltage switchboard.
- (b) If there is only a single main circuit breaker, the above surge diverters shall be installed directly onto the High Voltage bus bars on the line side of the main circuit breaker.
- (c) If there are multiple main circuit breakers, the above surge diverters shall be installed onto the load side of the main switchfuse controlling the local auxiliary supply transformer

3.3.4 Incoming Feeder Ratings

- (a) It is an additional specific requirement of Western Power that no single High Voltage main switchboard connected to the Western Power normal High Voltage distribution network be rated greater than 4 MVA.
- (b) Consequently within a particular treatment plant with a total electrical load $> 4 \text{ MVA}$, $\leq 8 \text{ MVA}$, the loads will have to be distributed across two incoming main switchboards.
- (c) Both such switchboards are required to have two incoming isolators on the line side of the switchboard metering unit. Western Power will provide a separate feeder to each switchboard and reserve the right to parallel the two switchboards using a Western Power cable inter connecting the second incoming isolator on each switchboard. However, paralleling of the two switchboards within the Corporation's distribution system is not permitted.

3.3.5 Point of Common Coupling

The point on the network where Corporation assets associated with a connection point are connected to primary network assets that are shared with other Users. For Corporation assets this is usually the line side of the Corporation's incoming High Voltage equipment.

3.4 High Voltage Distribution

3.4.1 General

- (a) All of the Corporation's High Voltage distribution on the treatment plant site shall be underground cable type and High Voltage switchgear shall be indoor type suitably enclosed.

The use of overhead line mounted recloser switchgear shall not be permitted, neither shall the use of air insulated and/or air break switchgear be permitted within the treatment plant High Voltage distribution system,

- (b) The High Voltage distribution system may be of the radial or the open ring main type. If the open ring main type of distribution is used, interlocking shall be provided to prevent closure of the ring main.

If an open ring main system is used in conjunction with two incoming High Voltage switchboards, operational procedures shall be put in place to ensure that ring main switching does not result in the load on either switchboard exceeding 4 MVA.

- (c) All High Voltage main switchboards shall be located in separate purpose built switchrooms (or for smaller treatment plants in weatherproof kiosks) close to the point of attachment to the incoming electrical supply distribution network.
- (d) Transformer substations shall be located near the associated electrical loads and shall consist of primary voltage switchgear, transformer(s) and earthing system, all suitably enclosed separately from enclosures for associated secondary voltage switchgear and treatment plant equipment.
- (e) The treatment plant electrical supply configuration shall be such that the Low Voltage prospective fault current levels do not exceed 50 kA.

3.4.2 Protection Equipment

- (a) High Voltage distribution cable systems within a treatment plants shall be protected by circuit breakers and associated protection relays. Definite Minimum Inverse Time Delay overcurrent and earth fault protection shall be provided as a minimum.

If the High Voltage distribution system is of the open ring main type, directional overcurrent and earth fault protection shall be provided so as to provide adequate protection grading regardless of the location of the open point.

- (b) If the treatment plant includes embedded generation equipment, additional protection equipment shall be provided as detailed in para. 3.7 hereunder.

3.4.3 Tripping Releases and Power Supplies

- (a) High Voltage circuit breakers supplying transformers rated >1250 kVA shall be equipped with D.C shunt trip releases and D.C. under voltage releases.

All protective devices on circuit breakers supplying transformers rated > 1250 kVA shall trip the circuit breaker utilising either the D.C. shunt trip release or the primary current sensor powered release (if the latter is fitted also).

- (b) High Voltage circuit breakers supplying transformers rated ≤ 1250 kVA shall be equipped either with D.C shunt trip releases and D.C. under voltage releases, or shall be supplied with primary current sensor powered releases and A.C. shunt trip releases.

Overcurrent and earth fault protection relays on circuit breakers supplying transformers rated ≤ 1250 kVA shall trip the circuit breaker utilising either the D.C. shunt trip release or the primary current sensor powered release (if the latter is fitted). Other protective devices shall be connected to such circuit breakers so as to trip the circuit breaker via the associated D.C. shunt trip release or A.C. shunt trip release, whichever is fitted.

- (c) High Voltage switch fuses supplying transformers rated ≤ 500 kVA may be fitted with an A.C. shunt trip release only for the purpose of tripping the switchfuse in the event of a transformer over temperature fault or for operational reasons.
- (d) AC shunt trip releases fitted to High Voltage circuit breakers (or high Voltage switch fuse units) supplying transformers shall be powered from the secondary side of the transformer fed by the particular High Voltage circuit breaker (or High Voltage switch fuse unit).

3.4.4 Voltage Surge Protection

The design of the insulation coordination for the complete High Voltage system shall be in accordance with Section 12 of Design Standard DS21. Suitably rated surge diverters shall be fitted to the primary winding terminals of all transformers connected directly to the High Voltage distribution system. The Designer shall ensure that the rating of these surge diverters and the length of the associated feeder cables are such that the above surge diverters will provide adequate surge protection for the associated High Voltage switchboard. If this cannot be achieved, suitably rated surge diverters shall be provided connected directly to the associated High Voltage switchboard busbars.

3.5 Substations

3.5.1 Dual Transformers

Dual transformers shall be provided in substations supplying Low Voltage power to critical areas of the treatment plant.

3.5.2 Switchgear Enclosures

High Voltage distribution system switchgear shall be housed in outdoor kiosk enclosures or in separate switchrooms located within treatment plant buildings.

Where the substation consists of more than one transformer or where the transformer rating exceeds 1250 kVA, the High Voltage switchgear shall be located in a separate switchroom.

Switchgear kiosk enclosures shall comply with the requirements of Section 3 of Design Standard DS21.

3.5.3 Transformer Enclosures

Transformers rated ≤ 1250 kVA may be housed in outdoor kiosk enclosures in accordance with the requirements of Section 7 of Design Standard DS21. Otherwise oil filled transformers shall be located outdoors in fenced enclosures and dry type transformers shall be housed in separate well ventilated transformer rooms located within treatment plant buildings.

3.5.4 Clearances

The clearances to be maintained between oil filled transformers and buildings and between each other shall comply with the requirements of Section 3 of Design Standard DS21.

3.5.5 Connections to Transformers

Connections to transformers shall comply with the requirements of Section 3 of Design Standard DS21.

3.5.6 Transformer Ratings

Transformer ratings shall comply with the requirements of Section 3 of Design Standard DS21.

3.5.7 Transformer Feeders

Transformer High Voltage and Low Voltage feeders shall comply with the requirements of Section 3 of Design Standard DS21.

3.6 Low Voltage Distribution

3.6.1 General

It may be necessary to provide Low Voltage distribution between various adjacent sections of the treatment plant, sometimes to provide an alternative source of supply. If the latter is the case, interlocking shall be provided to prevent voltage being back fed into the High Voltage distribution system.

3.6.2 Sectionalising Switchboards

In critical areas of the treatment plant consideration shall be given to sectionalising the main Low Voltage switchboard in each area. The decision as to whether or not to sectionalise such switchboards shall be in accordance with Sections of DS21.

3.6.3 Protection

All circuits within the Low Voltage distribution system shall be provided with short circuit protection by means of fault current limiting circuit breakers fitted with mains current operated over current and earth fault releases.

3.6.4 Neutral and Earth Connections

The Low Voltage star point of each transformer shall be connected directly to earth. All earth bars within a particular switchboard shall be connected directly to the switchboard's main earth bar.

3.7 Embedded Generation

3.7.1 Use of Earthing Transformer

If the treatment plant includes embedded generation which is required to transmit power over the internal High Voltage distribution system when the treatment plant site is disconnected from the incoming electrical supply distribution network, an earthing transformer shall be provided so as to earth the internal High Voltage distribution system during such times.

The circuit breaker controlling the earthing transformer shall be closed automatically whenever the main incoming supply circuit breaker or its associated isolating switches are open. The circuit breaker controlling the earthing transformer shall be opened automatically once the main incoming supply circuit breaker and its associated isolating switches are closed.

3.7.2 Selection of Earthing Transformers

Earthing transformers shall be of the interconnected star (i.e. zig-zag) type. The kVA rating of a three phase earthing transformer shall be defined as the product of the line to neutral voltage (kV) and the neutral to earth current (amps).

Earthing transformers shall be designed to have a zero sequence impedance of 100%, i.e. if the transformer is supplied from an otherwise unearthed three phase supply, a solid earth fault on one line shall result in the circulation of the earthing transformers rated neutral to earth current.

The one minute kVA rating of an earthing transformer shall be not less than the 30% of the combined three phase kVA rating of all embedded generator step up transformers feeding into the associated treatment plant High Voltage distribution system.

3.7.3 Synchronising with the Incoming Supply

Embedded generators shall be connected to the incoming mains supply via automatic synchronising equipment.

3.7.4 Point of Connection of Embedded Generators and Earthing Transformer

Wherever practical the point of connection of embedded generators and their associated earthing transformer to the High Voltage distribution system shall be at the site main switchboard so as to make the interlocking, between the circuit breakers controlling these items and the main circuit breaker, as direct as possible.

3.7.5 Harmonic Circulating Currents

Embedded generation is often required to supply a significant local load which must be able to be supplied from the incoming supply if the local embedded generators are shut down.

If the generators are Low Voltage, these will be required to be connected in parallel with the Low Voltage side of a delta/star step down transformer. In such circumstances it is necessary that the neutrals be connected in parallel.

The preferred two thirds pitch wound generators produce negligible triplen harmonic voltages. However, this design results in generators which have very low zero sequence impedance, so that these machines will allow significant triplen harmonic currents to flow if these are connected in parallel with other machines which produce significant triplen voltages.

A delta/star transformer will produce significant triplen harmonic voltages (which will be zero sequence).

For example a typical standard delta/star 2000 kVA 22/0.415 kV transformer operating at 108 % of nominal voltage will cause a circulating current of approximately 140 amps if connected in parallel with a two thirds pitch wound generator.

If the generator was rated at 400 kVA (i.e. 560 amps), the above circulating current would be 25% of full load current. This current would be shared between the three phases so that at fundamental full load current, the resulting r.m.s. current overload would be less than 0.5%. So from an overload point of view, provided the generator star point connection is rated for full load current, the above circulating current would not cause a problem.

However, the third harmonic circulating current appears as an earth fault current to generator earth fault protection. Since it is normal to set generator earth fault protection to 10%, in the above example it would be desirable to reduce the third harmonic current circulating through the generator to 3%. In

the above example a 0.04 ohm series resistor connected between the generator winding star point and the connections to neutral and earth bus bars would achieve this result.

Use of a low loss design transformer will reduce the third harmonic current significantly.

The Westinghouse Electrical Transmission and Distribution Reference Book is a useful reference in regard to the above matters.

The approximate value of the third harmonic circulating current can be calculated as follows:

$$I_{o3} = I_{e3} * X_{p3} / (R_n + 0.33 * X_{t3} * j + 3 * |X_{g0}| * j) = \text{third harmonic circulating current, amps}$$

where: $I_e = I_r * F_e$ = excitation current at 108% of V_t , amps

$$I_r = Q_t / (3^{0.5} * V_t)$$

= transformer rated current, amps

Q_t = transformer rating, kVA

V_t = transformer secondary voltage rating, kV (= 0.415 kV)

F_e = 50 Hz excitation current, per unit of I_r

$$I_{e3} = I_e * F_3$$

= 3rd harmonic content of I_e , amps

F_3 = 3rd harmonic content of excitation current, per unit of I_e

$$X_{p3} = X_{t3} * F_z$$

= transformer primary winding 3rd harmonic impedance, ohms

$$X_{t3} = |Z_t| * |X_t| * j * 150 / 50$$

= transformer total 3rd harmonic impedance, ohms

$$|Z_t| = V_t^2 * 1000 / Q_t$$

= transformer base 50 Hz impedance, ohms

F_z = ratio of transformer primary winding impedance to total impedance

$|X_t|$ = transformer 50 Hz impedance, per unit of $|Z_t|$

R_n = neutral resistor, ohms

$|X_{g0}|$ = generator 50 Hz zero sequence impedance, ohms

If the embedded generators are High Voltage, these should not exhibit significant circulating current provided two thirds pitch machines are used.

3.7.6 Fault Levels

The provision of embedded generators will increase significantly the fault level within the treatment plant's electrical system and the Designer shall carry out calculations so as to ensure that equipment

specified fault ratings are adequate. Because the zero sequence impedance of two thirds pitch alternators is very low, the increase in earth fault level can be particularly significant.

3.7.7 Generator Specifications

- (a) The generating set engine shall be sized to the mechanical load demand and the generator set alternator shall be sized to the electrical load demand.
- (b) Engines on generating sets supplying loads with significant proportions of non-linear load shall be fitted with electronic governors.
- (c) The sub transient reactance of any alternator supplying a non-linear load shall be not more than 0.05 per unit assuming the non-linear load kVA as the per unit values base kVA.
- (d) Alternators fitted to embedded generating sets shall comply with the requirements of DS26-27 - Type Specification for Alternators Fitted to Embedded Generating Sets.

3.7.8 Generator Protection

Embedded generators shall be provided with the following protection by relays separate from the generator set management system :

- (a) Phase overcurrent,
- (b) Restricted earth fault (or differential protection),
- (c) Neutral overcurrent (only if the generator neutral connection is rated less than generator full load rated phase current),
- (d) Reverse power,
- (e) Loss of excitation,
- (f) Pole slip,
- (g) Over voltage,
- (h) Under frequency,
- (i) Synchronism check
- (j) Negative sequence over current (only for alternators rated > 1000kVA)

3.7.9 Loss of Incoming Mains Protection

It is important that the loss of incoming mains supply causes the treatment plant main circuit breaker to open before the relevant Network Operator's circuit breaker recloses, so as to prevent the incoming supply returning on to unsynchronised embedded generation. Consequently the following protection equipment shall be provided on the treatment plant main circuit breaker as well as that specified para. 3.3 above:

- (a) Voltage vector shift,
- (b) Rate of change of frequency,
- (c) Neutral displacement,

- (d) Directional earth fault (monitoring the incoming supply),
- (e) Directional overcurrent (monitoring the incoming supply)
- (f) Under frequency,
- (g) Under voltage,
- (h) Reverse power (if power export is prohibited),
- (i) Over frequency (if power export is permitted),
- (j) Over voltage (if power export is permitted),
- (k) Synchronism check.

3.7.10 Generator Circuit Breakers

Circuit breakers controlling generators shall be of the fully withdrawable type and shall have an operational durability rating of 10,000 open and close operations without current in the main circuit.

3.7.11 Network Operator's Special Requirements

Depending on the location of the treatment plant, the Network Operator may have special requirements in respect to the operation and protection of embedded generators, which the Designer shall ascertain and take into account in the preparation of the design.

3.7.12 Use of Uninterruptible Power Supplies

Critical instrumentation shall be supported by small local uninterruptible power supplies (UPS's) rather than use of smaller numbers of a larger UPS's.

UPS's shall be arranged so that back feeding onto associated mains supply cables is prevented.

Small local UPS's shall be purchased in accordance with the requirements of either Type Specification DS26-30 or DS26-31 as appropriate.

3.8 Treatment Plant Wide Harmonic Analysis

Converters including those associated with variable speed drives give rise to harmonic currents in the supply lines and hence cause harmonic distortion of the supply voltage. Network Operators impose limits on the levels of harmonic currents which may be drawn by any one consumer from the electrical supply network and on the resulting level of voltage harmonic distortion at the point of common coupling to the network. The Designer shall ensure that the design is such that these limits are not exceeded. In this respect the Designer shall refer to section 4 of Corporation Design Standard DS21.

Using manufacturer's harmonic current spectrum values for each particular converter, the Designer shall calculate harmonic current and harmonic distortion values for the whole plant by:

- (a) first calculating total values of each individual harmonic current using the second summation law as defined in AS /NZS 61000-3-6 para. 6.2,
- (b) then calculating harmonic impedance values using the worst case impedance curve method as defined in AS /NZS 61000-3-6 Appendix G, and

- (c) then calculating harmonic voltage distortion values using the above values.

In respect to any alternators involved in these calculations, care shall be taken to use manufacturer's values of sub transient reactances wherever possible. However for preliminary calculations in the absence of a known alternator make and model, a sub transient reactance value of 13 % can be assumed.

3.9 Power Factor Correction

3.9.1 General

WA Electrical requirements require that the power factor which an electrical installation presents at the point of attachment to the incoming electrical supply distribution network shall be not less than 0.8 lagging at the time of peak load and shall not at any time become leading. Western Power reserve the right, in some particular cases, to require the power factor at the time of peak load to be not less than 0.95.

Power factor correction within treatment plants will be achieved usually by the use of capacitor banks, but in some instances may be achieved by use of the embedded generation alternator control.

The requirement for power factor correction can be reduced by specifying equipment with relatively high power factors. In this respect the use of variable speed drives is beneficial because variable speed controllers of the type complying with the Corporation's type specification have an inherently high power factor.

However, the increasing use of variable speed drives within treatment plants means that the effects of harmonic currents will need to be taken into account if capacitor banks are proposed for power factor correction purposes, thus increasing significantly both the complexity of the design and the cost of the installation.

In order to minimise the need for power factor correction, electrical equipment shall be selected so as to minimise within practical limits reactive current demand.

Power factor correction shall be applied only if necessary to meet statutory or Network Operator requirements.

If capacitor power factor correction is required, it shall be applied centrally (i.e. near the point of attachment), rather than at individual loads.

3.9.2 Calculation of Required Capacitive kVAR

The fundamental relationships between capacitance and capacitive kVAR are as follows:

- (a) for single phase connection:

$$Q_c = \omega * C * V^2 * 10^{-3}$$

$$Q_c = I_c * V$$

- (b) for three phase star connection:

$$Q_c = \omega * C * V^2 * 10^{-3}$$

$$Q_c = 3^{0.5} * I_c * V$$

- (c) for three phase delta connection:

$$Q_c = 3 * \omega * C * V^2 * 10^{-3}$$

$$Q_c = 3^{0.5} * I_c * V$$

where Q_c = total reactive power, kVAR

$$\omega = 2 * \pi * f$$

f = frequency, Hz

C = capacitance, μF per phase

V = line voltage, kV

I_c = line current, amps

Real and reactive power vector relationships for an uncompensated low power factor load are shown in Fig. 3.1 where:

S = load, kVA

P = load power, kW

Q = load lagging reactive power, kVAR

$\cos \phi_1 = P/S$ = load power factor

The effect of power factor correction is shown in Fig. 3.2 where:

$$Q_c = P * (\tan \phi_1 - \tan \phi_2)$$

= capacitor bank leading reactive power, kVAR

S_1 = corrected load, kVA

$\cos \phi_2 = P/S_1$ = corrected power factor

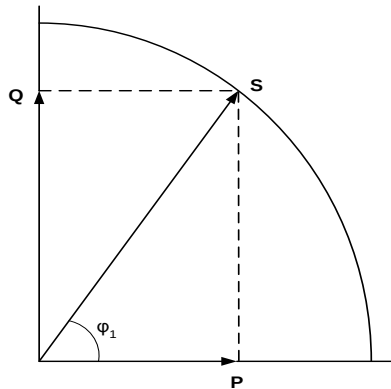


Fig 3.1

Uncompensated Load

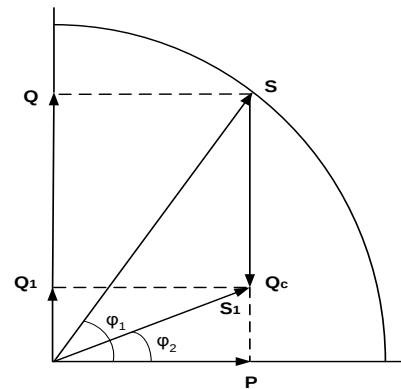


Fig 3.2

Compensated Load

3.9.3 Effect of Converters

Power factor correction capacitors shall be installed with series reactors chosen so that the tuned frequency (f_0) of the reactor and capacitor circuit falls well below 250 Hz, where:

$$f_0 = \omega^{-1} * (L_c * C)^{-0.5}$$

= tuned frequency , Hz

$$\omega = 2 * \pi * f$$

f = frequency = 50 Hz

L_c = inductance of series reactor, henries

C = capacitance, farads

The circuit design shall be checked to ensure that it does not resonate at any of the other harmonic frequencies as follows:

$$n = (S_k/Q_c)^{0.5}$$

where n = order of the harmonic in question

S_k = short circuit level including reactance of the series reactor, kVA

Q_c = capacitor bank leading reactive power, kVAR

The value of n shall not be equal or close to the order of the harmonics which occur in the supply, usually 5, 7, 11, 13.

In some cases it will be necessary to install the capacitor bank as a filter in a manner similar to that indicated in Fig. 3.3.

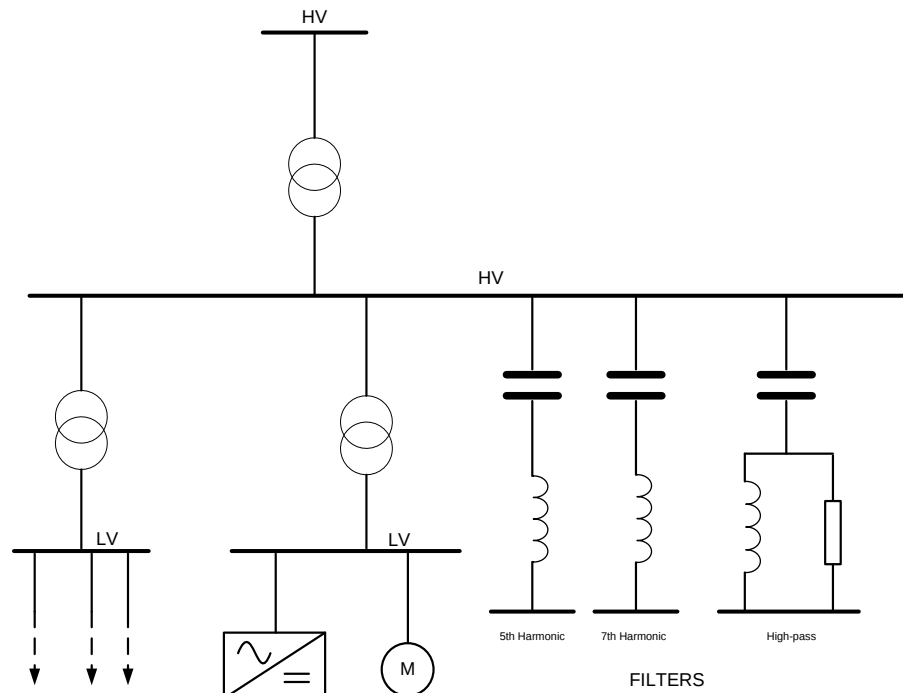


Fig. 3.3

3.9.4 Switching of Capacitors

As can be seen from Fig. 3.2, if the treatment plant load is reduced significantly and the capacity of the capacitor bank is not reduced, the power factor of the load as seen by the incoming electrical supply distribution network could become leading. As this is not permitted, some switching of capacitors may be required.

Switching of capacitors will cause a step change in treatment plant system voltage which shall be limited to less than 2% and the switching period shall be not less than 2 hours.

The voltage change brought about by capacitor switching can be calculated as follows:

$$\Delta V = 100 * Q_c / S_s$$

where ΔV = voltage change, %

Q_c = capacitor bank leading reactive power, kVAR

S_s = system short circuit level at the point of connection of the capacitor bank RC circuit, kVA

Switching on capacitors causes switching current transients which can be calculated as follows and protection equipment shall be rated to allow for these short term transient currents:

$$I_s = I_c * 2^{0.5} * (S_k / Q_c)^{0.5}$$

where I_s = surge current peak, amps

I_c = switched capacitors rated current, amps

S_k = short circuit level including reactance of the series reactor, kVA

Q_c = capacitor bank leading reactive power, kVAR

3.9.5 Switching Apparatus and Protection

All apparatus and cables in capacitor circuits shall be rated not less than 140% of capacitor nominal current rating in order to allow for overvoltages and harmonic currents.

All switchgear used for capacitor switching shall be rated for that duty.

Capacitor banks shall be fitted with both overload and short circuit protection.

Capacitor banks connected in parallel shall be provided with separate overload and short circuit protection.

High Voltage capacitor banks connected parallel shall be protected as shown in Fig 3.4.

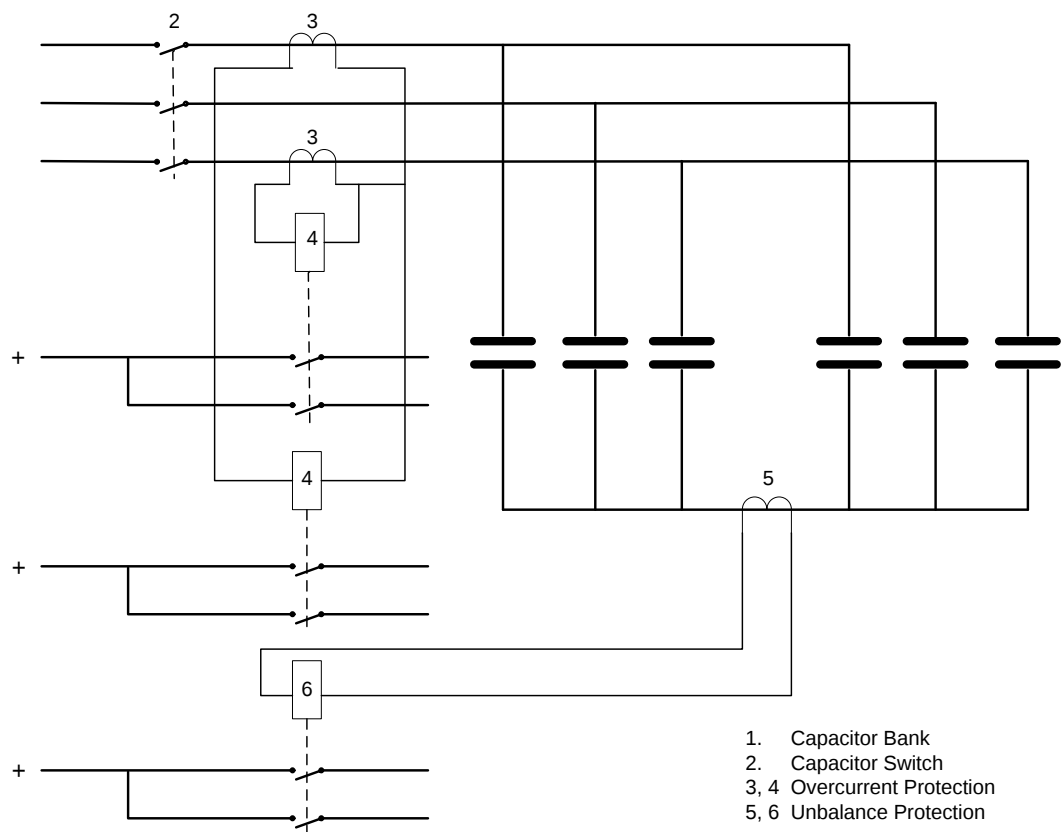


Fig 3.4

3.10 Power Supply Quality Monitoring

- (a) Power supply quality measuring equipment shall be installed on each main incoming supply for all treatment plant sites. The measuring equipment shall provide data as listed in the following table, with the specific requirements dependent on the size of the treatment plant.

Data Required	Small ≤ 315kVA	Medium >315kVA, ≤2MVA	Major (>2MVA)
Current each Phase	✓	✓	✓
Voltages Phase to Neutral	✓	✓	✓
Voltages Phase-to-Phase		✓	✓
Real Power	✓	✓	✓
Reactive Power	✓	✓	✓
Power Factor		✓	✓
Frequency	✓	✓	✓
Total Voltage Harmonic Distortion (%)	✓	✓	✓
Total Current Harmonic Distortion (%)	✓	✓	✓
Individual Harmonic Currents (A)		✓	✓
Event Recordings		*	✓
Disturbance Recordings		*	✓

- * The Designer shall determine requirements in consultation with representatives of the Region/ Alliance that will be responsible for operating the asset.

Note: All instantaneous signals (i.e. not event and disturbance recordings) shall be displayed on ViewX and stored in PI.

- (b) As the Supply Authority will not permit customer access to its metering current and voltage transformers for the purpose of power quality monitoring by the customer, a separate High Voltage metering unit shall be installed to provide the primary signals to the power quality monitoring equipment.
- (c) Consideration shall be made as to whether signals from the Supply Authority's meters, via Modbus, could be utilised in lieu of the separate HV metering unit for HV sites and quality metering equipment for LV sites.

4 MOTOR STARTERS AND CONTROLLERS

4.1 Motor Starters and Controllers Rated > 150 kW

The design of electrical drives rated >150 kW shall be in accordance with the requirements of Section 4 of Design Standard DS21.

4.2 Motor Starters and Controllers Rated ≤ 150 kW

The design of electrical drives rated ≤ 150 kW shall be in accordance with the requirements of Sections 3 and 7 of Design Standard DS22.

4.3 Power Monitoring

All motor starters and controllers for drives rated > 30 kW shall be fitted with power measuring equipment monitoring current per phase, voltages phase to neutral, real power, reactive power and, for variable speed drives, frequency.

Note: All power monitoring signals shall be displayed on ViewX and stored in PI.

5 MOTOR ISOLATION AND EMERGENCY STOP

5.1 Motor Isolation for Motors Rated $\leq 11\text{kW}$

Motors rated $\leq 11\text{ kW}$ shall be provided with a pad lockable isolating switch located close to the motor so that the motor can be isolated for maintenance purposes.

The isolating switch shall be 3 pole with an early break late make auxiliary contact which shall be connected in series with the coil of the associated line contactor. The main circuit contacts of the isolator shall be rated not less than motor full load current at Utilisation Category AC-23 to AS 3947.

Motors rated $\leq 11\text{ kW}$ shall be provided with a pad lockable latched emergency stop push button (red, mushroom type) located close to the motor so that the motor can be isolated in an emergency. The stop push button shall be connected in series with the associated line contactor.

5.2 Motor Isolation for Motors Rated $> 11\text{ kW}$

Motors rated $> 11\text{ kW}$ shall be provided with a pad lockable latched emergency stop push button (red, mushroom type) located close to the motor so that the motor can be isolated in an emergency. The stop push button shall be connected in series with the associated line contactor.

Motor isolation facilities for maintenance purposes shall be provided at the switchboard.

6 MOTOR SPECIFICATIONS AND TENDER ANALYSIS

6.1 Specifications for Motors Rated >150 kW

The specifications for motors rated >150 kW shall be in accordance with the requirements of Section 5 of Design Standard DS21.

6.2 Specifications for Motors Rated ≤ 150 kW

The specifications for motors rated ≤ 150 kW shall be in accordance with the requirements of Section 4 of Design Standard DS22.

6.3 Motor Tender Analysis

Tender analysis for motors of all ratings shall be done in accordance with the requirements of Section 6 of Design Standard DS21.

7 MOTOR PROTECTION

7.1 Motor Protection for Motors Rated > 150 kW

The protection for motors rated > 150 kW shall be designed and specified in accordance with Sections 9.7 and 9.8 of Design Standard DS21.

7.2 Motor Protection for Motors Rated ≤ 150 kW

The protection for motors rated ≤ 150 kW shall be designed and specified in accordance with Sections 8.5 to 8.8 inclusive of Design Standard DS22.

8 TRANSFORMER SPECIFICATIONS AND TENDER ANALYSIS

8.1 Transformer Specifications

The specifications for power transformers of all ratings shall be in accordance with the requirements of Section 7 of Design Standard DS21.

8.2 Transformer Tender Analysis

Tender analysis for power transformers of all ratings shall be done in accordance with the requirements of Section 8 of Design Standard DS21.

9 TRANSFORMER PROTECTION

The protection for transformers shall be designed and specified in accordance with Section 7 of Design Standard DS21.

10 SWITCHBOARDS

10.1 High Voltage Switchboards

High Voltage switchboards shall be designed and specified in accordance with the requirements of Section 9 of Design Standard DS21.

10.2 Low Voltage Switchboards Rated > 440 amps

Low Voltage switchboards rated >440 amps shall be designed and specified in accordance with Section 9 of Design Standard DS21 and the Type Specification DS26-17.

10.3 Low Voltage Switchboards Rated $\leq$ 440 amps

Low Voltage switchboards rated $\leq$ 440 amps shall be designed and specified in accordance with Section 8 of Design Standard DS22.

In addition, if such switchboards are of the motor control centre type, these shall be specified in accordance with Design Standard DS 26-17.

10.4 L.V. Switchboard Form of Internal Separation

Low Voltage switchboards rated $\leq$ 440 amps shall have a minimum form of separation in accordance with Section 8 of Design Standard DS22.

Low Voltage switchboards rated > 440 amps shall have a minimum form of separation in accordance with Section 9 of Design Standard DS21.

10.5 Sectionalising Motor Control Switchboards

The advantages and disadvantages of sectionalising motor control switchboards are discussed at Section 3.5 of Design Standard DS21.

10.6 Motor Control Switchboard Incoming Feeder Isolators

Incoming feeder isolators on motor control switchboards shall comply with the requirements specified in Section 3.6 of Design Standard DS21.

10.7 Switchboard Isolation, Earthing and Interlocking

Switchboard isolation, earthing and Interlocking facilities shall comply with the requirements specified at Section 3.7 of Design Standard DS21.

10.8 Switchboard Control

Motor control centre switchboards shall form part of the treatment plant overall Plant Control System as defined in the Appendix.

Each motor control centre switchboard shall be provided with a switchboard controlling system housed in a separate Plant Area Control Cubicle and connected to the treatment plant overall control system as defined in the Appendix.

10.9 Power Monitoring

All high voltage switchboards and all low voltage switchboards rated $\geq 220\text{A}$ shall be fitted with incoming power measuring equipment monitoring current per phase, voltages phase to neutral, real power, reactive power, total voltage harmonic distortion and total current harmonic distortion.

For low voltage switchboards rated $< 220\text{A}$, the Designer shall determine requirements for power monitoring in consultation with representatives of the Region/Alliance that will be responsible for operating the asset. Consideration shall be given to the Region's/Alliance's potential requirement for monitoring of individual circuits or groups of circuits in proprietary distribution boards.

Note: All power monitoring signals shall be displayed on ViewX and stored in PI.

10.10 Vendor Equipment Packages

The term "Vendor Equipment Package" covers equipment that, while it may be more or less of a standard design, is manufactured or assembled to order. The Designer, as specifier, will generally have at least some control over the type of equipment and performance requirements provided. Examples of vendor equipment packages include filters, chlorinators, chemical batching and dosing plants, aeration blowers, gas flares, modular package plants and the like.

Power equipment shall comply with the performance requirements of the Corporation's Design Standards listed in section 1 of this standard. Furthermore, switchboard requirements for vendor equipment shall comply with the requirements of DS20 section 3.11. Switchboards supplying loads greater than 50 amps load demand shall comply with the requirements of clause 10 of this standard.

11 ELECTRICAL EARTHING AND BONDING

11.1 Major Earthing Connections

Major earthing connections shall be designed and specified in accordance with Section 11 of Design Standard DS 21 with the proviso that the meaning of the term "pump station" in the figures shall be taken to include all individual sections of the treatment plant which are supplied by a separate transformer. The earthing and bonding of cathodically protected pipelines shall be as shown in Section 11 of Design Standard DS 21.

The design of the earthing connections to the general mass of earth shall be such that, under the worst case climatic conditions and without reliance on connection to the Supply Authority earth system, the touch and step voltages do not exceed the limits determined by the application of AS2067 and Design Standard DS23.

11.2 Interconnection of Power and Light Current Earthing Systems

Within each switchboard earth bars separate from the power system protective earth bar shall be provided for instrumentation/communication systems and for intrinsically safe systems (if these light current systems exist within the particular switchboard). Generally all such earth bars shall be bonded together and connected to the main earth system. However if special conditions exist requiring a separate instrumentation/communication earthing system, the instrumentation/ communication system shall be connected to the main power protective earth system via transient earth clamps with a rated DC 100 V /sec spark over voltage of 150 V +/- 20% and a 1 kV /µsec surge spark over voltage of <800 volts.

11.3 Site Wide Earthing Interconnection

All transformer earthing systems within a treatment plant having a High Voltage distribution system shall be bonded together using 35 mm² (minimum) copper conductor PVC insulated cable (green with yellow stripe).

11.4 Earth Bonding of Pipework and Structures

Metal pipework and structural metal shall be earthed generally as described in Section 11 of Design Standard DS21.

11.5 Lightning Protection of Buildings and Structures

The Designer shall carry out a lightning risk assessment in accordance with AS/NZS 1768:2007 in order to determine what level of lightning protection should be provided to the building or structure.

The Designer shall incorporate equipment into the electrical design such that the level lightning damage risk in each risk category will be less than the associated acceptable risk level as specified in AS/NZS 1768:2007.

In respect to the damage category 4 – economic loss, the acceptable risk level shall be 0.001.

12 POWER CABLES

12.1 Cable Types

Power and control cables shall be specified in accordance with the Section 13 of Design Standard DS21.

High Voltage distribution cables shall be as specified for incoming cables to transformers in Section 13 of Design Standard DS21.

Low Voltage cables running between switchboards shall be PVC or XLPE insulated, PVC sheathed and shall be nylon sheathed, PVC sheathed overall if run underground.

Cables not covered by the above shall be the type best suited for the particular purpose in accordance with industry best practice.

Cables traversing or installed within hazardous areas shall be specified in accordance with HA-ST-03: EEHA Selection and Installation Manual.

12.2 Cable Ratings

Power cable continuous, intermittent and fault ratings shall be calculated in accordance with the Section 13 of Design Standard DS21 and cable systems designed accordingly.

13 CABLE INSTALLATION METHODS

13.1 High Voltage Distribution Cables

High Voltage distribution system cables running between various sections of the treatment plant:

- (a) Shall have a fault rating in accordance with WA Electrical Requirements,
- (b) Shall be rated in accordance with the manufacturer's recommendations and, if run underground, with the measured thermal resistivity of the backfill soil type,
- (c) Shall be laid in trefoil formation,
- (d) Shall be protected from rodent and termite damage,
- (d) Shall be protected from mechanical damage including vibration damage,
- (e) Shall be buried directly, protected by polymeric cable cover strip in accordance with AS3000;
 - Run in enclosed cable ducts on cable ladders separate from cable ladders carrying other cables, or
 - Run within buildings on cable ladders separate from cable ladders carrying other cables.

In respect to item (b) above, in the absence of soil resistivity measurements, it can be taken that well drained sand has a thermal resistivity of $2.5^{\circ}\text{C}\cdot\text{m}/\text{W}$ and that bricklayers' sand has a thermal resistivity of $1.2^{\circ}\text{C}\cdot\text{m}/\text{W}$. The routes of all buried High Voltage cables shall be marked with approved above ground markers.

13.2 High Voltage Drive Cables

High Voltage cables associated directly with drives:

- (a) Shall be run either in non-metallic conduits, or on cable ladders of either stainless steel if run in chemical dosing or mixing areas or of aluminium if run in general areas,
- (b) Shall be protected from sun, rodent and termite damage,
- (c) Shall be protected from mechanical damage including vibration damage, and
- (d) Shall be laid with cores clamped in trefoil formation where run on cable ladders.

13.3 Low Voltage Distribution Cables

Low Voltage distribution system cables running between switchboards in various sections of the treatment plant:

- (a) Shall be run in non-metallic conduits if run underground,
- (b) Shall be run on shaded stainless steel cable ladder if run above ground in chemical dosing or mixing areas,
- (c) Shall be run on shaded aluminium cable ladder if run above ground in general areas,

- (d) Shall be protected from rodent and termite damage,
- (e) Shall be laid in trefoil formation where run on cable ladders if single core, and
- (f) Shall be rated in accordance with the measured thermal resistivity of the backfill soil type.
- (g) Shall when traversing or installed within hazardous areas be in accordance with HA-ST-03: EEHA Selection and Installation Manual.

In respect to item (e) above, in the absence of soil resistivity measurements, it can be taken that well drained sand has a thermal resistivity of 2.5°C.m/W and that bricklayers' sand has a thermal resistivity of 1.2°C.m/W .

13.4 Other Cables

Cables other than distribution cables and High Voltage drive cables shall be installed in the manner best suited for the particular purpose in accordance with industry best practice.

13.5 Cable Trays and Ladders

There is no current restriction in the use of non-metallic (e.g. PVC) based cable tray/ladder systems provided that the non-metallic based system is fit for purpose appropriate to the project and environmental conditions under consideration. Hence, whether non-metallic based cable trays systems are used at a site will be determined by the designer of the particular project.

Such non-metallic tray/ladder systems shall be non-flammable, UV stabilised suitable for outdoor use, minimum service temperature performance of -20 to 60 degrees Celsius and verification tested by a third party to IEC (BS EN) 61537.

Benefits to consider are:

- Increased electrical safety due to double insulation.
- No requirement for tray/ladder earthing
- Reduced installation costs. (No earthing cables, snap-on accessories, lack of sharp edges, ease of handling).
- Reduced maintenance costs (no corrosion and no earthing system to maintain).

14 BUILDING SERVICES

14.1 Internal Lighting

Lighting within treatment plant buildings shall be designed in accordance with AS/NZS 1680.

The lighting levels and other characteristics shall be designed so as to conform to the recommendations given in AS/NZS 1680.2.4 Table E1 Item 43 for Petroleum, Chemical and Petrochemical Works.

14.2 Emergency Lighting

Emergency lighting shall be provided to illuminate hazards and to enable safe movement within buildings in the event of power failure. Emergency lighting shall also be provided for illumination of rotating plant, chemical storage and handling areas, switchrooms and control rooms.

Illuminated exit signs shall be provided in accordance with the Building Code of Australia only in areas that are likely to be occupied on a regular basis, such as administration buildings, control rooms, offices, workshops and laboratories.

Emergency lighting shall conform to AS/NZS 2293.1, "Emergency evacuation lighting for buildings" and shall be designed for an in-service duration of 90 minutes minimum following power failure, with an initial duration as required by AS/NZS 2293.1. Manually-initiated discharge testing facilities shall be provided as required by AS/NZS 2293.1.

14.3 Exterior Lighting

Illumination shall be provided for process areas, valve and meter pits, substations, walkways, roadways, doorways and general access areas within the treatment plant boundaries. Special attention shall be paid to illumination of trip and fall hazards, open tanks, trenches, pits and the like.

Outdoor substations shall be provided with sufficient illumination for safety of access and equipment operation.

Exterior lighting within treatment plants shall be designed in accordance with the AS/NZS 1158.3.1 categories as follows;

- | | | |
|-----|--|-------------|
| (a) | Entrance roads and internal roadways - | category P4 |
| (b) | Areas that require night time maintenance operations - | category P6 |
| (c) | General plant areas - | category P8 |
| (d) | Steps and stairways, ramps, footbridges, and other
areas which contain trip or fall hazards - | category P9 |
| (e) | Footpaths and walkways- | category P3 |

If practical, exterior lighting shall utilise high pressure sodium lamps due to their availability, high efficiency and long life,

Wherever practical, exterior luminaires shall be mounted on walls or structures. The number of lighting poles within the treatment plant shall be minimised, so that as few obstructions as possible

are presented to vehicle movements. All lighting poles greater than 3 metres in height shall incorporate a means to lower and raise the column for lamp maintenance without the need for specialised equipment.

The possibility of damage to external luminaires by acts of vandalism shall be minimised by selection of appropriate luminaire types or fitting with guards.

All exterior doorway lighting on each building shall be controlled by a switch located on the outside of the building adjacent to the main personnel access door.

Exterior lighting shall be designed for minimal environmental impact and to contain light within the site boundaries.

14.4 Control of Exterior Lighting

Roadway lighting shall be controlled by an automatic daylight switch with a manual override.

Other exterior lighting shall be controlled by an automatic daylight switch with provision for manual override by means of an 'Off/Auto/On' switch. For small to medium treatment plants, lighting control shall be located in the administration building or main control room. For major plants, consideration shall be given to individual lighting control of each plant area from a central location.

For safety reasons, automatic switch on of exterior lights when vehicles approach the front gate, may be required for smaller country plants. The Designer shall check with the Corporation whether this will be a requirement of the project.

14.5 General Purpose Power Socket Outlets

Ideally, single phase general purpose switched socket outlets should be located in buildings and outdoor areas such that any working area of the treatment plant can be reached with a 30 m extension cord. However due to the widespread use of portable generators for operation and maintenance activities it may not be necessary to provide single phase general purpose switched socket outlets in every area,

In addition to single phase general purpose switched socket outlets provided for plant operation and maintenance duties, single phase general purpose switched socket outlets shall be provided in all buildings as follows:

- (a) At least two double outlets in each office,
- (b) At least four double outlets in each amenities area,
- (c) Two double outlets located at each workstation, and
- (d) At least one double outlet located at each High Voltage switchboard, motor control centre switchboard and at each control cubicle,

A three phase 20 amp 5 pin general purpose switched socket outlet shall be installed in each switchroom. In addition, such three phase outlets shall be provided within buildings and in outdoor areas where required to facilitate the operation cleaning and maintenance of the plant,

All general purpose switched socket outlets shall be provided with Residual Current Detection protection and labelled as "RCD PROTECTED" at each outlet.

14.6 Air Conditioning

Generally all electrical equipment should be rated for operation in the on-site atmospheric conditions. However, in some instances it may be necessary to take measures to ensure that the equipment operating environment is modified so as to match the rating of the class of equipment which is available economically. Generally it is not practical to modify the atmospheric environment within the whole of a treatment plant building. However following locations shall be investigated to determine if some form of air conditioning is required:

- (a) Control rooms,
- (b) Switchrooms,
- (c) Rooms containing power transformers , and
- (d) Rooms containing large variable speed controllers,

If the above rooms are located in areas of wastewater treatment plants subject to H₂S gas pollution, activated carbon filters shall be provided at associated air conditioning system air intakes.

Electrical equipment cabinets located in areas of wastewater treatment plants subject to H₂S gas pollution which are not air conditioned shall be pressurised with clean filtered air.

For rooms housing large variable speed controllers and/or power transformers the most common type of air conditioning required is mechanical ventilation which takes cooling air from an area which is free of chemical pollution and dust, and discharges the exhaust air well away from the intake. Such air conditioning shall be sized so that the heat losses from the equipment in the room do not raise the room temperature by more than 5°C with the equipment operating at full load

In rooms housing large variable speed controllers the arrangement shall be in accordance with one of the arrangements shown Fig. 14.1, Fig. 14.2 and Fig. 14.3. However in locations where chemical and dust free cooling air is not available, refrigerated cooling as shown in Fig. 14.4 shall be used and shall be sized so that the heat losses from the equipment in the room do not raise the room temperature by more than 5°C, with the equipment operating at full load.

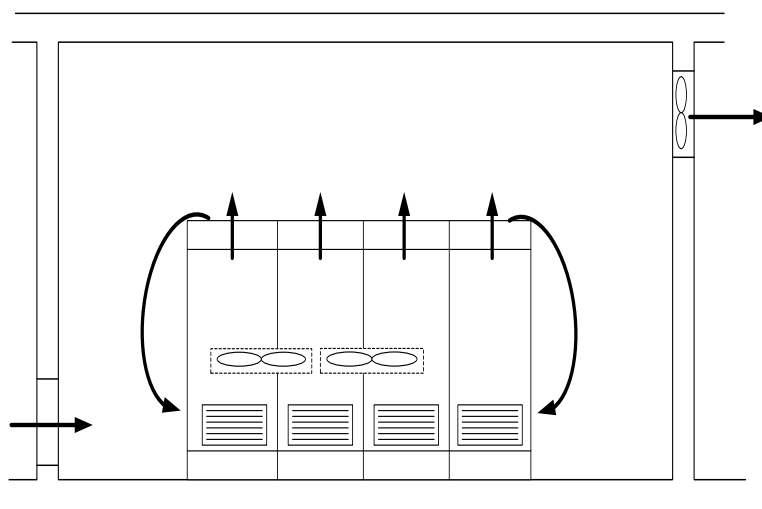


Fig 14.1

Simple Room Ventilation System

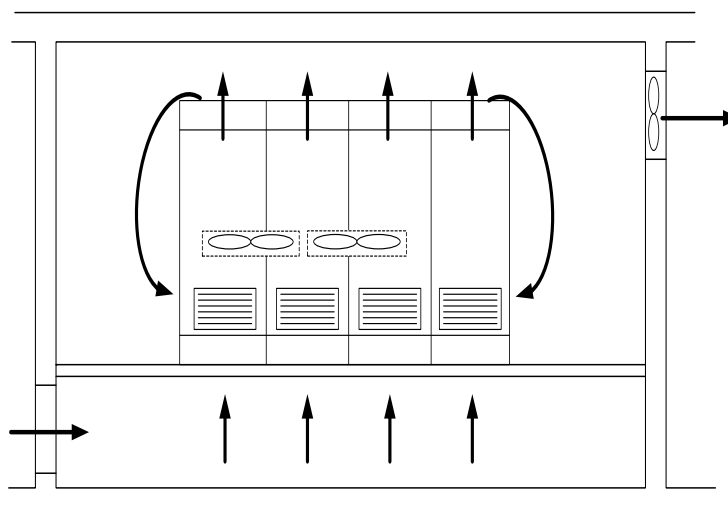


Fig 14.2

Simple Room Ventilation System with Air Inlet through false floor

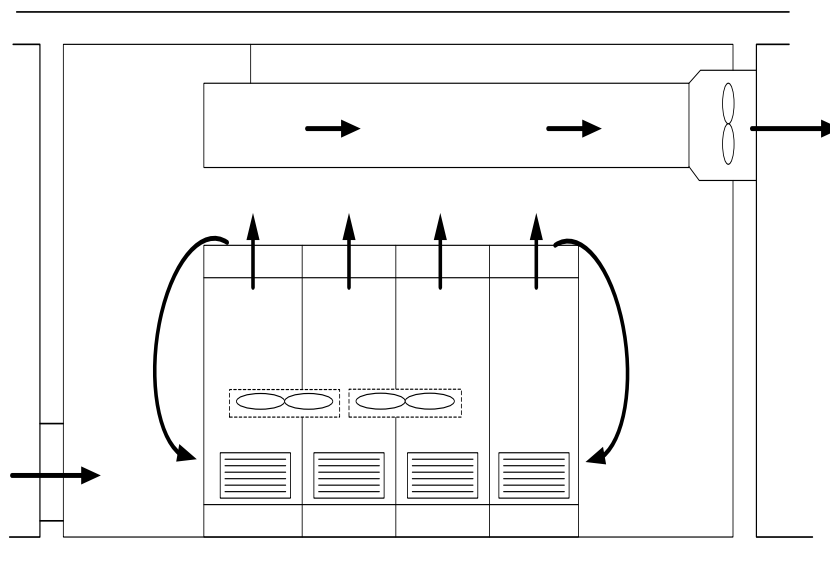


Fig 14.3

Room Ventilation with Air Extraction System

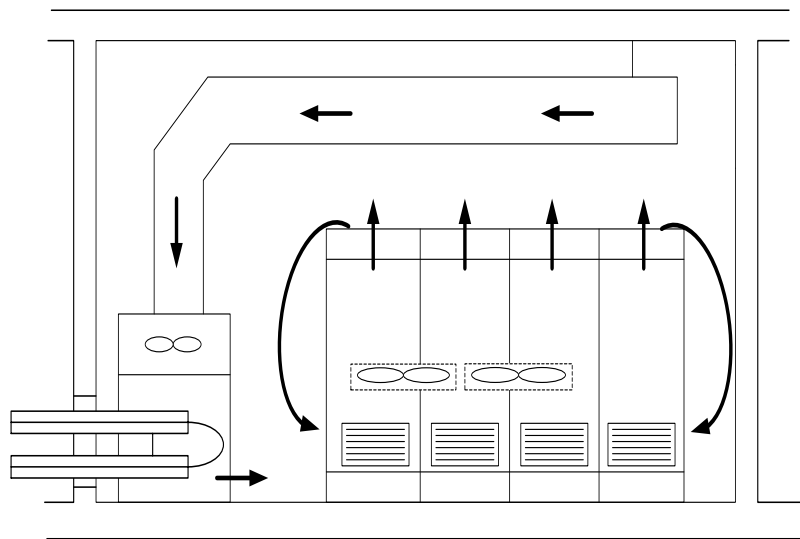


Fig 14.4

Room Ventilation System with Internal Cooling

Some variable speed controllers are provided with facilities which allow an exhaust duct of limited length to be connected directly to the controller with the air flow being powered solely by the cooling air fan within the controller. However the use of a supplementary cooling air duct exhaust fan may not be permitted.

If the cooling system shown at Fig. 14.2 is used, the cooling air inlet gratings in the false floor shall be located directly adjacent to the cooling air inlets into the variable speed controller cabinets.

The required cooling air flow rate for the cooling systems shown at Fig. 14.1 and 14.2 can be calculated as follows:

$$F_a = k * P_1 * e^{0.1251 * h} * T_k / [(T_r - T_k) * T_0]$$

Where;

F_a = required air flow, m³/h

k = 2770

P_1 = controller losses, kW

T_r = allowable room temperature, °K

T_k = inlet air temperature, °K

T_0 = reference temperature = 273 °K

h = altitude mean sea level, km

However, because of the relatively high inlet air temperatures in Western Australia, it will generally be advantageous to extract the warm air from above the variable speed controller as indicated in Fig. 14.3,

For systems shown in Fig. 14.3 and Fig. 14.4, the air extraction ducts should not be flanged onto the variable speed controller cabinets because generally the controller air flow rate will much higher than the required room air flow rate.

The required cooling air flow rate for the cooling systems shown at Fig. 14.3 and 14.4 can be calculated as follows:

$$F_a = k * P_1 / [(T_r - T_k) + k * P_1 * F_c^{-1}]$$

Where;

F_a = required air flow, m³/h

k = 2770

P_1 = controller losses, kW

T_r = allowable room temperature, °K

T_k = inlet air temperature, °K

F_c = controller required air flow, m³/h

Room cooling air fans shall be equipped with variable speed drives and proportional/integral controllers, so as to minimise fan speed consistent with keeping the room temperature within acceptable limits, and hence to minimise dust collection and acoustic noise.

Room temperature shall be monitored as part of the treatment plant automatic control system.

14.7 Acoustic Noise Control

The overall design of a treatment plant must comply with the acoustic noise limits imposed by environmental legislation. In locations where plant acoustic noise is likely to be a problem, low acoustic noise electrical equipment shall be specified wherever practical, so as to minimise the building costs associated with acoustic noise control.

15 VALVE ACTUATORS

Valve actuators shall be designed and specified in accordance with Section 12 of Design Standard DS22 and Type Specification DS26.41.

16 MISCELLANEOUS PLANT SERVICES

16.1 Lighting

16.1.1 Interior Lighting

Interior lighting for buildings within treatment plants shall be designed in accordance with Australian standard AS/NZS 1680, "Interior lighting". Lighting levels shall be in accordance with the relevant AS/NZS 1680 recommendations referred to in the following table.

Room or area type	Applicable Australian standards reference	Item in table	Comments
Indoor process or mechanical plant (pump rooms, process equipment etc.)	AS 1680.2.4 Table E1	43: Petroleum, chemical and petrochemical works	
Pipe and cable galleries	AS 1680.2.4 Table E1	15: Electricity generating stations	As for walkways and cable tunnels
Indoor substations, transformer rooms, switchrooms etc.	AS 1680.2.4 Table E1	15: Electricity generating stations	
Plant administration buildings and offices	AS 1680.2.1 Table E1	(As applicable)	
Control rooms	AS 1680.2.1 Table E1	10: Control and monitoring rooms	

For process areas, plant rooms, galleries, switchrooms and the like appropriately-protected industrial 36W fluorescent luminaires shall be used as light sources. Luminaires shall be mounted on suitable trunking wherever practical. Alternatively high bay luminaires may be used if the design of the building allows and if adequate provision is made to enable safe maintenance of the luminaires. The use of winches for maintenance access to luminaires shall be avoided due to the tendency of winches and lowering gear to jam because of their intermittent use.

Lighting of rooms containing rotating machinery shall be evenly distributed over a 3 phase circuit switched by a contactor to avoid possible stroboscopic effects.

Where necessary additional lighting shall be provided so that the interiors of switchboard cubicles, control panels and the like are adequately illuminated when open for maintenance. Supplementary lighting shall be installed inside cubicles where necessary. Care shall be taken to ensure that pushbuttons, switches, instruments and the like are well lit and are free of shadows.

For administration buildings, offices, control rooms and the like 36W fluorescent luminaires shall be used as light sources. Luminaires shall be recessed where possible and shall be functionally and aesthetically appropriate to the area in which they are to be installed.

16.1.2 Emergency Lighting

Emergency lighting shall be provided to illuminate hazards and to enable safe movement within buildings in the event of power failure. Emergency lighting shall also be provided for illumination of rotating plant, chemical storage and handling areas, switchrooms and control rooms.

Illuminated exit signs shall be provided in accordance with the Building Code of Australia only in areas that are likely to be occupied on a regular basis, such as administration buildings, control rooms, offices, workshops and laboratories.

Emergency lighting shall conform to AS/NZS 2293.1, "Emergency evacuation lighting for buildings" and shall be designed for an in-service duration of 90 minutes minimum following power failure, with an initial duration as required by AS/NZS 2293.1. Manually-initiated discharge testing facilities shall be provided as required by AS/NZS 2293.1.

16.1.3 Exterior Lighting

Illumination shall be provided for process areas, valve and meter pits, substations, walkways, roadways, doorways and general access areas within the treatment plant boundaries. Special attention shall be paid to illumination of trip and fall hazards, open tanks, trenches, pits and the like.

Outdoor substations shall be provided with sufficient illumination for safety of access and equipment operation.

Lighting of treatment plant areas shall be designed to conform to the following categories of AS/NZS 1158.0 and AS/NZS 1158.3.1, "Road lighting":

- (a) Entrance roads and internal roadways: category P4.
- (b) Areas that may require night-time maintenance operations: category P6.
- (c) General plant areas: category P8.
- (d) Steps and stairways, ramps, footbridges, and other areas containing trip or fall hazards: category P9
- (e) Walkways and footpaths: category P4.

If practical, exterior lighting shall utilise high pressure sodium lamps due to their availability, high efficiency and long life.

Wherever practical, exterior luminaires shall be mounted on walls or structures. The number of lighting poles within the treatment plant shall be minimised, so that as few obstructions as possible are presented to vehicle movements. All lighting poles greater than 3 metres in height shall incorporate a means to lower and raise the column for lamp maintenance without the need for specialised equipment.

The possibility of damage to external luminaires by acts of vandalism shall be minimised by selection of appropriate luminaire types or fitting with guards.

All exterior doorway lighting on each building shall be controlled by a switch located on the outside of the building adjacent to the main personnel access door.

Exterior lighting shall be designed for minimal environmental impact and to contain light within the site boundaries.

16.1.4 Lighting Control

Roadway lighting shall be controlled by an automatic daylight switch with a manual override.

Exterior lighting shall be controlled by an automatic daylight switch with provision for manual override by means of an OFF/AUTO/ON switch. For small to medium treatment plants lighting control shall be located in the administration building or main control room. For major plants consideration shall be given to individual lighting control of each plant area from a central location.

Control of individual lighting by motion sensors with automatic daylight cut-out and manual override shall also be provided where appropriate.

16.2 Power Outlets

General purpose outlet requirements are referenced in section 14.5.

Critical equipment within a plant (chlorinators, instruments etc) may be adversely affected by operation of RCDs connected to these final subcircuits. Such disruption to plant operations is costly and restricts efficient performance of the installation. In accordance with the requirements of AS3000 (clause 2.6.3.2.1, exception) all socket outlets on final subcircuits installed for connection of specific items of critical equipment do not require RCD protection.

16.3 Fire and Gas Detection and Alarm System

16.3.1 General

A fire and gas detection and alarm system shall be provided for all but very small (e.g. package) treatment plants. The system shall cover the following areas:

- (a) Administration and amenities buildings;
- (b) Control rooms and associated equipment rooms;
- (c) Switchrooms and substations;
- (d) Plant rooms;
- (e) Gas handling, processing and storage areas.

Where the plant includes special facilities such as maintenance workshops and laboratories a risk assessment shall be carried out to identify any fire or chemical hazards, assess the likely consequences of fire or chemical release and determine the most appropriate form of detection and/or protection. The assessment shall take into account the risks posed by any flammable or hazardous materials likely to be stored on the site.

Automatic sprinkler or gas flooding systems shall not be provided unless there are particular risks that justify their use.

16.3.2 Design

Detectors shall be suitable for the areas in which they are to be installed. In particular, detectors to be installed in wastewater treatment plants shall be resistant to attack from low concentrations of hydrogen sulfide.

Fire detection and alarm systems shall be designed in accordance with AS 1670, “Fire detection, warning, control and intercom systems” and the Building Code of Australia. Detectors, manual call points and indicators shall comply with the AS 1603 series of standards.

The main fire panel shall be located in the administration or amenities building and shall be connected to the PCS, the alarm dialler system (if provided) and the local Fire Brigade. It shall include routine testing facilities as required by the standards and codes.

For major plants sub-indicator panels shall be provided in local plant areas where appropriate.

Alarm zones shall be allocated in accordance with AS 1670, commensurate with the size and layout of the plant.

The system shall provide local visual and audible alarm indication. The audible alarm shall be interfaced to the voice paging system if provided. If appropriate, interlocks shall be provided to disconnect power to specific areas or to shut down process equipment.

16.3.3 Equipment

Smoke detectors shall be provided in all switchrooms and control rooms. Thermal detectors may be used in offices and indoor process areas and shall be used in areas which are subject to smoke, fumes or dust during normal plant operation.

Depending on the nature of the risk the Designer may need to consider the use of other types of detector such as UV flame detectors or aspirated smoke detection systems.

A manual call point shall be provided in a prominent position at the entrance to the administration or amenities building. For major plants additional call points shall be located around the plant in suitable locations.

Visual and audible alarms shall be provided on the exterior of key buildings.

Areas where toxic or flammable gases (e.g. chlorine, digester gas) are handled, processed or stored shall be provided with suitable gas alarms linked to the main fire panel.

17 WORK ON EXISTING TREATMENT PLANTS

17.1 General

The design of additions and upgrades to existing treatment plants shall follow the same general principles as for new plants. However the Designer needs to be aware of a number of issues that are likely to arise when working on existing plants.

17.1.1 Site Survey

Before commencing work on additions to or upgrades of an existing treatment plant the Designer shall:

- (a) Obtain copies of all available drawings and documentation for the plant from the Design Manager;
- (b) Carry out a site survey of the areas affected by the new works in order to confirm the completeness and accuracy of existing documentation and to determine the condition of the existing installation.

Any issues arising from the site survey which may affect the scope or design of the new works shall be reported to the Design Manager.

It is strongly recommended that the Designer meets with plant operations and maintenance personnel on a regular basis during the design phase to brief them on the proposed works and to provide an opportunity for discussion and feedback. Such meetings shall be coordinated through the Design Manager and any proposed or requested design changes arising from them shall be referred to the Design Manager for approval.

17.1.2 Standards and Regulations

All new work shall conform to current Corporation, Australian and international standards and to current statutory regulations.

Some of the standards and regulations to which existing plants, particularly older plants, have been designed may have been superseded. In many cases this may be of little consequence. However the Designer will sometimes encounter compatibility or safety issues when interfacing with equipment or facilities built to superseded standards. This is particularly so when designing additions and upgrades to older plants that have been subject to several previous upgrades. In such cases the Designer shall identify the issues and propose solutions for consideration by the Senior Principal Engineer.

17.1.3 Safety and Environmental Issues

The conformance of existing facilities affected by the new works to current statutory requirements shall be checked. The Designer shall refer any non-conformances, particularly those which relate to safety or the environment, to the Senior Principal Engineer with recommendations for resolving them.

If the Designer becomes aware of any safety or environmental issues relating to existing plant or equipment, even though the plant or equipment may not be directly affected by the new works, the issues shall be referred in writing to the Senior Principal Engineer.

Such issues may include:

- (a) Plant or equipment that does not meet current safety or environmental regulations;

- (b) Existence of hazardous materials (e.g. asbestos) on the site;
- (c) Plant or equipment in poor or unsafe condition.

17.1.4 Numbering

Numbering of equipment and instruments for the new works shall be in accordance with this standard and Section 4 of the Corporation's "DS80 WCX CAD STANDARD Manual".

Before allocating any new numbers, the Designer shall check if any blocks of numbers have been reserved in the existing scheme for future additions. If any such blocks exist they shall be allocated first. For instance if the plant includes three equipment items of a particular type and a fourth item is to be installed, numbering for the new item may already have been allocated by a previous designer.

Where numbering has not already been allocated, numbering of new equipment and instruments shall continue existing sequences. For example if the last number used in an existing area is 1534, the new equipment numbering could start from 1540. (It is recommended that a gap be left between the old and new numbers.)

Numbering in some older plants may have been carried out to older standards not compatible with the current practice specified in the DS80 WCX CAD STANDARD Manual. Generally it is not feasible to renumber existing equipment and instruments to conform to current practice, so a compromise system must be adopted. Such cases shall be referred to the Design Manager.

Above all, numbering of new equipment and instruments shall follow a logical method which is consistent as far as possible with existing practices at the plant.

17.2 Electrical Equipment and Cabling

The Senior Principal Engineer may require that existing electrical equipment and cabling affected by the new works be upgraded or replaced if it has insufficient capacity for the additional loads, does not conform to current Corporation standards, is in poor condition or is nearing the end of its useful life.

17.3 Hazardous Areas

The Designer shall carry out a full review of existing hazardous area classifications for those areas affected by the new works. Existing areas shall be reclassified where necessary when the hazardous areas created by the new works overlap existing plant, or the new works are within an area that is already classified as a hazardous area.

Re-classification shall be undertaken in accordance with HA-ST-02: EEHA Classification Manual with the existing site hazardous classification report updated.

When the new works affects the hazardous area classification of existing plant areas, the Designer shall review existing electrical equipment in those areas to ensure they are suitable for the new classification.

If the Designer becomes aware of any hazardous area non-conformance issues relating to existing plant or equipment not affected by the new works, the issues shall be referred in writing to the Senior Principal Engineer.

The existing Hazardous Area Verification Dossier shall be kept up to date at all times by the addition of new material from the new works as components and systems are designed, installed and commissioned and brought on line.

APPENDIX 1 – CONTROL, INSTRUMENTATION AND SCADA SYSTEMS

1 HYDRAULIC SURGE VESSELS

Hydraulic surge vessels to be installed at pump stations within treatment plants shall be designed and specified in accordance with Appendix A1 of Design Standard DS22.

2 PLANT CONTROL SYSTEM OVERVIEW

2.1 General Requirements

This section sets out the general requirements of control systems for water and wastewater Treatment Plants being acquired by the Corporation. It does not address all issues that will need to be considered by the Designer in respect of a particular Treatment Plant.

The following sections of this design standard are intended for the guidance of control system designers. They are not intended as a type specification for equipment or installation work and shall not be quoted in specifications for the purpose of purchasing equipment or installations except as part of the prime specification for a major design and construct contract.

The Designer shall refer to Section 1.3 of this Design Standard on the use of type specifications and Corporation standard designs.

2.1.1 Abbreviations

The following abbreviations shall apply:

ACS	Automatic Control System
CD	Compact disk
CPU	Central processing unit
DTE	Data terminal equipment
I/O	Input/output
LAN	Local area network
PACC	Plant area control cubicle
PACS	Plant area control system
PC	Personal computer
PCS	Plant control system
PLC	Programmable Logic Controller
RTU	Remote Telemetry Unit
ROM	Read-only memory

R/W	Read/write
SOE	Standard operating environment
SCADA	Supervisory control and data acquisition system
UPS	Uninterruptible power supply
VSC	Variable-speed controller

2.1.2 Definitions

2.1.2.1 Plant Area Control System (PACS)

Treatment plants are usually divided into a number of separate physical and/or operational areas, reflecting the plant's layout and the stages of the treatment process. The division into areas facilitates design, documentation, operation and maintenance of the plant.

The control system design shall reflect this division. Control of each treatment plant area shall be autonomous and independent of other treatment plant areas except where it is necessary to coordinate particular functions between areas.

For the purposes of this standard, Plant Area Control System (PACS) shall mean the PLC(s) and associated ancillary equipment which form an autonomous controlling system for the switchboard(s) and associated drives and other electromechanical output devices in a particular treatment plant area. The term Plant Area Control System shall be deemed to include all instruments and controlling equipment specific to that particular treatment plant area.

Where coordination of a particular function is necessary between Plant Area Control Systems, one such system shall provide coordinating control over the other.

2.1.2.2 Plant Area Control Cubicle (PACC)

For the purposes of this standard the Plant Area Control Cubicle shall mean the cubicle which houses the PACS PLC(s).

2.1.2.3 Automatic Control System (ACS)

For the purposes of this standard, Automatic Control System (ACS) shall mean the combination of all Plant Area Control Systems in the treatment plant.

2.1.2.4 Supervisory Control and Data Acquisition (SCADA) System

For the purposes of this standard, the superordinated controlling system for the Automatic Control System shall be known as the Supervisory Control and Data Acquisition (SCADA) System and shall be deemed to include the primary and where required, standby servers; on-site and off-site workstations; data storage and retrieval systems; and associated equipment including connections to the Corporation's corporate network.

The Supervisory Control and Data Acquisition System shall monitor the operation of the various Plant Area Control Systems which make up the Automatic Control System and shall be capable of issuing commands and set points to the latter. However all automatic control functions shall be executed within the various Plant Area Control Systems.

2.1.2.5 Plant Control System (PCS)

For the purposes of this standard, Plant Control System (PCS) shall mean the SCADA system together with the Automatic Control System.

Typical PCS block diagrams for major and minor treatment plants are shown at Fig. 2.1 and 2.2 respectively.

2.1.2.6 Process

“Process” refers to a specific operation or a stage of the treatment carried out at the plant.

2.1.2.7 Standard Operating Environment (SOE)

Standard Operating Environment (SOE) shall mean the Corporation’s standard operating environment for computing equipment including operating system, security and application software, as defined in the Corporation’s DS40 series of Design Standards.

2.1.3 Automatic Control System (ACS)

The function of the ACS is to control and protect the plant to meet the parameters set by operators. It does this by:

- (a) Monitoring inputs from sensors and instruments in the field;
- (b) Responding to commands from the field and from the SCADA system;
- (c) Directly controlling equipment and processes in response to field inputs and operator commands according to logic programmed into its PLC(s).

2.1.4 Supervisory Control and Data Acquisition (SCADA) System

The SCADA system shall be the operator’s interface to the PCS. It shall be arranged so as to provide a “window” to the plant and to perform the following functions:

- (a) Display real-time operating data in a readily comprehensible form;
- (b) Allow operators to start and stop equipment and processes, adjust setpoints and the like;
- (c) Alert operators to abnormal or alarm conditions;
- (d) Facilitate on-site and off-site supervision of plant operation;
- (e) Enable the preparation of reports;
- (f) Collect and store trend and historical data;
- (g) Enable plant data to be transferred to the Corporation’s corporate data systems;
- (h) Via password protection, enable ACS and SCADA system program changes from on-site and off-site Workstations.

It is not the function of the SCADA system to control equipment or processes directly; all direct process control shall be carried out by the ACS.

2.2 System Architecture

2.2.1 Typical Arrangement

Figures 2.1 and 2.2 show typical PCS block diagrams for a major treatment plant and a minor treatment plant respectively. The following description applies to both figures where appropriate.

2.2.1.1 Fig. 2.1

- (a) The **PCS LAN** (Section 4.1 of this Appendix) links all components of the PCS. For all but the smallest plants it typically consists of one or more optical fibre cables. For major plants it is typically configured as a closed or self-healing ring to provide increased security. To further increase security, the use of dual redundant LANs may be considered. In major or complex plants where combined ACS and SCADA system traffic may result in unacceptable delays on a single LAN, it may be necessary to provide separate ACS and SCADA system LANs.
- (b) The LAN **switch** permits connection of one or more devices (DTEs) to the LAN
- (c) The **servers** shall be Corporate standard machines, running the Corporate Standard Operating Environment (SOE). For major sites, separate server hardware and operator Workstations are to be installed. Small sites may be combined server and workstation units.
- (d) A **primary server** is required for every plant.
- (e) A **standby server** is generally only required for major or critical plants. It shall be configured as a hot standby that will take over automatically in the event that the primary server fails.
- (f) All plants shall be connected to the Corporation's corporate network, allowing real-time plant data to be collected and stored by the Corporation's off-site Data Historian systems. The connection shall be either via a PCS workstation (using a separate network card to that used for the PCS LAN connection) or direct from the PCS LAN via a firewall. All Treatment Plants will be connected to the Utility Wide SCADA System. Connections may be different for Major and Minor Treatment Plants. Minor Treatment Plants may be connected via PSTN.
- (g) All ACS control functions shall be carried out by **PLCs** that communicate with field I/O, motor control centres, variable-speed controllers, local control stations and other field devices.
- (h) Self-contained **vendor packages** shall communicate with ACS PLCs either by data bus (preferred) or by hard-wiring. Where vendor packages include PLCs they shall communicate with ACS PLCs by data bus.
- (i) Local **graphic display panels** shall be interfaced directly to ACS or vendor-provided PLCs and shall provide a local operator interface to specific processes or equipment items.
- (j) **Ancillary systems** tend to be specific to each plant but may typically include such things as power system monitoring and protection, on-site generation controls and the like. (Telephone, paging, closed-circuit TV, fire detection and security systems shall not be connected to the PCS LAN but shall be provided with separate communication paths.)
- (k) **Workstations** shall be desk-top PCs and portable notebook PCs running the Corporate Standard Operating Environment (SOE).
- (l) **Printers.** For medium/major plants one or more colour printers and one or more high speed monochrome, laser printers shall be provided. For small plants, at least one A4-size colour printer shall be provided.
- (m) A **radio paging** system shall be provided for major or critical plants to alert operators to the occurrence of critical alarms or other conditions requiring immediate attention. The paging system shall be interfaced to the primary server, with a backup system at the standby server if applicable.
- (n) **Remote access** facilities shall be provided to allow secure dial-up or network access to the PCS by operators and other authorised personnel. For major plants having a Corporate network

connection, remote access shall be via the Corporate network. The remote access system shall provide the same facilities for off-site operators and maintenance personnel as the normal on-site Workstations. Design of Corporate Network system is to be done by ISB/CSC. ISB/CSC can be engaged via the LTM/PTM form.

2.2.1.2 Fig 2.2

(Refer end of document)

2.2.2 Automatic Control System (ACS)

The ACS is the combination of the separate Plant Area Control Systems (PACS). It provides automatic control of the entire plant, independently of the SCADA system.

2.2.3 Plant Area Control Systems (PACS)

Each PACS shall consist of one or more interconnected PLCs installed in a plant area control cubicle conforming to Type Specification DS26-26. Each plant area control cubicle shall be installed in a secure indoor area near the equipment that it controls. Allocation of control functions to plant area control cubicles shall reflect the treatment process stages and the physical plant layout.

As far as possible, all control and monitoring of a particular process or equipment item shall be carried out by one PLC. The Designer shall avoid splitting control of a process or equipment item between PLCs as this tends to increase the complexity and reduce the reliability of the control system.

If it is necessary to provide interlocks to or from other PLCs – for example where there are dependent processes in other areas – the interlocks shall use direct PLC-to-PLC communications over the LAN unless there is a safety issue involved, in which case the interlocks shall be hard-wired. To ensure the functional independence of each PACS, process interlocking and other PLC-to-PLC communications shall not depend on the SCADA system.

Interlocks between PLCs shall be continuously supervised. In the event of communications failure the PLCs shall attempt to re-establish communications; such attempts shall not interfere with other system communications. If communications cannot be re-established within a reasonable time an alarm shall be raised and the local process or equipment item shall default to a safe mode of operation or, if this cannot be ensured, shall shut down safely.

Where there are numbers of identical process units (e.g. multiple pumps, filters, screens, sedimentation tanks and the like) the Designer shall distribute control of the identical units evenly over two or more PLCs so that failure of any one PLC will not result in the loss of all units.

Where the units have unusually complex control requirements or are particularly critical to plant operation each shall be controlled by its own dedicated PLC. Where operation of the units needs to be closely coordinated (for example a group of pumps or blowers discharging into a common header) consideration shall be given to providing individual unit PLCs with a master PLC to carry out common control and coordination functions if appropriate. Such considerations may include:

- (a) Treatment plant availability. Multiple process lines to allow a level of redundancy, such that if one PLC failed the plant can run at reduced capacity.
- (b) Individual pump size falls under DS21 (Major Pump Stations), hence use a PLC for each pump and a common control PLC.
- (c) Where all pumps are considered 'minor' as defined in DS22, all controls should be housed in a single PLC.

The inputs and outputs belonging to each identical process unit shall be allocated to separate I/O racks or modules.

As far as the nature of the process permits, the design of the ACS shall ensure that:

- (a) Each PLC will continue to monitor and control the equipment and processes allocated to it notwithstanding failure of other PLCs, communications or the SCADA system; and
- (b) Failure of a single PLC will not lead to plant shutdown, though plant operation may be limited.

PLC requirements are described further in Section 3 of this Appendix and in Type Specification DS26-26.

The design of the ACS shall also allow for integration of:

- (a) PLCs provided as part of vendor equipment packages;
- (b) Local control panels and displays provided as part of an equipment package (for example the proprietary control panel for a chemical batching plant);
- (c) Control stations and display units necessary to facilitate operation, for example to allow testing, startup or maintenance of a particular piece of equipment.

As far as possible the interface between the ACS and such equipment shall be by means of an approved data bus system (see section 4 of this Appendix) in preference to hard wiring.

2.2.4 SCADA System

The architecture of the SCADA system shall conform to the appropriate model in the Water Corporation's SCADA Infrastructure Plan.

For major plants the supervisory control hardware, including primary server, workstations and printers, shall be housed in a secure control room in the plant's administration building. For minor plants it is acceptable to locate the equipment in a plant office or amenities building providing that the area in which it is located is clean and can be adequately secured.

For increased security the standby server (if provided) shall be installed in a separate building if possible or at least in a fire-separated area of the same building.

For all plants, facilities shall be provided to connect a portable workstation (notebook computer) at each plant area control cubicle.

In major plants it is usual to provide local control rooms with permanent workstations in major process areas. The need for, and location of, local control rooms shall be determined in consultation with the Design Manager, process designers and plant operators. Issues to be considered include:

- (a) Physical size and complexity of the plant;
- (b) Operational efficiency – the ability to monitor particular processes with minimal distraction and without interfering with operations in other areas;
- (c) Operational convenience – the ability to monitor and make adjustments to processes and equipment from nearby, without having to go to the main control room;
- (d) Security and redundancy – in the event of failure of either the main control room or local control room equipment, supervisory control is still available from the other control room.

All rooms housing supervisory control hardware, whether central or local, shall be air-conditioned, provided with dust filters and, where necessary to ensure a non-corrosive environment, provided with activated carbon filters.

2.3 Control Philosophy

2.3.1 Control Modes, Control Location and Hierarchy

2.3.1.1 Control Mode Selection

In general, each process and equipment item shall be capable of being controlled either automatically (AUTO control mode) or manually (MANUAL control mode) or of being turned off (OFF mode).

Control mode selection shall be available from the applicable PACS and from the SCADA system. Selection at the PACS shall be via switches or pushbuttons on the plant area control cubicle, motor starter module or equipment control panel. Selection from the SCADA system shall be via the operator workstations.

Control mode selection from the PACS shall operate as follows:

- (a) When AUTO is selected, the SCADA system shall take control of the process or equipment item as described below. This is the normal mode of operation.
- (b) When MANUAL is selected, the process or equipment item shall be manually controllable from the plant area control cubicle, motor starter or equipment control panel. Control from the SCADA system shall be prevented.
- (c) The OFF mode shall inhibit starting of the process or equipment item and shall shut it down if already running.

Control from the SCADA system shall only be possible when AUTO is selected at the PACS, i.e. control shall be delegated upwards from the PACS to the SCADA system.

Assuming that AUTO has been selected at the PACS, control mode selection from the SCADA system shall operate as follows:

- (d) When AUTO is selected at the SCADA system the process or equipment item shall be automatically controlled by the program configured in the PACS, with supervisory control from the SCADA system. This is the normal mode of operation.
- (e) When MANUAL mode is selected at the SCADA system the process or equipment item shall be manually controllable from the operator workstations, e.g. by configured buttons or keystrokes.
- (f) The OFF mode shall inhibit starting of the process or equipment item from the SCADA system and shall shut it down if already running.

2.3.1.2 Control Location Selection

In some cases it may also be necessary to be able to control an item locally, i.e. adjacent to the item itself. This is typically the case with motorised valves and penstocks. In such cases a LOCAL/REMOTE selector shall be provided and shall be located in the field, on or adjacent to the item itself.

2.3.1.3 Control Hierarchy

Emergency stops and primary protection devices (refer Corporation design standard DS21 part 9.5) shall take precedence over all other controls and shall not be capable of being overridden.

Control mode selection at the PACS shall override control mode selection from the SCADA system.

The control hierarchy is illustrated diagrammatically in Fig. 2.3.

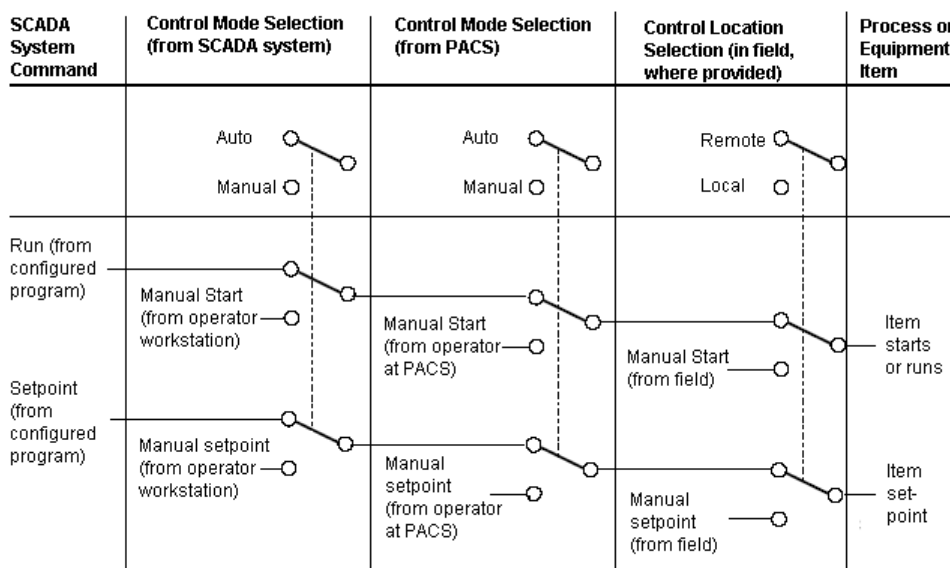


Fig. 2.3: PCS control hierarchy.

2.3.2 Equipment Status, Faults and Alarms

The status of each process or equipment item shall be continuously monitored and reported to the PCS regardless of which control mode is selected. Information to be reported shall include "AVAILABLE", "ISOLATED", "RUNNING", the current control mode selection (AUTO/OFF/MANUAL) and, where applicable, information such as position, level, speed, stage in a process sequence and the like.

All faults occurring in any process or equipment item shall be automatically reported to the PCS regardless of which control mode is selected. Each fault condition for which a separate sensor or protective device is provided shall be reported separately so that the cause of the problem can be identified remotely; grouping of multiple faults under general descriptions such as "fault", "not available" or the like provides little useful information and shall be avoided.

Fault conditions shall be classified as follows:

- **Warning** faults are non-critical faults that indicate undesired or abnormal operation. They require attention but are not cause for immediate shutdown. Warning faults may develop into shutdown faults if not attended to.
- **Shutdown** faults are critical faults that require immediate shutdown of the equipment in order to avoid danger to personnel, damage to equipment or serious process disturbance.

The PCS shall take the following action on occurrence of a fault:

- (a) Warning fault

- (i) A warning alarm shall be raised.
 - (ii) Corrective action shall be initiated automatically where appropriate (e.g. start standby or additional units).
 - (iii) The fault and subsequent actions shall be reported and logged by the SCADA system.
- (b) Shutdown fault
 - (i) A shutdown alarm shall be raised.
 - (ii) The ACS shall turn the item OFF. Further operation shall be prevented until the alarm has been acknowledged and reset.
 - (iii) Corrective action shall be initiated automatically where appropriate (e.g. shut down dependent processes, revert to alternative modes of operation, start standby or additional units).
 - (iv) The fault and subsequent actions shall be reported and logged by the SCADA system.

The PCS shall allow alarms to be acknowledged from the workstations but it shall not be possible to reset an ACS alarm unless the cause has been removed and the alarm reset in the field.

2.4 Sub-Systems

The sub-systems likely to be encountered in treatment plants can be classified into two general types as follows.

2.4.1 Standard Products

Standard products are “off-the-shelf” items of more or less standard design that are manufactured in quantity and intended for general use. Generally the treatment plant designer has little control over product design and must select the most suitable type from the available models and options. Examples include variable-speed controllers, valve actuators, dosing pumps, air compressors and the like.

Standard equipment shall be selected in accordance with the following principles:

- (a) Specify equipment from the Corporation’s Preferred Equipment List or in accordance with the relevant Type Specification in the DS26 series.
- (b) If the equipment is not covered by either of the above, a suitable performance specification shall be prepared.
- (c) Select the control options that most closely conform to the philosophy set out for Vendor Equipment Packages (see section 2.4.2 of this Appendix). The equipment shall be specified to accept the types of control signals and provide the types of alarm and status signals that will enable it to be integrated as smoothly as possible into the overall control system.
- (d) Select equipment having a recognised, compatible communications interface and which provides a data bus connection to the controlling PLC rather than hard-wired I/O.
- (e) If available, select equipment that can be configured remotely from the PCS.

2.4.2 Vendor Equipment Packages

The term “Vendor Equipment Package” covers equipment that, while it may be of more or less standard design, is manufactured or assembled to order. The Designer, as specifier, will generally have at least some control over the type of equipment and control interface provided. Examples include filters, chlorinators, chemical batching and dosing plants, aeration blowers, gas flares and the like.

Small control panels (and generally not complex) for vendor equipment packages shall comply with the requirements of clause 10.9. Major control panels for vendor equipment packages shall comply with DS26-26 where appropriate. If the package includes PLCs they should preferably be of the same type as the ACS PLCs but must at least communicate with the ACS PLCs via a standard data bus. More complex equipment packages shall be provided with graphic display and touch panels communicating by data link with the package PLC. Simple packages may use panel-mounted switches, pushbuttons, indicators, alphanumeric displays and the like.

Equipment packages shall include an AUTO/OFF/MANUAL control mode selector and shall be specified with a control interface that will allow the PCS to control them as a unit. The interface shall typically operate as follows:

- (a) When power is applied to the package, when all its alarms have been reset, when all its subsystems and equipment items are ready and provided its control mode is not set to OFF it shall signal to the PCS that it is available for operation.
- (b) If the package’s control mode is set to OFF it shall not be possible to start it under either auto or manual control. If already running it shall shut down. Selection of the OFF mode shall immediately signal to the PCS that the package is not available.
- (c) If the package’s control mode is set to MANUAL it shall be under the exclusive control of its local control panel or control stations. PCS commands shall have no effect.
- (d) If the package’s control mode is set to AUTO it shall transmit a signal to the PCS to indicate this. Providing the package is available for operation the PCS shall then be able to initiate or terminate its operation by issuing or withdrawing a start command.
- (e) On receipt of the PCS start command the package’s local controller shall manage all start-up sequencing and protection functions for the drives and other equipment that make up the package.
- (f) As soon as the package has successfully completed its start-up sequence and is running normally it shall transmit a RUNNING signal to the PCS.
- (g) The package shall continuously monitor itself whether running or not and shall transmit information to the PCS indicating the status of its components. The package controller shall automatically and independently take appropriate action in the event of a fault and shall transmit detailed alarm and diagnostic information to the PCS.
- (h) Local alarm and status indication shall be provided for each drive or equipment item and for the package as a whole. Local indication shall typically include status for each drive or equipment item and alarm indication for each fault condition.

2.4.3 Small Vendor Equipment Control Cubicles

Vendor equipment packages are supplied with proprietary control systems that must be housed in suitable enclosures appropriate to the environment where they are to be deployed. Such small control cubicles:

- (a) Shall comply with the requirements of “Type Specification for Low Voltage Switchboards General Requirements DS26-09” where appropriate.
- (b) Shall have a degree of protection rating of not less than IP56 where installed outdoors.
- (c) Shall have a degree of protection rating of not less than IP53 where installed indoors.
- (d) Shall have all equipment housed behind hinged lockable doors with no equipment placed on the external doors of the cubicles, where installed outdoors.
- (e) May have equipment mounted on the external door of indoor cubicles provided the degree of protection rating is suitable for the environment and the operation and maintenance activities performed in the area and, in any case, not less than (c) above.
- (f) Shall be suitably labelled as to describe the function.

2.5 Access and Security

2.5.1 Levels of Access

To maintain security the PCS shall provide several password-protected levels of access appropriate to the needs and authority of different users. The levels of access and the user rights at each level will depend on the nature of the plant but typically include the following.

2.5.1.1 Visitor Level

“View only” access to designated graphics pages, trends, lists and reports. Cannot perform any control actions or modify any settings. Visitor Level shall normally be the default level and need not require a password.

2.5.1.2 Operator Level

Access to all plant control graphics pages, trends, lists and reports. Can start and stop designated equipment and processes, change designated set-points, acknowledge and reset designated alarms, print reports etc.

2.5.1.3 Supervisor Level

Unrestricted access to all plant control graphics pages, trends, lists and reports. Can start and stop equipment and processes, change set-points, acknowledge and reset alarms, print reports etc. Can reset Operator Level passwords.

2.5.1.4 Engineer Level

Unrestricted access to all graphics pages, trends, lists and reports. Access to PCS configuration and programming. Can upload, modify and download ACS PLC programs and SCADA system configuration. Under particular circumstances (e.g. during commissioning) may be permitted to start and stop equipment and processes, change set-points, acknowledge and reset alarms, print reports etc.

2.5.1.5 Administrator Level

Unrestricted access to all graphics pages, trends, lists and reports, system configuration and system information. Access to PCS configuration and programming. Can install and remove software. Can modify server and workstation configuration and communications settings. Can reset all passwords.

3 PCS HARDWARE AND SOFTWARE

3.1 Programmable Logic Controllers

3.1.1 Type

PLCs shall conform to the requirements of Type Specification DS26-26 (Type Specification for plant area control cubicle) in addition to the requirements of this standard.

PLCs shall be capable of carrying out all the required control, including logic, sequencing and analogue control. The use of separate hardware logic or loop controllers shall be avoided.

In the event of SCADA system or communication failure, each PLC shall be able to continue operating on its last settings, independent of other PLCs and of the SCADA system and without the need for an operator interface.

3.1.2 PLCs Supplied with Vendor Equipment

Although PLCs supplied as part of vendor equipment should preferably be of the same type as the ACS PLCs, in practice this is not always achievable. For example the vendor may have standardised on a different type of PLC. Substitution of the plant standard PLC would require the Vendor to rewrite and re-test existing proven software which may not be desirable or feasible. In such cases the Vendor's PLC may be accepted providing it is of acceptable quality, has adequate local support including service and spare parts, and can communicate with the ACS PLCs via a data link using a compatible communications protocol. The vendor shall be made responsible for configuring, commissioning and proving the link.

3.1.3 Location and Installation

PLC equipment shall be installed in plant area control cubicles conforming to DS26-26. As a general rule plant area control cubicles shall be separate from switchgear or power electronic equipment. In any case adequate separation shall be maintained between PLCs (including remote I/O racks, power supplies, accessories and associated cabling) and electrical switchgear, variable-speed controllers and their associated cabling in order to avoid conducted or radiated electromagnetic interference.

3.1.4 LAN Communications

All PLCs shall be supplied with standard communications interfaces (e.g. Ethernet, Profibus) to suit the PCS LAN and field communication requirements of the plant (refer to section 4 of this Appendix). PLCs shall allow read/write access to registers and program upload/download via the PCS LAN.

It shall be possible to back up to or download from the SCADA system server on demand the programs and configuration of any PLC connected to the PCS LAN. All the PLCs shall be configurable online via the PCS LAN.

3.1.5 Hardware

PLCs shall be of modular rack-mount construction. Module addresses shall be software selectable so that it is possible to insert any module in any slot. With power applied it shall be possible to insert or remove any PLC module without damage to the module.

All modules shall incorporate operational status indicators.

Scan time (the time required to read all inputs, solve all networks and update all outputs) shall not be more than 50ms and ideally should be less than 20ms. The Designer shall limit the I/O count and

amount of program code per PLC if necessary to achieve this. Counter input modules shall be used for high-speed counting applications.

Power supply to PLCs and I/O shall be backed up by UPS (if AC supply is required) or battery (if DC supply is required) and shall be sized to provide at least 25% spare capacity. UPS or battery backup time shall suit the application but in any case shall not be less than 0.5 h at maximum PLC load. In critical applications duplicate power supplies with no-break changeover shall be provided and shall be arranged so that either supply can fail and be replaced on line without affecting PLC operation.

3.1.6 Inputs and Outputs

Inputs shall be fuse-protected in groups corresponding to discrete processes or equipment items so that a fault on any input group will not cause loss of inputs belonging to other processes or equipment items.

Digital outputs shall be voltage-free relay contacts, preferably with no common connections. Care shall be taken to ensure that the load on each output is consistent with the PLC contact rating and will not limit contact life unduly. Solid-state outputs shall be provided where high switching rates are involved.

All digital I/O modules shall incorporate status (on/off) indicators for each input and output.

Analogue inputs shall generally be 4-20mA, but other types of analogue inputs (e.g. thermocouple, RTD) shall be provided where appropriate.

Resolution of analogue inputs and outputs shall be equivalent to 12-bit with a linearity of ± 1 bit and a repeatability of $\pm \frac{1}{2}$ bit. Any analogue input that falls outside the range of the analogue-to-digital converter shall initiate an alarm.

Calibration of analogue I/O modules shall be carried out in software without the need for any physical adjustments on the I/O module, so that module replacement shall not require physical re-calibration.

Analogue values used in PLC programs shall be in engineering units. Conversion to or from engineering units shall take place at the I/O modules.

Inputs and outputs shall be allocated so that failure of any I/O module will affect the minimum number of processes or equipment items. I/Os for duty and stand by equipment shall be allocated to different modules.

Allocation and numbering of I/Os shall follow a logical and consistent pattern. Where there are several identical processes or equipment items, I/O numbering for each shall correspond.

3.1.7 Field Connections

Facilities for connecting field cables to PLC I/O shall meet the following requirements:

- (a) They shall enable individual field cable cores to be connected to adjacent terminals sequentially in core order;
- (b) They shall facilitate neat, orderly wiring with ready access to all terminations;
- (c) They shall enable field wiring to be easily connected, disconnected and tested without disturbing adjacent wiring or risking damage to PLC I/O modules or other hardware.

The use of marshalling terminals assists in meeting the above requirements and is preferred. However subject to the above requirements being met, field cables may be terminated direct to PLC I/O if the I/O units are of a sufficiently robust design and are specifically intended for this purpose

For plant area control cubicles with large amounts of hard-wired I/O it is convenient to provide two sets of marshalling terminal rails; a PLC rail with terminals connected sequentially to the PLC I/O module terminals and a field rail to which each field cable is connected sequentially in core order. This arrangement is often advantageous for fast-track projects because it allows PLC I/O wiring and field cables to be terminated before PLC I/Os are allocated. Once PLC I/Os have been allocated, the two rails – which shall be mounted adjacent and parallel to each other – are linked by jumper wires. The Designer shall employ this method where appropriate.

For smaller plant area control cubicles a single terminal rail may be provided. In this case the rail terminals shall be arranged to allow field cables to be connected sequentially in core order, with jumper wires from the rail to the PLC I/O terminals.

Individual and overall cable screens shall be earthed to an instrument earth bar at the PLC end only, unless otherwise recommended by the instrument manufacturer.

Marshalling terminal and earthing arrangements shall be shown on the detailed design drawings.

3.1.8 Diagnostics

PLCs shall include visual alarms to indicate system malfunctions such as watchdog timer fault, faulty or missing I/O modules, power supply failure or low battery volts.

The CPU shall incorporate self-test diagnostics which shall run at switch-on and periodically during normal operation. It shall also be possible to initiate a self-test manually. The self-test diagnostic checks shall typically include:

- (a) Power supplies;
- (b) Corruption of ROM/RAM contents;
- (c) RAM read/write ability;
- (d) Correct operation of CPU;
- (e) I/O module communications and integrity of interconnections including backplane;
- (f) I/O complement (missing/faulty modules).

No false actions, outputs or alarms shall occur as a result of running diagnostic checks.

In addition the PLC shall continue to report any overrides (“forces”) that have been set until the overrides are reset.

3.1.9 Programming and Documentation

All programs shall include detailed annotation and descriptions to facilitate ongoing operation and maintenance. AS4008 is referred in this regard. An electronic copy of the as-commissioned program and a hard copy of the fully-annotated program documentation shall be included in the plant operation and maintenance manual.

3.2 SCADA system

3.2.1 General Requirements

The SCADA system shall be based on a software package conforming to the Corporation's current standards. The Corporation will from time to time arrange corporate licences for its preferred SCADA software. Such software shall be treated as "Principal-supplied". The software package shall run on server and workstation PCs.

The Designer shall ensure that sufficient software licences are provided to allow concurrent use of all servers and workstations, including offsite workstations and notebook computers used by visiting engineering and maintenance staff.

3.2.2 Hardware

Unless otherwise directed by the Design Manager, computing and networking hardware for use in Treatment Plants shall be sourced through the Corporation's IT supplier and shall conform to the corporate requirements for such equipment. The equipment shall be loaded with the applicable Corporate SOE.

See also Section 2.2.1 of this Appendix. SCADA system hardware shall typically include:

- (a) Primary server and, where required, backup server. Servers shall be either mid-range (for major plants) or small-range (for minor plants) servers. Each server shall be provided with server support hardware (monitor, keyboard, mouse etc.).
- (b) One or more workstations. Workstations shall be desktop PCs comprising computer, monitor (minimum 17-inch diagonal LCD, or equivalent CRT), keyboard and mouse.
- (c) A backup CD-R/W drive for each server, enabling plant data, PLC programs and SCADA system configuration to be backed up to CD-ROM.
- (d) One or more A4 colour and/or monochrome printers. Inkjet printers are suitable for situations where usage is likely to be light to moderate. Laser printers shall be used where there is likely to be heavy usage. For smaller plants printer usage is likely to be low and infrequent; printers shall therefore be of a type that will continue to operate reliably under such conditions. Colour printers shall be four-colour, i.e. of the type that uses both a colour and a black ink cartridge. On major plants with multiple workstations, printers shall be attached directly to the network rather than to individual workstations.

Uninterruptible power supply with a backup time of at least 0.5 hour shall be provided for all SCADA system hardware. Depending on the location of the plant and the reliability of the normal power supply, backup time may need to be increased beyond this.

3.2.3 Architecture

The SCADA system shall be based on a standard client-server architecture and shall be capable of being extended by the addition of extra servers, workstations, PLCs or other components without the need to replace existing hardware or software.

The SCADA system shall support the use of a redundant standby server if required, with automatic transfer of tasks to or from the primary server in the event of failure of either.

The SCADA system shall be able to read data from and write data to all devices on the PCS LAN. The design of the system shall ensure that data transfer is sufficiently fast to allow updating of the SCADA database and screens within one second.

Where required the SCADA system shall be able to support dual LANs – either separate ACS and SCADA LANs or dual redundant PCS LANs.

The primary server shall support periodic backup, both automatically and manually initiated, of the complete system configuration and database. Data shall be backed up either to the standby server or to removable media (e.g. CD, removable drive etc.).

3.2.4 Access

The SCADA system shall support a minimum of five password-protected levels of access from any workstation in the system. All screens and all operator functions shall be available from each workstation subject only to access level rights.

3.2.5 Displays and Graphics

All graphics pages shall be designed using the standard Water Corporation Template for the particular SCADA software.

Graphics pages shall be organised in a hierarchical structure, shall display real-time plant data and shall include:

- (a) one-page plant overviews (geographic and schematic);
- (b) one or more pages for each process area;
- (c) summary and detail pages for particular processes or equipment as necessary;
- (d) pages for plant services (e.g. electrical power, water and chemical dosing reticulation);
- (e) pages for PCS block diagrams and data communications networks.

All pages shall employ live graphics and animation where necessary to enable current plant status to be quickly visualised and to draw attention to abnormal situations. Pages shall be designed for ease of viewing, logical layout, readability and freedom from unnecessary detail or clutter.

Live graphics shall update within 0.5 s. Call-up time for any page shall not exceed 2 s.

The software shall include an easy-to-use graphics development package with extensive symbol libraries to enable pages to be modified or new pages designed quickly and easily.

3.2.6 Reports

The SCADA system software shall enable simple design and flexible formatting of reports. It shall be possible to include any combination of the following in reports:

- (a) user-entered text and formatting;
- (b) current and historical plant data;
- (c) summary and totalised data;
- (d) calculation results;
- (e) operator actions.

It shall be possible to:

- (a) generate reports automatically or on demand;
- (b) display them on the workstation screen;
- (c) print them;
- (d) save them to disk as text, word-processor documents, spreadsheets, databases, graphics or HTML/XML documents; and
- (e) save them to the Data Historian.

3.2.7 Alarms

Process, hardware and system alarms shall be time-stamped and displayed on the current page of the workstation, regardless of which page is currently selected. It shall be possible to sort and display alarms by time of occurrence, priority and status (unacknowledged or acknowledged) and to differentiate between alarm classes by display colour and font. It shall also be possible to hide alarms depending on the nature of the alarm and the user's access level. Display, sorting and hiding of alarms shall be individually configurable on each workstation.

The SCADA system shall also provide audible alarm indication, activation of the alarm paging system and activation of the remote alarm system for selected alarms.

The system shall enable generation of reports for the following classes of alarms:

- (a) loop alarms (e.g. high, high-high, low, low-low, deviation, and rate-of-change)
- (b) Active and cleared process and equipment alarms
- (c) Active and cleared PCS hardware alarms
- (d) Active and cleared SCADA system alarms

3.2.8 Data Logging and Trending

It shall be possible to log, trend or totalise any process variable, calculated value, event or operator action either periodically or on occurrence of specific events. Sample rates shall be selectable over a range of at least 0.5 s to 24 hrs. The SCADA system shall be configured to log system alarms, hardware failures, communication and network errors.

Trend and log data shall be sent to the Water Corporation's Data Historian. It may also be stored on the local server. It shall be possible to time-stamp trend and log records and to append user-defined fields or text to them. It shall also be possible to sort, filter and display logs according to user-defined criteria.

3.2.9 Programming and Documentation

Configuration and programming of the SCADA system shall be possible from each workstation with the SCADA system online and subject only to access level rights. The configuration and programming process shall be windows-based, intuitive and interactive.

The SCADA system software shall support an unlimited number of tag names of at least 20 alphanumeric characters each. The software shall allow tag lists to be developed in, and imported from, other programs, e.g. Microsoft Access, Microsoft Excel, text files and the like.

3.2.10 Help and Diagnostics

The SCADA system shall provide extensive on-line, context-sensitive, searchable help documentation and tutorials.

The SCADA system shall include comprehensive diagnostics capable of verifying and reporting on its own operation and the operation of peripheral devices, including I/O. Faults and diagnostic details shall be reported and logged automatically.

3.2.11 System Restart

On restoration of power following interruption, the SCADA system shall automatically re-boot without requiring operator intervention and, subject to the following, the SCADA software shall automatically restart and resume supervisory control of the plant.

Depending on the time for which the SCADA system has been shut down, resumption of automatic control shall be either:

- (a) Automatic, requiring minimal operator intervention; or
- (b) Manual, under operator control.

Following restart, the system shall be able to:

- (a) deal with the high volume of alarm traffic likely to be generated as a result of the failure without overloading;
- (b) recover data that was stored in system databases or was being retrieved from or transmitted to PLCs at the time of failure.

After hardware or software failure, the SCADA system shall be restarted manually.

3.3 Other PCS Components

3.3.1 Network switch units

Network switch units shall provide two Ethernet LAN backbone connections and at least four twisted-pair and/or fibre optic ports to suit the connected network elements (DTEs). Switch units shall permit remote configuration and fault diagnosis over the PCS LAN and shall support SNMP (Simple Network Management Protocol) monitoring.

3.3.2 Radio Paging

For medium/major plants a radio paging system shall be provided and shall be connected to the primary server, and to the standby server if provided. It shall be possible to configure any PCS alarm or group of alarms to activate any pager or group of pagers.

Each pager shall provide an audible alarm signal with at least two levels of urgency as well as a configurable text message identifying the time, urgency and details of the alarm.

3.3.3 Remote Access Router

A firewall-protected remote access router shall be provided and connected directly to the PCS LAN. The router shall permit at least two remote workstations to be connected concurrently to the PCS LAN over the Corporate wide-area network or over the public switched telephone network via dial-up modem connections.

3.3.4 Corporate Network Connection

For Major Treatment Plants, unless otherwise directed, the PCS LAN shall be accessible to the Corporation's wide-area network. The Designer shall refer to the Design Manager for details of requirements.

3.3.5 Local Display Panels

Local graphic display and control panels shall be selected using the Corporation's preferred equipment list as a guide. Colour graphic displays shall be provided where this will assist in making the displayed information clearer.

Display and control panels installed in outdoor locations shall be weatherproof and protected against deterioration due to high temperatures and ultraviolet radiation. Displayed text and graphics shall be clearly readable in direct sunlight.

Panel size shall be chosen so that the displayed text and graphics are large enough to be clearly readable from normal viewing distances.

Display and control panels shall communicate directly with a PLC via an industry-standard communications link.

3.3.6 Ancillary systems

Ancillary systems include any other network devices that need to communicate with the PCS LAN. These systems could include such things as:

- (a) Routers connecting to the PCS at another site, e.g. a satellite pump station or pre-treatment plant;
- (b) Gateways to other networks, e.g. a PLC sub-network using Modbus or other protocol which controls a power cogeneration installation;
- (c) Communications with a power system protection relay network.

3.4 PCS Factory Acceptance Tests

The Designer shall ensure that provision is made for Factory Acceptance Tests to be carried out on all PCS equipment at the supplier's premises or other suitable off-site location prior to delivery of any PCS equipment to site. The tests shall be carried out with all PCS hardware items (including servers, workstations, LAN switches, PACCs, PLCs, remote I/O racks, communications equipment and the like) interconnected exactly as they are to be connected on site and with all software (including PLC and SCADA software) installed and configured.

The purpose of the tests shall be to demonstrate that the PCS functions correctly in accordance with the Principal's requirements. Tests shall include:

- (a) Proving of LAN communications and (where there are redundant LANs) error-free communications transfer from a failed LAN to the healthy LAN
- (b) Proving of correct communications between all items
- (c) PLC-to-PLC communication tests within and between areas
- (d) Workstation tests

- (e) Error-free automatic transfer from a failed server to the backup server (if applicable)
- (f) Correct operation of all software including PLC programs and SCADA system configuration
- (g) PLC logic simulation tests
- (h) PLC-to-motor control centre tests (particularly where “intelligent” motor control centres are used)
- (i) PLC-to-equipment package tests
- (j) PLC-to-SCADA system communication tests
- (k) Proving of inbuilt diagnostic tests
- (l) Proving of immunity from electromagnetic interference

Where PCS equipment is to be delivered in stages, or where it is impractical to include equipment from other suppliers (e.g. motor control centre switchboards, variable-speed controllers, equipment packages) in the tests, partial tests are acceptable provided that the interactions of the missing items with the items under test can be adequately simulated.

4 DATA COMMUNICATIONS

4.1 PCS LAN

4.1.1 General Requirements

The PCS LAN links all components of the SCADA system and ACS down to the ACS PLC level. The LAN backbone and the connections to data terminal equipment (DTE) shall utilise Fast Ethernet (100 MBits/s) communications protocol. (This requires all ACS PLCs to be fitted with an Ethernet interface.)

The LAN shall be designed to carry the maximum volume of traffic expected under worst-case conditions with sufficient margin to allow for anticipated future expansion. Momentary overloads, due for example to the occurrence of large numbers of simultaneous alarms and events, shall not result in system shutdown or malfunction. It shall be possible to extend the LAN and to connect and configure additional equipment with the PCS on line and without interrupting system operation.

The LAN backbone shall consist of one or more optical fibre cables. On all but minor plants the LAN shall be arranged as a self-healing ring so a break at any one point will not result in isolation of any nodes.

Cabling within buildings may be twisted pair cable as specified in Section 4.1.2 of this Appendix, providing the total route distance does not exceed 50m.

For major plants where there is a high volume of traffic on the LAN, it may be necessary to provide separate ACS and SCADA LANs in order to keep transmission delays to an acceptable level.

For increased security in critical plants, physically-separated dual redundant LANs shall be provided, with automatic transfer from the failed LAN to the healthy LAN. This also requires duplication of network switches, PC and PLC interface cards and other equipment.

In special circumstances the use of radio links or of a complete wireless LAN may be considered. Where the Designer believes that the use of wireless technology is appropriate, the matter shall be referred to the Senior Principal Engineer.

4.1.2 Transmission Media

4.1.2.1 Optical Fibre

Optical fibre cable shall comprise 62.5/125 μm multi-mode glass fibres having a loss not exceeding 1.5 dB/km at a wavelength of 1,300 nm unless there are sound technical reasons for using single mode fibres. (Although single-mode cable is generally less expensive and has greater bandwidth and lower loss than multi-mode cable, its cost advantage may be offset by more expensive terminal equipment and greater difficulty in jointing and terminating. In practice the bandwidth and loss of multi-mode cable are generally satisfactory for PCS LAN applications.)

Cable shall be of jelly-filled loose-tube construction, with external reinforcement, polyethylene sheath, nylon jacket and black PVC sacrificial sheath. It shall be suitable for installation underground either in conduit or direct buried. Cables shall be specified with a minimum of 4 cores and a minimum of 50% spare cores.

The design of optical fibre LAN cables and their associated equipment shall ensure reliable data transmission over a route length of at least 2 km without the need for repeaters.

For optical fibre that traverses or installed within hazardous areas the requirements of HA-ST-03: EEHA Selection and Installation Manual shall be adhered to.

4.1.2.2 Twisted-Pair

Twisted-pair cable used in LAN applications shall be Category 5e or Category 6 unshielded twisted pair (UTP) cable to IEC 11801. Sheath colour shall be grey. To avoid confusion with cables of intrinsically-safe circuits, blue-sheathed UTP cable shall not be used.

4.1.2.3 Radio Link

Point-to-point or point-to-multi-point radio links, if used, shall be based on the IEEE 802.11 series of standards. Links shall utilise frequency-hopping spread-spectrum technology. Transmission shall be full duplex at not less than 115 kBits/s. The design of the system shall incorporate appropriate security to prevent unauthorised access.

4.1.3 Installation

To provide additional mechanical protection above-ground optical fibre cables shall be installed in conduit, separate from electrical power cables, whether surface-run, in trenches or on ladder or tray. Optical fibre cables intended for direct burial may be installed underground without further protection.

Permanently-installed UTP cable (i.e. excluding patch leads) shall be installed in conduit. UTP cable shall be separated from other cables by at least 0.5 m where possible. UTP cable shall not be installed out-of-doors or underground except for runs of up to 20 m between adjacent buildings, where it may be installed underground in conduit.

Where dual redundant LANs are provided, a separation of at least 2 m within buildings and 6 m elsewhere shall be maintained between the two LANs where possible.

4.2 PCS Communications with Process Equipment

The types of process equipment likely to be encountered in treatment plants which require an interface to the PCS include:

- (a) Motor control centres
- (b) VSC units
- (c) PLCs included in vendor equipment packages
- (d) Proprietary controllers
- (e) Graphic display panels

Wherever possible, interfaces between ACS PLCs and process equipment shall utilise a widely-supported open data communications interface rather than hard-wired I/O. Hard-wired interfaces shall be avoided due to their greater complexity, higher cost of installation and maintenance and poorer reliability due to the larger number of connections.

The software in the ACS shall monitor all process equipment communications links. If a communications failure is detected alarms shall be generated at the SCADA system. The relevant PACs shall automatically cause the equipment to revert to a safe mode of operation or, if this cannot be ensured, shall shut it down safely.

Where possible, process equipment shall incorporate facilities to detect loss of communication with the ACS and shall be configured to revert to a safe state automatically if communications fails.

(Table deleted)

Note that the ACS PLCs with which the process equipment communicates will need to be fitted with the appropriate communications interface modules.

Data communications cables shall be as required by the particular communications standard or as recommended by the equipment manufacturer.

Low-speed communications over route lengths exceeding 150 m and high-speed communications over route lengths exceeding 50 m shall utilise optical fibre cables in accordance with Section 4.1.2(a) of this Appendix where possible.

High-speed communications not exceeding 50 m route length and contained within the one building, or low-speed communications up to 150 m route length whether indoor or outdoor, may use either optical fibre or suitable screened twisted-pair cable. However in order to reduce susceptibility to surges, optical fibre cables are preferred for all outdoor data communications where feasible.

Where metallic cable runs out-of-doors, whether underground or not, it shall be fitted with surge suppressors at both ends in accordance with DS25. Metallic data cables shall be separated from power and control cables by at least 0.5 m where possible. Cable screens shall be earthed at the PLC rack end and insulated from earth at the process equipment or field end.

4.3 Communications with Field Instruments and Control Devices

The most suitable type of communications to be used between field instruments and control devices will depend on the type and complexity of the instrument or device.

For simple on-off devices such as limit, proximity, level, temperature and flow switches, solenoid valves and the like hard-wired I/O is generally the most appropriate choice at present.

For basic analogue instruments such as flowmeters and pressure, differential pressure, level, temperature and analyser transmitters a widely-supported open standard data bus connection shall be used if readily available. If not, conventional 4-20 mA hard-wired I/O may be used.

For more complex instruments or control devices such as valve actuators, vibration monitoring systems and automatic samplers a widely-supported open standard data bus connection shall be used in preference to hard-wired I/O.

The type of data bus shall be selected from the Corporation's Preferred Equipment List. Non-preferred data bus systems shall only be used with the approval of the Senior Principal Engineer.

Note that the controllers or PLCs to which the devices are connected will need to be fitted with the appropriate communications interface modules.

Where data bus communications are used and the total route length exceeds 150 metres or there is a risk of lightning strike, electrical interference or significant earth potential rise the links shall utilise optical fibre cable. In other cases suitable screened twisted pair cable, fitted with surge suppressors at both ends in accordance with DS25, may be used as an alternative.

Redundant or multiple paths shall be provided for multi-drop data bus connections to limit the extent of control loss should one path fail. Where there are duty/standby or multiple units a separate path shall be provided for each. The use of a single cable to connect all items creates a serious process control risk and shall be avoided.

It shall be possible to disconnect and reconnect individual equipment items on multi-drop data bus cables without disrupting communications to other equipment on the same path.

Metallic instrument cables shall be separated from power cables by at least 0.5 m where possible. Screens shall be earthed at the controller or PLC rack end and insulated from earth at the field end.

For further details of instrument connection requirements refer to section 5 of this Appendix, as well as to DS25.

5 PROCESS INSTRUMENTATION

5.1 General Requirements

Detailed design requirements for instrumentation systems and control devices, including primary elements, converters, transmitters, displays, controllers and control valves are given in Design Standard DS25.

This section covers requirements that are specific to treatment plants and provides additional guidelines for the selection and installation of the most suitable types of instruments and control devices for treatment plant applications.

5.1.1 Instrument numbering

Allocation of instrument numbers for new treatment plants shall follow the following process.

The Designer shall develop the instrument list from the P&ID, with the addition of control loop and process control system details. The list shall contain at least the following information:

- (a) Plant area
- (b) Instrument tag number
- (c) Instrument type
- (d) Location and purpose
- (e) Technical details (range, input, output, line size etc.)
- (f) Power supply,
- (g) Number of PLC inputs and outputs required
- (h) PLC to which connected

Instrument numbers shall be allocated according to Section 4 of the Corporation's "DS80 WCX Manual". Instrument numbers are generally of the form CC{C{C}} aannn, where:

- (a) CC{C{C}}, the instrument tag name, represents from two to four letters selected from Table 1 of ISA standard ISA 5.1 1984 (R1992) which identify the instrument's function;
- (b) aa represents the two-digit process area number from Section 4 of the DS80 WCX Manual;
- (c) nnn is a sequential 3-digit instrument loop number. For new plants the loop numbers should start from 001 in each process area.

For example: FT 15003 might be the third loop (a flow transmitter) in process area 15 (raw water pump station); PDSH 02001 might be the first loop (a filter high differential pressure switch) in process area 02 (reclaimed effluent services).

All instruments in a loop shall be allocated the same area and loop number but will usually be distinguished by different tag names. In rare cases where there are two or more instruments in a loop with identical tag names, a letter suffix may be added to the instrument number, e.g. ZS82012A, ZS82012B.

Guidelines for allocation of instrument numbers for upgrades or extensions of existing treatment plants are given in section 8 of this Appendix.

5.1.2 Loop diagrams

Instrument loop details shall be shown on PLC I/O drawings rather than conventional loop diagrams, however the information included in the drawings shall conform generally to the requirements of DS24 Section 21.

5.2 Instrument Specifications

5.2.1 General

General design requirements for instruments and control devices are covered in Section 2 of DS25.

5.2.2 Materials

Wetted parts and seals of instruments shall be compatible with the fluid and the piping class to which they are connected. Unless there are specific compatibility problems they shall be 316 stainless steel as a minimum. Non-wetted parts of instruments shall be suitable for their environment.

Wetted parts in contact with potable water must comply to AS4020.

5.2.3 Process and Signal Connections

Process connections on instruments, other than instruments required to be flanged, shall be ½ inch NPT female. Flanged connections shall be 50 mm NB to AS 4087. Pressure rating shall generally be in accordance with the piping specification but in any case not less than Class 14 on piping and Class 21 on vessels. All direct process connections shall be provided with isolating valves.

Field instruments shall be located as close as practicable to the process connection and impulse lines shall be kept as short and direct as possible to minimise signal errors and the risk of blockage. Liquid lines shall be graded to prevent air build-up and air lines shall be graded to prevent condensation build-up.. Where caking or scaling is likely to occur facilities for rodding-out the process connection shall be provided.

Pneumatic line connections shall generally be ¼ inch NPT female, however larger connections may be required in certain cases, for example high-speed actuators.

Electrical cable entries shall be 20 mm ISO female as a minimum.

Care shall be taken to ensure that the recommended line terminators are fitted at each termination on multi-drop instrument data bus cables and that the termination method allows disconnection and reconnection of looped data cables without the need to disassemble the instrument..

5.2.4 Instrument Installation

In addition to the requirements of DS25, instruments shall be installed so that they are readily accessible from ground, floor or walkway level for inspection, adjustment and maintenance. Special attention shall be given to ensuring that displays are easily readable.

Instruments shall be provided with lightning surge protection as required by DS25.

Instruments installed out of doors shall be provided with sunshades for weather and UV protection. Displays on outdoor instruments shall be easily readable in direct sunlight.

Connections for compressed air and potable water shall be provided adjacent to instruments where required for maintenance and cleaning. Special consideration shall be given to instruments such as dissolved oxygen and ORP probes installed through covers on aeration tanks, channels and the like. The installation shall provide an effective odour seal while allowing the probe to be withdrawn for inspection, cleaning, maintenance or calibration. There shall also be a temporary means of sealing the cover penetration when the probe is withdrawn.

5.2.5 Instrument Junction Boxes

Where hard-wiring is used for field instruments, junction boxes shall be used to marshal cables from individual instruments and control devices and to connect them to PLC I/O using multi-pair or multicore cable. Junction boxes shall utilise rail-mounted terminal strips with at least 20% spare terminals.

Instrument and control junction boxes shall contain ELV wiring only and shall not be used for power cables.

5.3 Electronic Instruments

Signals from inherently non-linear primary elements such as orifice plates and weirs shall be linearised at the instrument transmitter prior to transmission.

All analogue transmitters and converters shall incorporate digital or analogue indicators scaled in engineering units. All indicators shall be linear. Full-scale readings of analogue indicators shall be multiples of 2, 5 or 10 and scaling shall be chosen so that the pointer reads at about two-thirds full scale in normal operation.

4-20 mA hard-wired instruments should be two-wire in preference to four-wire, provided that a 2 wire instrument can provide the required accuracy and response time.

5.4 Pneumatic Instruments and Actuators

Electronic instruments are generally preferred over pneumatic instruments, however there are some applications (e.g. bubbler tubes) where pneumatic instruments may be more suitable, or even the only practical choice.

Instrument air for measuring instruments, actuated valves and the like is typically obtained from the plant air system via a filter and dryer. Any pneumatic instrumentation systems shall be capable of working over an operating pressure range from 400–800 kPa. Refer to section 5.6 of this Appendix for further details.

Air supply to field-mounted instruments and control devices shall be via individual isolating valves and filter regulator sets. All headers shall be fitted with low point drain valves. The air reticulation from the header shall use 316L stainless steel tubing and double ferrule compression fittings.

5.5 Instruments for Specific Applications

The selection of instruments for specific applications in treatment plants shall be guided by the following general principles:

- (a) Meets or exceeds the technical requirements of DS25;

- (b) Included in the Corporation's Preferred Equipment List;
- (c) Meets the technical requirements of HA-ST-03: EEHA Selection and Installation Manual;
- (d) Recognised brand or manufacturer;
- (e) A history of successful use for similar applications in Water Corporation plants or in the water industry generally;
- (f) Good local technical and maintenance support, preferably based in Western Australia but at least in Australia;
- (g) Suitable for the application, considering such factors as:
 - (i) accuracy and repeatability
 - (ii) compatibility with existing instruments and systems
 - (iii) ability to withstand service and environmental conditions
 - (iv) resistance to blocking or fouling
 - (v) hazardous area classification
 - (vi) ease of installation and maintenance;
 - (vii) whole-of-life cost

Where it is proposed to use instruments that are not covered by DS25 or included in the Preferred Equipment List the Designer shall refer the matter to the Senior Principal Engineer giving reasons for the choice.

The Designer shall also obtain the views of plant operations and maintenance staff on instrument selection and consider these views during the design phase.

The following table lists the recommended types of instruments for applications commonly encountered in Water and Wastewater Treatment Plants. The list is not exhaustive and the Designer will often encounter situations which call for novel solutions. Such situations and the Designer's proposed solutions shall be discussed with the Senior Principal Engineer.

Measured quantity	Application	Instrument type		Notes
		Recommended	Alternatives (subject to approval)	
Flow (measurement)	Water or wastewater in open channels (flume or weir)	Ultrasonic or radar open-channel flowmeter		Radar not suitable where foaming likely to occur.
	Water, wastewater or sludge in closed pipes	Magnetic flowmeter	Turbine (clean fluids only); Ultrasonic transit-time; Venturi	
	Air in closed pipes, low pressure, high volume	Thermal mass flowmeter	Orifice plate	
	Air in closed pipes, high pressure, low volume	Orifice plate	Thermal mass flowmeter	
	Flammable gas	Ultrasonic transit-time	Thermal mass flowmeter	Must be certified for Zone 0 in accordance with HA-ST-02: EEHA Selection and Installation Manual
	Chemical solution lines	Magnetic flowmeter	Coriolis (for high-accuracy applications)	
Flow (sensing)	Clean water	Paddle switch		
	Air or gas	Thermal sensor		For flammable gases, must be appropriately certified in accordance with HA-ST-02: EEHA Selection and Installation Manual
Level	Clearwater or treated effluent in open pump wells or tanks	Ultrasonic; Radar; Hydrostatic; Pressure Transmitter	Conductivity probe; Float switch	Instrument accessibility to be considered. Capillary tubes, used as atmospheric reference on hydrostatic probes to be protected from the ingress of moisture or condensation.
	Wastewater in channels, pump wells or tanks	Ultrasonic; Radar	Float switch; Bubbler tube	Radar not suitable where foaming likely to occur.

Measured quantity	Application	Instrument type		Notes
		Recommended	Alternatives (subject to approval)	
	Water or wastewater in closed vessels (non pressurised)	Ultrasonic; Radar	Hydrostatic (DP)	
	Bar screen differential	Ultrasonic; Radar	Bubbler tube	
	Sludge interface in sedimentation tanks and clarifiers	Optical; Ultrasonic	Ultrasonic (heavy sludges only)	
	Sludge in open digesters or storage tanks	Ultrasonic; Pressure Transmitter	Hydrostatic (filled system)	
	Sludge in anaerobic digesters	Hydrostatic (water-purged or filled system)	Gas bubbler	
	Dewatered sludge or other semi-dry materials in hoppers	Ultrasonic	Load cells	Load cells preferred for sludge hoppers.
	Granules or dry powder	Ultrasonic	Load cells; Vibrating sensor	
Pressure	All normal applications	DP cell		
	Local indication only	Bourdon gauge (clean fluids only)		
Temperature	Fluids (remote measurement)	RTD in thermowell		
	Fluids (local indication only)	Alcohol-in-glass or dial thermometer in thermowell		
	Exhaust gases	Thermocouple		
	Bearings	RTD		
	Motor windings	Thermistor; RTD		
Density	Sludge density	Nuclear	Ultrasonic	Nuclear meter installation to be certified by an authorised person
Position	Linear	Magnetostrictive transducer; Linear variable differential transformer (LVDT)	Linear potentiometer	
	Angular	Shaft encoder	Potentiometer	
	Sensor	Magnetic proximity; Photoelectric	Mechanically-actuated limit switch	

Measured quantity	Application	Instrument type		Notes
		Recommended	Alternatives (subject to approval)	
Vibration	Rotating machinery	Accelerometer		Preferably supplied as part of a complete condition monitoring system
Analytical	Chlorine gas detector	Refer to Corporation design standard DS25 and Preferred Equipment List		
	Conductivity			
	Dissolved oxygen			
	Flammable gas detector			
	Fluoride analyser			
	H ₂ S gas detector			
	ORP			
	pH			
	Residual chlorine analyser			
	Turbidity and suspended solids			

The following table lists the recommended types of control devices for Treatment Plant applications. With regard to valve actuators reference shall also be made to DS26-41 and to section 12 of design standard DS22. Again the list is not exhaustive and unusual situations shall be discussed with the Senior Principal Engineer.

Requirements for valves are covered in design standard DS31.

Device	Application	Type		Notes
		Recommended	Alternatives (subject to approval)	
Valve actuators	Modulating duty	Electric (infrequent operation); Pneumatic (frequent operation)		Control system design shall seek to minimise hunting and consider safe failure mode.
	On-off valves	Electric	Pneumatic	Design shall consider safe failure mode
	Multi-turn (e.g. penstocks)	Electric		

5.6 Instrumentation Supplies

5.6.1 Power

Instrumentation power supplies shall conform generally to design standard DS25.

Supply to two-wire instruments shall be regulated 24 V DC and shall be backed up by battery and/or UPS. A 24 V DC instrument power distribution panel shall be provided in each process area for supplying two-wire instruments in that area. Where available, PLC DC supplies shall be used for this purpose.

Supply to four-wire instruments shall be 240 V AC; 110 V AC shall not be used for instrument power supply. Instrument AC power supplies shall be backed up by UPS. A 240 V AC instrumentation power distribution panel shall be provided in each process area where there are four-wire instruments.

A switched plug/socket outlet fitted with surge protection shall be provided for the 240 V field connection of 4-wire instruments. The socket shall be of a type that will not accept a normal 3-pin plug, to prevent it being used for other purposes. The outlet shall also be labelled to identify it as being for instrument use only. (refer also to clause 23.3)

5.6.2 Air

Instrument air supply for process instrumentation, actuated valves and the like shall be at a nominal pressure of 700 kPa, filtered and dried. The instrument air system shall incorporate air receivers with sufficient capacity to allow limited operation and safe shutdown of the plant in the event of plant air system failure.

As a general rule instrument air shall be obtained from the plant air system.

6 HAZARDOUS AREAS

6.1 General

A hazardous area is defined as an area in which an explosive atmosphere is present, or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of potential ignition sources. The explosive atmosphere may be caused by the presence of a flammable liquid, gas or vapour or by the presence of combustible dust in suspension or in layers or a combination of explosive gas and dust atmospheres.

Water treatment plants do not usually use or produce flammable gases or combustible dusts in sufficient quantities to constitute an explosion risk. However wastewater treatment plants frequently produce significant quantities of flammable gas either deliberately or accidentally as a by-product of the treatment process. Therefore explosion risks must be considered by the Designer.

The flammable gases produced in wastewater treatment consist mainly of methane and tend to be concentrated in particular process areas including anaerobic digesters, digester-gas handling plant, digester-gas fired boilers and generators. However flammable gases may also accumulate in poorly-ventilated areas containing sewage or sludge, such as enclosed air spaces above sewers, inlet channels, screens, primary sedimentation tanks, digested and dewatered sludge storages.

Combustible dusts are generally not a problem in treatment plants, although any dry powder material produced or used in the plant, such as dried sludge or polyelectrolyte powder, shall be assessed for flammability and appropriate measures taken.

The Designer shall ensure that area classification, plant design and equipment selection are carried out in accordance with the requirements of the HA-ST-02: EEHA Hazardous Area Classification Manual and the HA-ST-03: EEHA Selection and Installation Manual.

6.2 Competency Requirements

The classification of hazardous areas, the selection of electrical equipment to be used in hazardous areas and the design of electrical installations within hazardous areas shall only be undertaken by those persons who satisfy the requirements of HA-ST-04: EEHA Competency Manual.

6.3 Area Classification

Hazardous Area classification is the first step in designing the electrical installation for hazardous areas in treatment plants. Hazardous Area classification shall be carried out in accordance with HA-ST-02: EEHA Hazardous Area Classification Manual.

6.4 Equipment Selection

6.4.1 Use of Certified Equipment

All electrical equipment used in hazardous areas of treatment plants shall have appropriate certification in accordance with the requirements of HA-ST-03: EEHA Selection and Installation Manual.

6.4.2 Explosion-Protection Techniques

Explosion techniques listed within HA-ST-03: EEHA Selection and Installation Manual' are preferred and shall be adopted in the first instance.

Other techniques maybe considered but their use is subject to approval from the Senior Principal Engineer and the EEHA Technical Integrity Custodian (TIC).

6.5 Installation

Electrical installation design in hazardous areas shall conform to the following

- (a) AS/NZS 3000:2007, “Wiring Rules”
- (b) AS/NZS 60079.14-2009 Explosive atmospheres Part 14: Electrical installations design, selection and erection
- (c) HA-ST-03: EEHA Selection and Installation Manual.

6.6 Documentation

The Designer shall prepare and maintain a hazardous area Verification Dossier in accordance with the HA-ST-10: EEHA Verification Dossier Manual’

The Verification Dossier shall be kept up to date at all times during the design process.

Following construction and commissioning the Verification Dossier will be used by the Corporation, maintenance contractors and future designers for maintenance purposes and for the recording of test results, inspections, equipment overhauls, repairs and modifications and changes to area classifications.

The dossier shall therefore be prepared and maintained by the Designer with the needs of operators, maintenance staff and future designers in mind.

The Verification Dossier shall be available for inspection by the Senior Principal Engineer at all times during the design phase.

6.7 Type Specifications

Type Specifications (DS26) have been written for projects that do not incorporate hazardous areas as defined above. In accordance with the requirements of clause 1.3 the Designer shall prepare appropriate specifications based on the HA documents referenced in clause 1.4.

7 MISCELLANEOUS PLANT SERVICES

7.1 Abbreviations

The following abbreviations and definitions, additional to those given in Section 2.1.1 of this Appendix, shall apply:

Abbreviations

ACA	Australian Communications Authority
CCTV	Closed-circuit television
ISDN	Integrated services digital network
PABX	Private automatic branch exchange
PSTN	Public switched telephone network
RCD	Residual current device (earth leakage circuit breaker)

7.2 Paging Systems

7.2.1 Voice Paging and Intercom Systems

Centralised voice-paging and intercom systems shall be provided for major treatment plants where there may be a significant number of personnel on the site. Such systems shall incorporate the following features:

- (a) Intercom units installed at readily-accessible locations around the plant;
- (b) Paging loudspeakers located so as to provide adequate coverage of major plant areas;
- (c) Master console unit located adjacent to the PABX console or master telephone handset;
- (d) Full duplex intercommunication between two or more units without blocking group paging;
- (e) Interface to telephone system so that telephone calls can be directed to any intercom unit.

The design of the system shall ensure that noise levels at the plant boundaries comply with the relevant government environmental agency regulations.

7.2.2 Radio Paging Systems

A portable radio paging system shall be provided for major plants. Design requirements of radio paging systems are given in section 3.3 of this Appendix.

7.3 Telecommunications

7.3.1 General Requirements

For small plants a minimum of two PSTN lines shall be provided; one for telephone and one for data.

For medium/major plants a number of PSTN lines and/or ISDN connections will be required. The number and type of lines will depend on the facilities installed at the plant.

The Designer shall consult via the Design Manager with the Corporation's Information Services Branch to ensure that voice, facsimile and data communications facilities comply with current corporate requirements and take advantage of Corporate contracts.

7.3.2 Telephone and Facsimile

All treatment plants shall be provided with telephone facilities.

For large plants a PABX will be required. The type of PABX will depend on the needs of each plant. As a minimum the PABX shall provide facilities for extension-to-extension dialling, call transfer, direct in-dialling and selective barring of outgoing calls (local, STD or ISD).

Plants which include offices, conference rooms, staff amenities rooms, maintenance workshops, testing laboratories or the like will require additional lines and facilities to service these areas.

Telephone facilities and wiring shall be designed to ACA requirements. As a guideline the following minimum facilities shall be provided:

- (a) At least one telephone handset in the main control room (office, amenities room or main control cubicle for small plants);
- (b) Telephone handset adjacent to each workstation or group of workstations;
- (c) Telephone handset in each HV switchroom
- (d) Plain-paper facsimile machine in the main control room (medium and major treatment plants);

Separate lines, independent of any PABX, shall be provided as required by the relevant codes and standards for fire alarm panels, intruder detection panels and lifts.

7.3.3 Computing and Data Communications

The following shall be provided for all treatment plants as required:

- (a) General-use personal computers for applications such as word processing, spreadsheets, databases, Internet access, email communications and specialised plant management and reporting software;
- (b) LAN cabling and outlets;
- (c) Connection to the corporate WAN.

Via the Design Manager, the Designer shall liaise with the Corporation's Information Services Branch for the provision of servers, routers, PCs etc. as required.

7.4 Fire and Gas Detection and Alarm System

7.4.1 General

A fire and gas detection and alarm system shall be provided for all but very small (e.g. package) treatment plants. The system shall cover the following areas:

- (a) Administration and amenities buildings;

- (b) Control rooms and associated equipment rooms;
- (c) Switchrooms and substations;
- (d) Plant rooms;
- (e) Gas handling, processing and storage areas.

Where the plant includes special facilities such as maintenance workshops and laboratories a risk assessment shall be carried out to identify any fire or chemical hazards, assess the likely consequences of fire or chemical release and determine the most appropriate form of detection and/or protection. The assessment shall take into account the risks posed by any flammable or hazardous materials likely to be stored on the site.

Automatic sprinkler or gas flooding systems shall not be provided unless there are particular risks that justify their use.

7.4.2 Design

Detectors shall be suitable for the areas in which they are to be installed. In particular, detectors to be installed in wastewater treatment plants shall be resistant to attack from low concentrations of hydrogen sulfide.

Fire detection and alarm systems shall be designed in accordance with AS 1670, "Fire detection, warning, control and intercom systems" and the Building Code of Australia. Detectors, manual call points and indicators shall comply with the AS 1603 series of standards.

The main fire panel shall be located in the administration or amenities building and shall be connected to the PCS, the alarm dialler system (if provided) and the local Fire Brigade. It shall include routine testing facilities as required by the standards and codes.

For medium/major plants sub-indicator panels shall be provided in local plant areas where appropriate.

Alarm zones shall be allocated in accordance with AS 1670, commensurate with the size and layout of the plant.

The system shall provide local visual and audible alarm indication. The audible alarm shall be interfaced to the voice paging system if provided. If appropriate, interlocks shall be provided to disconnect power to specific areas or to shut down process equipment.

7.4.3 Equipment

Smoke detectors shall be provided in all switchrooms and control rooms. Thermal detectors may be used in offices and indoor process areas and shall be used in areas which are subject to smoke, fumes or dust during normal plant operation.

Depending on the nature of the risk the Designer may need to consider the use of other types of detector such as UV flame detectors or aspirated smoke detection systems.

A manual call point shall be provided in a prominent position at the entrance to the administration or amenities building. For major plants additional call points shall be located around the plant in suitable locations.

Visual and audible alarms shall be provided on the exterior of key buildings.

Areas where toxic or flammable gases (e.g. chlorine, digester gas) are handled, processed or stored shall be provided with suitable gas alarms linked to the main fire panel.

7.5 Intruder Detection, Access Control and CCTV Systems

7.5.1 General

Security systems shall be provided for all treatment plants to reduce the incidence of vandalism and to prevent acts of malicious damage. Security assessment shall be carried out in accordance with Corporation Standard DS62. The following systems shall be provided:

- (a) Control of access to the treatment plant. For major treatment plants, automatically-controlled gates shall be provided.
- (b) Intruder detection and alarm system for buildings.
- (c) Audible and visual alarms.
- (d) For major or critical plants: CCTV system to monitor plant entrances, buildings and general plant areas.
- (e) Personal emergency alarm for operators.
- (f) Remote monitoring of security alarms.

For critical plants, perimeter protection based upon a multiple infrared beam barrier system, integrated with a CCTV system, may be required. An electrified security fence may also be required.

7.5.2 Design

The intruder alarm system shall be designed in accordance with the AS 2201 series of standards, "Intruder alarm systems". The system shall incorporate features to detect cable or sensor tampering.

The central security and access panel shall be located in the administration or amenities building and shall be connected to the PCS and to the alarm dialler system (if provided). Alarm display shall be grouped by building or plant area. The system shall include a data logger and printer to log all access to the plant, arming, disarming and alarms.

A local arming station with keypad shall be provided at each protected building.

The intruder alarm system shall provide local visual and audible alarm indication.

Each automatically-controlled gate shall be provided with a swipe-card reader, intercom station and CCTV camera.

CCTV cameras shall also be installed to cover the following areas of major or critical plants:

- (a) General plant areas;
- (b) Specific equipment items or installations which require monitoring or which are considered to be a security risk.

One or more colour CCTV monitors together with camera switching facilities, remote camera controls and video recorder shall be installed in the main control room.

Electrified security fences shall be designed in accordance with AS/NZS 3016, “Electrical installations - Electric security fences”.

7.5.3 Equipment

Each protected area shall be fitted with the following types of equipment as appropriate:

- (a) Individually-monitored magnetic or reed switches on each door;
- (b) Magnetic or reed switches on each window;
- (c) Infra-red or radar motion detectors for internal areas;
- (d) Infra-red beam barrier system for external areas;
- (e) Arming station with keypad;
- (f) Local audible and visual alarms.

Automatically-controlled gates shall be provided with an inductive loop vehicle detector arranged to open the gate automatically for exiting vehicles.

Personal emergency alarms shall be portable devices with pocket or belt clip which enable personnel to summon assistance in the event of accident, injury or lock-in.

CCTV cameras shall be colour, with remotely-controlled pan/tilt/zoom capabilities. They shall be provided with appropriate weather protection and shielding.

8 WORK ON EXISTING TREATMENT PLANTS

8.1 General

The design of additions and upgrades to existing treatment plants shall follow the same general principles as for new plants. However the Designer needs to be aware of a number of issues that are likely to arise when working on existing plants.

8.1.1 Site Survey

Before commencing work on additions to or upgrades of an existing treatment plant the Designer shall:

- (a) Obtain copies of all available drawings and documentation for the plant from the Design Manager;
- (b) Carry out a site survey of the areas affected by the new works in order to confirm the completeness and accuracy of existing documentation and to determine the condition of the existing installation.

Any issues arising from the site survey which may affect the scope or design of the new works shall be reported to the Design Manager.

It is strongly recommended that the Designer meets with plant operations and maintenance personnel on a regular basis during the design phase to brief them on the proposed works and to provide an opportunity for discussion and feedback. Such meetings shall be coordinated through the Design Manager and any proposed or requested design changes arising from them shall be referred to the Design Manager for approval.

8.1.2 Standards and Regulations

All new work shall conform to current Corporation, Australian and international standards and to current statutory regulations.

Some of the standards and regulations to which existing plants, particularly older plants, have been designed may have been superseded. In many cases this may be of little consequence. However the Designer will sometimes encounter compatibility or safety issues when interfacing with equipment or facilities built to superseded standards. This is particularly so when designing additions and upgrades to older plants that have been subject to several previous upgrades. In such cases the Designer shall identify the issues and propose solutions for consideration by the Senior Principal Engineer.

8.1.3 Safety and Environmental Issues

The conformance of existing facilities affected by the new works to current statutory requirements shall be checked. The Designer shall refer any non-conformances, particularly those which relate to safety or the environment, to the Senior Principal Engineer with recommendations for resolving them.

If the Designer becomes aware of any safety or environmental issues relating to existing plant or equipment, even though the plant or equipment may not be directly affected by the new works, the issues shall be referred in writing to the Senior Principal Engineer.

Such issues may include:

- (a) Plant or equipment that does not meet current safety or environmental regulations;

- (b) Existence of hazardous materials (e.g. asbestos) on the site;
- (c) Plant or equipment in poor or unsafe condition.

8.1.4 Numbering

Numbering of equipment and instruments for the new works shall be in accordance with this standard and Section 4 of the Corporation's "DS80 WCX CAD STANDARD Manual".

Before allocating any new numbers, the Designer shall check if any blocks of numbers have been reserved in the existing scheme for future additions. If any such blocks exist they shall be allocated first. For instance if the plant includes three equipment items of a particular type and a fourth item is to be installed, numbering for the new item may already have been allocated by a previous designer.

Where numbering has not already been allocated, numbering of new equipment and instruments shall continue existing sequences. For example if the last number used in an existing area is 1534, the new equipment numbering could start from 1540. (It is recommended that a gap be left between the old and new numbers.)

Numbering in some older plants may have been carried out to older standards not compatible with the current practice specified in the DS80 WCX CAD STANDARD Manual. Generally it is not feasible to renumber existing equipment and instruments to conform to current practice, so a compromise system must be adopted. Such cases shall be referred to the Design Manager.

Above all, numbering of new equipment and instruments shall follow a logical method which is consistent as far as possible with existing practices at the plant.

8.2 Plant Control Systems

All new processes and equipment items shall be integrated into the existing SCADA system, including all necessary updating of displays, graphics, reports, alarms, data logging, trending, programming and documentation.

Where any work is carried out on the existing SCADA system it shall be upgraded to the latest software revision.

8.3 Programmable Controllers

The Senior Principal Engineer may require that existing programmable controller hardware affected by the new works be upgraded or replaced if it is obsolete or does not conform to current Corporation standards.

8.4 Data communications

The Senior Principal Engineer may require that existing copper or radio communication networks be upgraded to optical fibre as part of the new works.

8.5 Field Instrumentation

The Senior Principal Engineer may require that existing field instruments be upgraded or replaced to bring them into conformity with current standards.

8.6 Hazardous Areas

The Designer shall carry out a full review of existing hazardous area classifications for those areas affected by the new works. Existing areas shall be reclassified where necessary when the hazardous areas created by the new works overlap existing plant, or the new works are within an area that is already classified as a hazardous area.

Re-classification shall be undertaken in accordance with HA-ST-02: EEHA Classification Manual with the existing site hazardous classification report updated.

When the new works affects the hazardous area classification of existing plant areas, the Designer shall review existing electrical equipment in those areas to ensure they are suitable for the new classification.

If the Designer becomes aware of any hazardous area non-conformance issues relating to existing plant or equipment not affected by the new works, the issues shall be referred in writing to the Senior Principal Engineer.

The existing Hazardous Area Verification Dossier shall be kept up to date at all times by the addition of new material from the new works as components and systems are designed, installed and commissioned and brought on line.

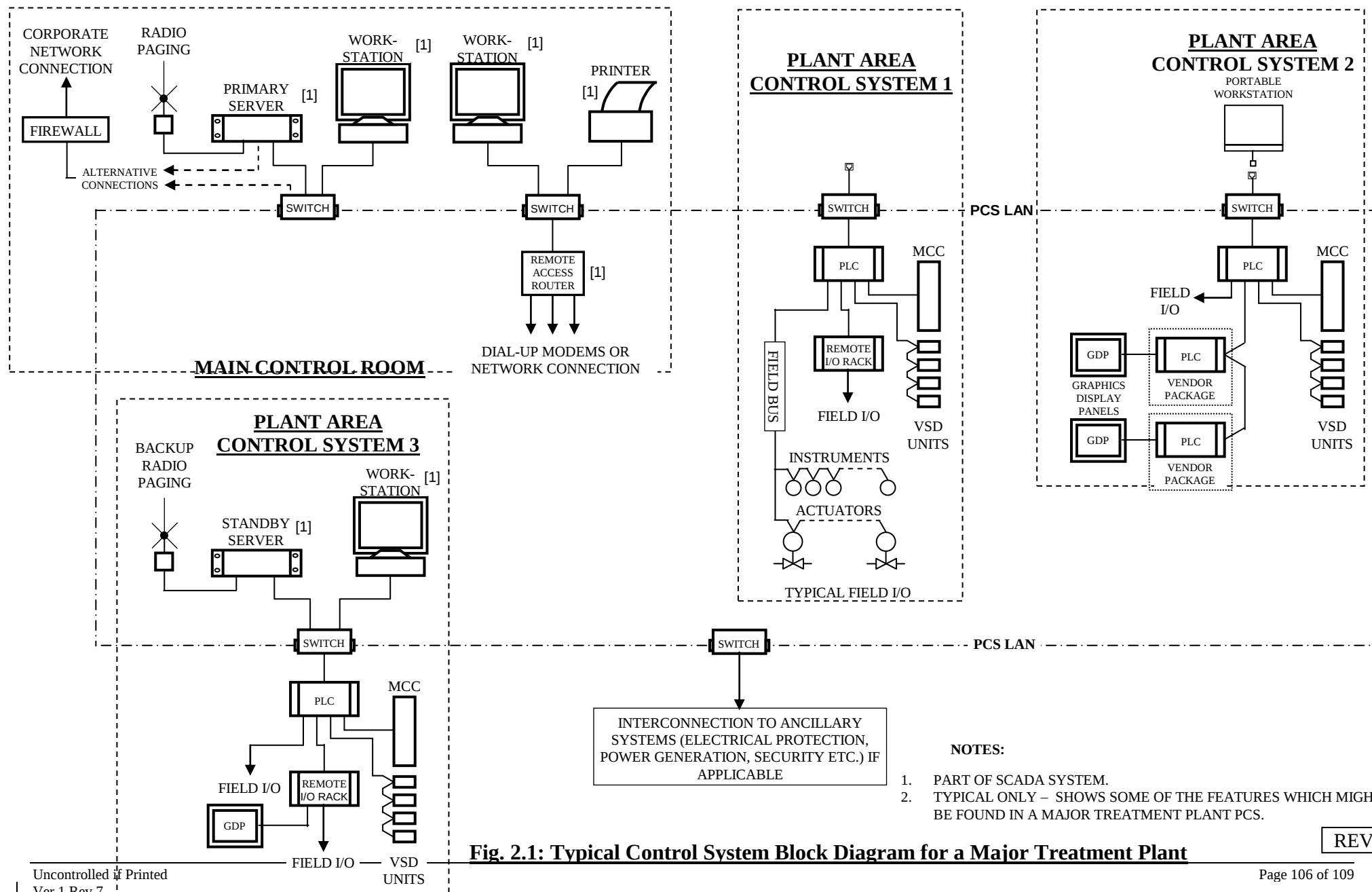
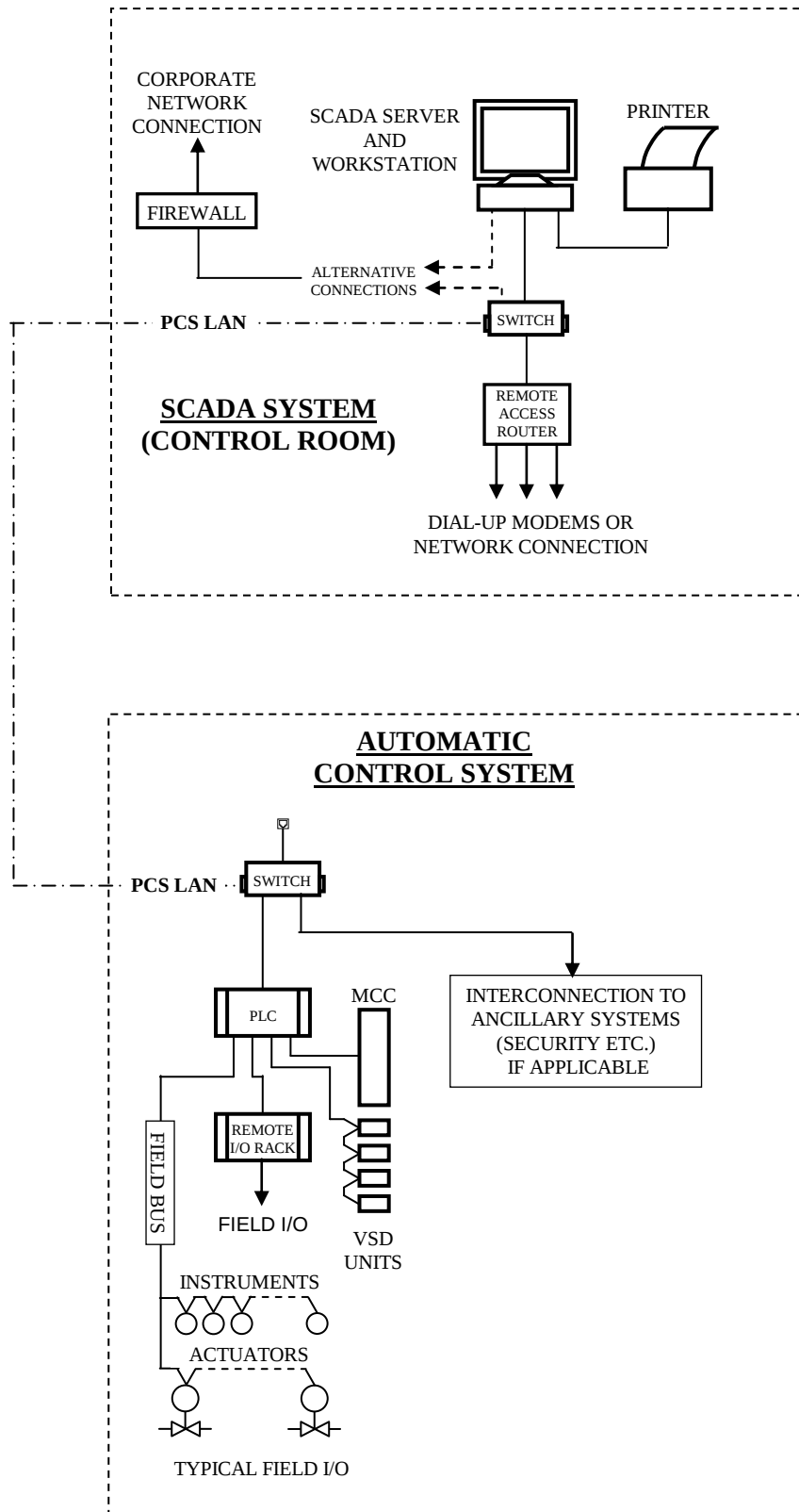


Fig. 2.1: Typical Control System Block Diagram for a Major Treatment Plant

REV. 3

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NOTES:

3. TYPICAL ONLY – SHOWS SOME OF THE FEATURES WHICH MIGHT BE FOUND IN A MINOR TREATMENT PLANT PCS.

Fig. 2.2: Typical Control System Block Diagram for a Minor Treatment Plant

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