Snowy Hydro Limited — renewable energy		
Snowy Technical Standards		
SHL-ELE-103	**Pipeline Protection**	
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1. Executive Summary

This standard sets out the requirements for the philosophy applied to hydraulic pipeline protection designs within Snowy Hydro.

It does not provide detailed protection design as this is performed with an engineering review due to variations between different sites.

The inclusion of the surge tank on the pipeline at Jindabyne Pumping Station is an additional level of complexity. Accordingly this document provides the design philosophy to be applied.

2. Scope

This standard applies to any new or altered Snowy Hydro hydraulic pipeline or station flood protection systems.

The inclusion of additional functionality, extensions, relocation or modification, including to the housing or cabinet are considered an alteration for the purposes of this standard.

This standard does not apply where the alteration is only for the like-for-like or functional replacement of a failed or suspect protection device.

An exemption from the application of parts of this standard may be provided under exceptional circumstances by the Manager Controls and Protection. Any exemptions must be obtained in writing prior to commencing design.

This standard is to be read in conjunction with other Snowy Standards, in particular SHL-ELE-102 Protection Design, and SHL-ELE-156 General LV Electrical Requirements.

2.1. Applicable Standards

All electrical works must comply with current laws and regulations, and with the relevant Australian Standards and Codes including annexures that are current at the date when the works are undertaken, or to the extent that there is no conflict, then with the relevant international Standards and Codes. Where a Standard or Code is named in this General Electrical Requirements document, it must take precedence over any other Standards or Codes.

In the event of a conflict between Standards or Codes, the standards appearing first in the following list must take precedence over those later in the list:

- Statutory regulations in force in the relevant State;
- Standards and Codes named in this document or the annexures;
- Australian Standards and Codes;

- International Standards and Codes

New South Wales Acts and Regulations

Legislative Requirements to be complied with include, but are not limited to:

- Electricity Supply Act 1995
- Electricity Supply (General) Regulation 2001
- Service and Installation Rules 2006
- Environmentally Hazardous Chemicals Act 1985
- Work Health and Safety Act 2011
- National Electricity Act 1997
- Electricity (Consumer Safety) Act 2004

Victoria Acts and Regulations

Legislative Requirements to be complied with include, but are not limited to:

- Environment Protection (Prescribed Waste) Regulations 1998
- Electricity Safety Act 1998
- Occupational Health and Safety Act 2004 and Occupational Health and Safety Regulations 2007
- Electrical Safety (Installations) Regulations 1999
- Electrical Safety (Network Assets) Regulations 1999
- National Electricity Act 1997 and National Electricity Act 2005
- Energy Safe Victoria Act 2005

South Australia Acts and Regulations

Legislative Requirements to be complied with include, but are not limited to:

- Electrical Act (1996)
- Electricity (General) Regulations 1997
- Occupational Health, Safety and Welfare (SafeWorkSA) Amendment Act 2005
- Work, Health and Safety Regulations 2012
- Environment Protection Act 1993
- Plumbers, Gas Fitters and Electricians Act 1995

Australian and International Standards

Electrical plant and equipment must be designed, supplied, installed and commissioned in accordance with the requirements of the specified Australian Standards, the following specific codes and standards; and any other relevant standards and regulations. These include, but are not limited to:

AS 1000	The International System of Units (SI) and its Applications
AS 1024	Direct recording electrical measuring instruments and their accessories
AS 1029	Low Voltage Contactors
AS 1046	Letter Symbols for use in Electrotechnology
AS 1100	Technical Drawing
AS 1101	Graphical Symbols for General Engineering

AS/NZS 1102	Graphical Symbols for Electrotechnology
AS 1125	Conductors in Insulated Electric Cables and Flexible Cords
AS 2067	Substations and HV installations
AS 2360	Measurement of fluid flow
AS 2373	Electric cables - Twisted pair for control and protection circuits
AS 2381	Electrical equipment for explosive gas atmospheres – Selection, installation and maintenance
AS/NZS 3000	Wiring Rules
AS/NZS 3008.1.1	Electrical installations - selection of cables - Cables for alternating voltages up to and including 0.6/1kV - Typical Australian installation conditions
AS 3010	Electrical installations - Generating sets
AS 3013	Electrical installations - Classification of the fire and mechanical performance of wiring system elements
AS/NZS 3017	Electrical installations – Verification guidelines
AS 3080	Information technology - Generic cabling for customer premises (ISO/IEC 11801:2011, mod)
AS 3808	Insulating and sheathing materials for electric cables
AS 3100	Approval and Test Specification - General requirements for electrical equipment
AS/NZS 3111	Approval and test specification for miniature over-current circuit-breakers
AS 3560	XLPE Power cables for rated voltages up to 1kV
AS 3820	Essential service requirements for electrical equipment
AS 4024	Safety of Machinery (all parts)
AS 4029	Stationary Batteries (Parts 1-3)
AS 4044	Battery Chargers for Stationary Batteries
AS 4070	Recommended practices for protection of low-voltage electrical installations and equipment in MEN systems from transient overvoltages
AS 4086	Secondary batteries for use with stand-alone power systems.
AS 4428	Fire detection, warning, control and intercom systems - control and indicating equipment (all parts)
AS 4509	Stand-alone power systems (Parts 1 and 2)
AS 4702	Polymer Cable Protection Covers
AS 4802	Local Area Networks
AS 4853	Electrical hazards on metallic pipelines
AS/NZS 5000	Electric cables - Polymeric insulated
AS/NZS ISO/IEC 24702	Telecommunications Installations - Generic cabling - Industrial premises

AS 60034	Rotating electrical machines (All parts)
AS 60038	Standard Voltages
AS 60044	Instrument Transformers
AS 60060	High-voltage test techniques
AS/NZS 60076	Power transformers (all parts)
AS/NZS 60079	Explosive atmospheres
AS 60146	Semiconductor converters (Parts 1.1, 1.2, 1.3 and 2)
AS 60529	Degrees of protection provided by enclosures (IP Code)
AS/NZS IEC 60947	Low-voltage switchgear and controlgear (all parts)
AS 61000	Electromagnetic compatibility (EMC)
AS IEC 61131	Programmable controllers (all parts)
AS 61204.1	Low voltage power supply devices D.C. output - Performance characteristics
AS 61386	Conduits and Fitting for Electrical Installations (all parts)
AS 61439	Low-Voltage switchgear and controlgear assemblies
AS IEC 61508	Functional safety of electrical/electronic/programmable electronic safety related systems.
AS IEC 61511	Functional safety – safety instrumented systems for the process industry sector
AS 62040	Uninterrupted Power Systems (UPS)
AS 62026	Low-voltage switchgear and control gear - Controller-device interfaces
AS/NZS 61000	Electromagnetic compatibility (EMC) (All parts)
AS/NZS IEC 61935	Testing of balanced communication cabling in accordance with ISO/IEC 11801 - Installed cabling
AS 62599	Alarm systems (all parts)
AS/ACIF S009:2006	Installation requirements for customer cabling (Wiring Rules)
AS/ACIF S008:2006	Requirements for customer cabling products
AS/NZS CISPR 11	Industrial, scientific and medical equipment—Radio-frequency disturbance characteristics - Limits and methods of measurement
AS/NZS CISPR 14.1	Electromagnetic compatibility - requirements for household appliances, electric tools and similar apparatus
AS/NZS CISPR 22	Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement
BS 6739	Code of practice for instrumentation in process control systems: installation design and practice
IEC 60051	Direct Acting Indicating Electrical Measuring Instruments and Accessories

IEC 60071	Insulation co-ordination
IEC 60073	Basic and safety principles for man-machine interface, marking and identification – Coding principles for indication devices and actuators
IEC 60255	Measuring relays and protection equipment
IEC 60258	Direct recording electrical measuring instruments and their accessories.
IEC 60269	Low-voltage fuses
IEC 60304	Standard colours for insulation for low-frequency cables and wires
IEC 60478	Stabilised power supplies dc output
IEC 60584	Thermocouples
IEC 60688	Electrical measuring transducers for converting A.C. and D.C. electrical quantities to analogue or digital signals
IEC 60751	Platinum Resistance Elements (PT100)
IEC 60793	Optical Fibres
IEC 61010	Safety requirements for electrical equipment
IEC 61158	Fieldbus
IEC 61850	Communication Networks in Substations
IEC 61868	Instrument Transformers (Parts 1-5)
IEC 62443-2	Security for industrial automation and control systems
IEC 62443-3	Industrial communication networks - Network and system security
IEC ISO 80000	Quantities and units
IEC TR 61869-102	Instrument transformers - Part 102: Ferroresonance oscillations in substations with inductive voltage transformers
IEC TR 61869-103	Instrument transformers - The use of instrument transformers for power quality measurement
IEEE 142	IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems
IEEE 450-2002	Recommended practice for maintenance, testing, and replacement of vented lead-acid batteries for stationary applications
IEEE 484-2002	Recommended practice for installation design and installation of vented lead-acid batteries for stationary applications
IEEE 485-2010	Recommended practice for sizing lead-acid batteries for stationary applications
IEEE 979	Guide for Substation Fire Protection
IEEE 1050	Guide for Instrumentation and Control Equipment grounding in Generating Stations
IEEE 1613	Environmental and Testing Requirements for Communications Networking Devices in Electric Power Substations
IEEE C37.90.1	Surge Withstand Capability

ANSI IEEE C37.2	Electrical Power System Device Function Numbers, Acronyms, and Contact Designations
EN 50081-2	Electromagnetic compatibility. Generic emission, Industrial environment
EN 50082-2	Electromagnetic compatibility. Generic immunity, Industrial environment
EN 55011	Limits and methods of measurement of radio disturbance
EN 61000	Electromagnetic Compatibility (EMC)
ENA EG1	Substation earthing guide
NFPA 70E	Standard for Electrical Safety in the Workplace
NER	National Electricity Rules

2.2. Units of Measure

The metric (SI) system must be used for electrical work in accordance with the provisions of AS ISO 1000 and IEC ISO 80000. All data, drawings, information and calculations must be presented in the metric unit system. Where British or American units are used by Suppliers, the equivalent SI units must be indicated on the drawing together with the non-SI original value.

3. Definitions

3.1. Duplicated

Two systems are installed to perform similar functions. The operation of any one system will cause a trip. This increases the reliability to trip for a fault. Duplication also extends to the protection communications systems.

3.2. Segregated

There are no interconnections between duplicated systems. Without segregation between systems one failure may cause both duplicated systems to fail.

Segregation removes common failure modes between the duplicated systems.

3.3. DNP 3

Distributed Network Protocol version 3 is a communications protocol used to transfer data from remote devices to the SCADA system. The physical connection is generally either fibre optic or copper signal wires.

3.4. SCADA

Supervisory control and data acquisition is the term given to the remote monitoring and control system. It is the method of providing data from the field to the controller staff in the Snowy Mountains Control Centre.

Protection functionality is not performed by the SCADA system. The SCADA system will receive data from the protection relays for monitoring functions.

3.5. SEL mirrored bits

Mirrored bits is a communications protocol from Schweitzer Engineering Laboratories. The communications system is very secure and high speed. It is used for protection signalling between ends of a pipeline.

3.6. ESPB

Emergency Stop Push Button is the local emergency stop button installed to allow manual tripping of plant.

3.7. SMCC

Snowy Mountains Control Centre is the control centre for all Snowy Hydro main plant. It is manned 24 hours a day, 7 days a week.

3.8. SIL

Safety Integrity Level is defined as a relative level of risk-reduction provided by a safety function, or to specify a target level of risk reduction. In simple terms, SIL is a measurement of performance required for a safety instrumented function

3. Power station or pumping station

All equipment within the power or pumping station shall be fully duplicated.

The duplicated equipment shall be powered by the A and B 250 V DC battery systems. There shall be no common failure modes between the A and B protection systems. The operation of the protection shall be a 1 out of 2 scenario – any one protection system operation shall cause a shutdown of the appropriate plant.

4. Technical Requirements

4.1. Power Station or Pumping Station

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4.1.1. Station tripping signals

The following signals will be required by the pipeline protection system.

4.1.1.1. Station Flooding

A signal for flooding at the bottom of the station shall be connected to each duplicate protection. Duplicate water level devices for each pipeline shall be installed to provide correct segregation.

Depending upon the design of the power station, other water level devices may need to be installed to cover for flooding in all areas of the station. All these devices shall be duplicated and installed on a per pipeline basis.

The station flooding signal shall send an intertrip to the valve house or intake structure to trip the guard gate or guard valve.

The station flooding shall initiate an immediate generator or pump trip if no pipeline water over velocity is detected.

4.1.1.2. Pipeline Trip Button

A pipeline trip push button shall be mounted on the front of the pipeline protection panel. The one push button shall have two electrically separate normally open contacts to operate into each A and B protection system.

The pipeline trip push button signal shall send an intertrip to the valve house or intake structure and initiate an unloading and then a trip on the generator.

At a pumping station it shall initiate a pump unit trip.

4.1.1.3. Remote SCADA Shutdown

A remote shutdown by the SCADA system shall be provided. It is a manually instigated function.

This can be provided by DNP 3 communications or by a relay with two electrically separate normally open contacts to operate into each A and B protection system.

The tripping from the remote SCADA shutdown shall be the same as for a pipeline trip push button.

4.1.2. Over velocity shutdown

4.1.2.1. Generator

Over velocity protection detects a pipeline failure by measuring higher than normal flow in the pipeline.

A generator shall not be immediately tripped in the case of a pipeline over velocity. If there is a pipeline break the sudden closing of the guide vanes can cause the water within the pipeline the escape through the pipeline rupture, possibly causing damage to the station and the surrounding environment.

When an over velocity trip is initiated, the turbine guide vanes shall be closed over a period of time to drain the pipeline through the unit. This time will be defined by an appropriate engineering study.

The setting of the over velocity device shall be subject to engineering consultation. The general setting method is to determine the maximum flow at full load of all the generators on the pipeline at minimum head. The over velocity trip setting is 110% of this value. This may be altered to suit specific applications.

4.1.2.2. Pump

A downhill over velocity whilst pumping shall result in the immediate shutdown of the pump.

4.1.3. Protection Response

Generally, the station drainage system is designed to cope with a break of the largest pipe takeoff on the largest pipeline in the station. This event is unlikely to cause an over velocity detection at the guard gate or guard valve.

Three possible pipeline rupture scenarios are considered.

- A rupture external to the station
- A break between the upstream wall of the station and the main inlet valve or discharge valve.
- A rupture downstream of the main inlet valve or discharge valve.

The pipeline protection response depends upon the location of the fault.

A site specific engineered solution will be used if the drainage system cannot cope with the rupture of the largest pipe takeoff on the largest pipeline in the station.

4.1.3.1. Rupture External to Station

The best solution is to trip the guard valve/gate immediately but not to immediately trip the unit, but rather drain the pipeline through the unit. This will avoid increasing the water flow from a pipeline rupture, which would cause greater damage to the station and surrounds. The unit is therefore unloaded over a period of time to drain the pipeline. The guard gate or guard valve is tripped immediately.

This will be detected by the water over velocity protection at the guard valve or guard gate.

The station flooding detection may operate if the external water runs to the bottom of the station. The over velocity will operate before the station flooding.

Detection of an over velocity and a station flood will result in the unit unloading followed by a unit trip. It is most likely an external event and the safest solution is to drain the pipeline through the unit.

4.1.3.2. Break Downstream of Station Upstream Wall

The station drainage system should cope with a break of the largest pipe takeoff. Alarms will be raised for the emergency drainage pumps running, alerting operations staff to the fault.

4.1.3.3. Rupture Downstream of the Main Inlet Valve or Discharge Valve

Depending upon the size of the rupture, the drainage system may cope with the rupture. If the size of the rupture overwhelms the drainage system the station flood detection will operate.

Operation of the station flood detection alone will cause an immediate trip of the unit. This will close the main inlet valve or discharge valve. As the break is most likely downstream of the main inlet or discharge valve, the safest option is to trip the unit immediately.

4.2. Valve House or Intake Structure

4.2.1. Flow Measurement

Pipeline water flow measurement shall be by the most suitable method.

4.2.2. Differential Pressure

The differential pressure flowmeter is based on the Bernoulli's Equation, where the pressure drop and the further measured signal is a function of the square flow speed.

Flow measurement by differential pressure is acceptable. Differential pressure transducers shall be SIL 2 rated or higher. Only one pressure transducer is required if it is a SIL 2 transducer and is monitored by both protection systems.

The most likely fault in a SIL 2 differential pressure system is the pipeline take off point, not the transducer. In this case duplicating the continuously monitored transducer provides little increase in reliability.

The impulse pipe work shall be lagged and heat traced when differential pressure transducers are installed where the ambient temperature may reach below 0°.

The differential pressure is proportional the square of the flow. The differential pressure transducer shall have a square root extraction enabled. The pressure transducer output is then proportional to flow. It shall be noted that differential pressure is very inaccurate at low flows due to the very small pressures measured.

4.2.3. Ultrasonic

An ultrasonic flow meter is a type of flow meter that measures the velocity of a liquid or gas (fluid) by using the principle of ultrasound. Using ultrasonic transducers, the flow meter can measure the average velocity along the path of an emitted beam of ultrasound, by averaging the difference in measured transit time between the pulses of ultrasound propagating into and against the direction of the flow.

Ultrasonic flow measurement is acceptable. It can be used where a large range of flows are required to be measured accurately. An example is Jindabyne Pumping station where large and small flows uphill and downhill are required for tripping.

Ultrasonic flow devices shall be duplicated for reliability requirements. As they are duplicated devices there shall be no connection between the A and B systems.

The ultrasonic transducers may require protection from vandalism as they may be installed outside the secure area of the valve house.

4.2.4. Pipeline Differential Flow Protection

The normal method of protection shall be water over velocity. Differential flow protection systems may be also considered.

4.2.5. Guard Valve or Guard Gate Control

Guard gates and valves shall have local opening and closing control. Guard gate and guard valve opening shall only be performed locally.

Guard gate and guard valve opening is a control function and is performed within control circuitry. However, the guard valve opening circuitry may be electrically simple. It may be performed within the A protection relay if no guard valve PLC is installed.

Guard gate controls generally have a greater level of complexity and have a separate PLC for the opening control.

Some guard gates are latched open whilst others rely on hydraulic pressure to be held open. These hydraulic systems shall have excess slump detection. The excess slump detection shall be in the control system and will initiate a generator or pump unloading and then a pipeline trip.

If the guard valve or guard gate control is in a PLC, the opening and closing control shall be on a panelview or separate control switches.

4.3. Protection Communications

The protection relays shall communicate between the valve house or intake structure and the power or pumping station. The A and B protection systems shall not share any common communications systems. There shall be full duplication and segregation of the communications systems.

The communications DC supplies shall be from two electrically separate battery supplies. There shall be continuous alarming of the communications battery supplies. The alarms shall be continuously monitored at SMCC.

The communications system routes shall be diverse.

The preferred communications protocol shall be SEL mirrored bits. Other communications protocols may also be approved after consultation with the Protection Engineer.

The preferred communications medium is optic fibre.

4.4. SCADA Communications

SCADA communications shall be connected to pipeline protection relays in the valve house or intake structure and the power or pumping station. These communications will allow data measured by the pipeline protection systems to be transferred to SCADA for remote monitoring.

The preferred communications protocol is DNP 3. Suitable mediums are Ethernet, fibre optic or RS485 over copper.

The SCADA system shall not be used to provide protection functionality.

The pipeline protection relays shall provide a fail safe life contact as a digital input to the SCADA system for alarming of relay failure.

5. References

- SHL-ELE-102 Protection Design
- SHL-ELE-156 General LV Requirements