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NITTO KOGYO GROUP

Operation & Maintenance Manual

On

Low Voltage Switchboards

Project Title:	D2019-00162-CONSTRUCTION OF 9 BUILDINGS AND A&A WORKS TO 2 BUILDINGS ALONG SEMBAWANG ROAD - BLOCK 2
Client:	CHIN SENG ENGINEERING (S) PTE LTD
Consultant:	OTHERS
Owner:	DSTA

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1. Introduction

The introduction covers the scope and purpose of this Operation & Maintenance Manual.

1.1 Scope

The scope of this document outlines the essential activities and responsibilities for the Operation & Maintenance of Low-Voltage Switchgear to ensure the safe, reliable, and efficient operation of electrical systems.

1.2 Purpose

The primary objectives of this Low Voltage (LV) Switchgear Operation & Maintenance are as follows:

a) To ensure the safety of personnel working with LV Switchgear.

b) Enable operators to have a general idea of how to conduct the Operation & Maintenance of LV Switchgear.

2. Relevant Acts and Regulations

Several Acts and statutory regulations apply to electrical switchgear in this recommendation is not intended to be in any way a substitute for any requirements laid down in legislation. It does however contain information that may be helpful in meeting the statutory requirements.

The Electrical Workers and Contractors Licensing Act, 1974 is relevant and applies to all work covered by this recommendation.

2.1 First Aid

It is a statutory requirement under the relevant regulations that a notice giving instructions for the treatment of persons suffering from electric shock should be affixed in a prominent position in all substations. First aid equipment must be available for the treatment of personnel.

The address and telephone number of the nearest doctor, first aid center, or hospital should be prominently displayed on the premises.

It is strongly recommended that all electrical maintenance personnel be trained in the application of artificial respiration.

2.2 Fire Extinguisher

The availability of firefighting equipment should exist, either by appliances permanently provided in the premises or by temporary appliances provided during the period of the work. All operators should be trained in the use of such appliances. The type of fire extinguisher equipment provided for use on electrical equipment should be compatible with the equipment.

2.3 Safety Rules

Safety in the control, operation, and maintenance of LV Switchgear is best achieved by observing a simple recommendation of safety rules. The electricity supply industry and other organizations have produced their own safety rules which specify procedures for operating, initiating, and carrying out work on electrical equipment. It is recommended on all premises, that the occupier should draft a set of safety rules appropriate to the type of electrical installation covering the operating of the work to be carried out on the equipment.

The policy to be followed in the drafting of safety rules should be to attempt to foresee any danger that can or may develop; such as preventing any person from being exposed to danger from live conductors. The best rules are of no avail unless all persons operating or working on the equipment covered by the rules are thoroughly conversant with them and comply strictly with the relevant statutory requirements.

Where switching or maintenance work is to be done on switchgear controlled by a public supply authority, the occupier should ascertain and comply with the supply undertaking's safety rules.

3. Operation of LV Switchgear

The specific components in an LV Switchgear can vary depending on the application and requirements. This section will cover the operation of generic components commonly found in LV Switchgear.

3.1 Air Circuit Breaker (ACB)

ACBs are electrical devices used to protect appliances from overloads and short circuits.

3.1.1 Charging the ACB

The spring mechanism inside the ACB must be charged to store the energy required to close the main contacts. The springs can be manually charged with a handle. Depending on the brand and model of the ACB, some ACBs can also be charged electrically by using a charging motor. Once the ACB springs have stored the required energy, the 'Charged' or 'OK' indication should be showing on the ACB. The ACB is now ready to be turned on.

3.1.2 Turning On the ACB

Press and release the 'On' Push button, which is usually located at the front of the ACB. Once the main contacts are closed, the 'On' indication should be showing on the ACB. Since the spring has released the stored energy, the 'Discharged' indication should be showing on the ACB.

3.1.3 Turning Off the ACB

Press and release the 'Off' Push button, which is usually located at the front of the ACB. Once the main contacts are opened, the 'Off' indication should be showing on the ACB.

3.2 Moulded Case Circuit Breaker (MCCB)

MCCBs are electrical devices used to protect appliances from overloads and short circuits.

3.2.1 Turning On the MCCB

Push the toggle switch to the ‘On’ position, which is usually located at the front of the MCCB. Some MCCBs are fitted with a rotary handle instead. The operator can turn the rotary handle to turn on the MCCB. Should the MCCB trip, push the toggle switch to the ‘Off’ position before pushing the toggle switch back to the ‘On’ position.

3.2.2 Turning Off the MCCB

Push the toggle switch to the ‘Off’ position, which is usually located at the front of the MCCB. Some MCCBs are fitted with a rotary handle instead. The operator can turn the rotary handle to turn off the MCCB.

3.3 Miniature Circuit Breaker (MCB)

MCBs are electrical devices used to protect appliances from overloads and short circuits.

3.3.1 Turning On the MCB

Flick the toggle switch to the ‘On’ position, which is usually located at the front of the MCB.

3.3.2 Turning Off the MCB

Flick the toggle switch to the ‘Off’ position, which is usually located at the front of the MCB.

3.4 Residual Current Device (RCD)

RCDs are electrical devices used to protect against electric shock caused by ground faults or leakage currents.

3.4.1 Turning On the RCD

Flick the toggle switch to the ‘On’ position, which is usually located at the front of the RCD.

3.4.2 Turning Off the RCD

Flick the toggle switch to the ‘Off’ position, which is usually located at the front of the RCD.

3.4.3 Functional Test

While the RCD remains in the ‘On’ position, press and release the test button. This action should trip the RCD. The toggle switch should move back to the ‘Off’ position.

3.5 Earth Leakage Relay/ Earth Fault Protection Relay

The Earth Leakage Relay or Earth Fault Protection Relay are electrical device used to protect against electric shock caused by ground faults or leakage currents.

3.5.1 Functional Test

Earth Leakage Relay or Earth Fault Relay often includes a test button to test its functionality. Press and release the test button. This action should trip the circuit breaker connected to it. The breaker should now be transitioned to its trip position. To clear the fault, press and release the reset button of the relay. Switch off the breaker from its trip status before proceeding to turn on the breaker to resume normal operation.

3.6 Overcurrent Protection Relay

The Overcurrent Protection Relay are electrical device used to protect electrical circuits against overcurrent.

3.6.1 Functional Test

Overcurrent protection relay often includes a test button to test its functionality. Press and release the test button. This action should trip the circuit breaker connected to it. The breaker should now be transitioned to its trip position. To clear the fault, press and release the reset button of the relay. Switch off the breaker from its trip status before proceeding to turn on the breaker to resume normal operation.

3.7 Coupler

A coupler is a bypass switch that allows or inhibits the flow of current into a controlled region of the electrical circuit within the LV Switchgear. It often works hand in hand with interlocking systems to ensure that certain operations can only occur in a specific sequence to maintain safety and proper functioning. Usually, a circuit breaker or isolator can act as a coupler.

Under normal circumstances, the coupler should be in the off position. Should any of these incoming sources malfunction, a coupler can be closed to divert the current flow from the alternative source to support the load demand that was originally powered by the failed source.

3.7.1 Functional Test

A simulation of a failed incoming source can be conducted to perform a functional test of the coupler. Switch off the incoming source that ‘fails’. After ensuring that the ‘failed’ incoming source is off, proceed to turn on the coupler. The load demand of the ‘failed’ source should begin to resume its power consumption again. In the event that the main power resumes back in the original incoming source, the coupler can then be switched off before turning on the original incoming source to regain normal operating conditions.

3.8 Auto Transfer Switch (ATS)

ATS is an electrical device used to automatically transfer an electrical power supply from one power source to another during a power source failure. ATS can be paired up with or without a controller display.

3.8.1 Functional Test with Controller Display (Electrical Switching)

To perform a change-over test via the use of electrical switching, ensure that the key switch is first rotated to the unlock position. Check the indicating light on the controller display to determine which source is the load currently tapping from. If the load is drawing power from Source I, do a changeover by pressing the OFF button, followed by the ON (II) button. If the load is drawing power from Source II, do a changeover by pressing the OFF button, followed by the ON (I) button. Wait for the ATS to perform its changeover function. Once the changeover is done, rotate the key switch to the LOCK position before pulling out the key. The change-over test is now completed.

3.8.2 Functional Test with Controller Display (Manual Switching)

To perform a manual change-over test via the use of manual switching, ensure that the key switch is first rotated to the unlock position. Check the indicating light on the controller display to determine which source is the load currently tapping from. Proceed by pressing the OFF button to conduct manual switching. After which, change the selector switch located at the front of the ATS from Auto to Manual. With the aid of an ATS rotary handle, rotate the ATS to the position intended. Wait for the ATS to perform its changeover function. Once the changeover is done, rotate the key switch to the LOCK position before pulling out the key. The change-over test is now completed.

3.8.3 Functional Test without Controller Display (Electrical Switching)

To perform a change-over test via the use of electrical switching, verify the key switch's rotation positioning first. If the key switch is pointed to auto mode, determine if Source I or II is supplying power by checking the ATS physically to determine its incoming source. If the load is drawing power from Source I, do a changeover by rotating the key switch to Source II. If the load is drawing power from Source II, do a changeover by rotating the key switch to Source I. Wait for the ATS to perform its changeover function. Once the changeover is done, pull out the key from the key switch. The change-over test is now completed.

3.8.4 Functional Test without Controller Display (Manual Switching)

To perform a manual change-over test via the use of manual switching, ensure that the key switch is rotated to the OFF position. Next, proceed to change the selector switch located at the front of the ATS from Auto to Manual. With the aid of an ATS rotary handle, rotate the ATS to the position intended. Wait for the ATS to perform its changeover function. Once the changeover is done, pull out the key from the key switch. The change-over test is now completed.

4. Maintenance of LV Switchgear

This section will address the safety procedures to be followed during maintenance, the frequency of maintenance for LV Switchgear, as well as the recommended tasks when conducting maintenance.

4.1 Safety Procedure During Maintenance

Before commencing maintenance work at the location, ensure that the area is barricaded to keep outsiders from having easy access to the live panel. Appropriate PPE should be worn during the maintenance of LV switchgear. The person carrying out maintenance duties should be qualified and have the necessary skills to operate the maintenance checks on LV switchgear. After maintenance, the workspace should be kept in an orderly and tidy fashion.

4.2 Frequency of Maintenance Schedule

The type of switchgear, its surroundings, and the industry the switchgear is operating for are all factors to take into consideration to determine how frequently it needs to be maintained. Conducting regular maintenance reduces the chance of the equipment breaking down, hence increasing the dependability of the switchgear. Switchgear maintenance can be performed on a monthly, quarterly, biannually, or annual basis. Operators of switchgear can determine the suitability of the type and duration of the means to inspect the switchgear.

4.3 Maintenance Tasks

The recommended sequence of events for performing a maintenance check on LV switchgear will be discussed in this section.

4.3.1 General Inspection

It is advised to perform a general inspection of the premises that house the switchgear on a monthly, quarterly, biannual, and annual basis. The following are included in the general inspection:

a) General cleanliness of the premises.
b) Temperature of the premises.
c) Ventilation of the premises.
d) Signs of cracks in the wall/floor/ceiling.
e) Hazards that are visible within the premises.
f) Signs of corrosion on the panel or the premises.
g) Leakage of oil or water on the premises.
h) External overview of the panels such as indicating lights.
i) Unconventional noises in the premises.
j) Any other signs of anomaly, etc.

4.3.2 Cleaning

The panels' external surfaces are recommended to be cleaned on a quarterly, biannual, and annual basis. It is advised to have the interior cleaned on an annual basis. These are the actions that are advised to be taken while cleaning:

a) Care should be taken to prevent loose parts such as tools or cloth from falling inside the switchgear compartment.
b) External dirt should be removed with a clean cloth. The cloth used for cleaning must be free of loose fibers and metallic threads. If brushes and blower are used to clean the panel, ensure that the nozzles do not contain any metallic parts.
c) Cleaning fluids must be very carefully selected to be compatible with organic insulation and plastics.

4.3.3 Insulation

Checking of insulation materials is recommended to be conducted on a biannual and annual basis. Inspection should be focused on signs of treeing, blistering, overheating, burn marks, cable puncture, and mechanical damage. Replace the insulation component when necessary. In the case where insulation is replaced, it is advised to do a megger test to ensure that the insulation is in good condition. Insulation materials comprised of the following:

a) Bus Bar Supports.
b) PVC Materials.
c) Phase Separators.
d) Cable Insulation.

4.3.4 Connections

Inspection of the connections is recommended to be conducted on a biannual and annual basis. Ensure that every connection is tightened to the proper degree; loose connections frequently result in overheating. Verify that none of the contact surfaces are worn, damaged, or torn. Replace the contacts if necessary. In the case where contacts are refitted or renewed, contact force alignment should be verified. In addition, a megger test is recommended to ensure that the connections are intact.

4.3.5 Operating Mechanisms

It is recommended to inspect the switchgear mechanisms on a biannual and annual basis. Mechanisms include moving components like door handles, hinges, locks, selector switches, key selector switches, and so forth. Replace worn components as needed.

4.3.6 Functions

It is recommended that switchgear components undergo functional tests on an annual basis. Functional checks include the following:

a) Circuit Breaker On/Off/Trip Test
b) Protection Relay Trip Test
c) Coupler System Test; If Applicable
d) Auto Transfer Switch (ATS); If Applicable
e) Mechanical and Electrical Interlocking System Tests; If Applicable

4.3.7 ACB Contacts and Arc Chute Cleaning (If Applicable)

Air Circuit Breaker (ACB) contacts inspection and cleaning is recommended to be done on an annual basis. The following checks are as followed:

a) Ensure that the ACB is in the off position. Use appropriate tools to disengage the ACB from its chassis. Carefully rack out the ACB from its chassis.
b) Inspect the main contacts of the ACB. The main contacts are usually hidden behind the closing latch. The latch should be revealed to examine the main contacts inside. Examine carefully for signs of erosion and corrosion. If unfamiliar with the process, it is advisable to consult with the Manufacturer.
c) Ensure that any unnecessary items such as leftover bolts and nuts found inside the ACB chassis zone are removed.
d) Cleaning of arc chutes: Visually inspect the arc chute to identify any signs of damage, debris, or contamination. Check for burnt materials or any foreign objects such as carbon and dust that have been accumulated. Use a soft brush to gently remove loose carbon, debris, and dust.
e) After inspection of the ACB contacts, perform a functional test to ensure that the ACB operates correctly.
f) It is also recommended to do a megger test to ensure that the connections are intact.

4.3.8 Megger Tests

The purpose of the megger tests is to ensure that the insulation is in good condition. It is recommended that the Megger Test is commenced on a biannual and annual basis. It is also highly recommended to do a Megger Test if any form of connection is retrofitted or insulation is replaced; examples include modification of cables and breakers that result in cable termination, or any replacement of bus bar supports.

4.3.9 Injection Tests

The purpose of injection tests is to ensure that the current transformer and protection relay function correctly. It is recommended that the injection test be conducted on an annual basis.

4.4 Summary of Maintenance Operations

The maintenance operations recommended for LV switchgear are summarized in Table 1.

Maintenance Tasks	Monthly	Quarterly	Biannually	Annually
General Inspection	✓	✓	✓	✓
Cleaning		✓	✓	✓
Insulation			✓	✓
Connection			✓	✓
Operating Mechanisms			✓	✓
Functions				✓
ACB Contacts and Arc Chute Cleaning				✓
Megger Test			✓	✓
Injection Test				✓

Table 1: Maintenance Tasks Checklist