

# Temporary Transformer Room Installations for Construction Sites: Cable Sizing, Testing, WR2, and Circuit Breaker Discrimination

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## ABSTRACT

Large-scale construction sites frequently require electrical power exceeding the capacity of a single 400A three-phase feeder. In such contexts, power utilities typically supply a small-capacity 11kV transformer (e.g., 200–300 kVA) housed within a purpose-built temporary transformer room. This paper examines the practical engineering considerations surrounding the construction of such temporary transformer rooms, with particular attention to design specifications for weatherproofing, oil containment, ventilation, and security. Beyond physical infrastructure, the paper addresses essential technical procedures including cable sizing in accordance with the EMSD Wiring Code, the role of the Registered Energy Assessor (REA) under Cap. 610, testing and commissioning (T&C) protocols, periodic inspection and testing (WR2), and the critical engineering task of circuit breaker discrimination. Drawing on authentic field experience from Hong Kong construction sites, this paper aims to share practical knowledge with industry peers, highlighting both technical requirements and common pitfalls that may lead to financial losses, regulatory non-compliance, or safety hazards. The paper concludes that early engagement of qualified professionals, rigorous adherence to testing protocols, and systematic verification of protective device coordination are essential to successful temporary electrical installations.

**Keywords:** building energy code, cable sizing, circuit breaker discrimination, temporary transformer room, testing and commissioning, WR2

## INTRODUCTION

The delivery of reliable temporary electrical power to large-scale construction sites presents unique engineering challenges that differ significantly from permanent building installations. Construction sites (Development Bureau, 2024) are dynamic environments characterized by rapidly changing load profiles, exposure to weather elements, and the need for rapid deployment and eventual removal of electrical infrastructure. Unlike permanent installations, which benefit from dedicated electrical rooms within building structures, temporary transformer rooms must be self-contained, weather-resistant, and capable of safe operation in outdoor environments for the duration of construction activities.

In Hong Kong, power utilities such as CLP Power (2025) and Hongkong Electric (HKE) provide temporary high-voltage (11kV) transformers to large construction sites where the power demand exceeds the capacity of standard low-voltage feeders. A typical temporary transformer installation may range from 200 kVA to 300 kVA, housed within a custom-fabricated metal room. The design, construction, testing, and ongoing maintenance of these installations must comply with multiple regulatory frameworks, including the EMSD (2025) Wiring Code, Cap. 610 Building Energy Efficiency Regulation (2013), the Building Energy Code (BEC), and safety regulations administered by the Labour Department and the Construction Industry Council (CIC).

This paper synthesizes practical field experience from multiple construction projects in Hong Kong, including the authors' direct involvement in the design, construction, testing, and commissioning of temporary transformer rooms. The objectives of this paper are threefold:

1. To document best practices for the physical construction of temporary transformer rooms, including plinth design, oil containment, ventilation, weatherproofing, and security features.
2. To explain the technical procedures for cable sizing, testing and commissioning (T&C), periodic inspection (WR2), and circuit breaker discrimination.
3. To highlight the regulatory requirements under Cap. 610, including the critical role of the Registered Energy Assessor (REA) and common compliance pitfalls that can lead to substantial financial losses.

It is important to note that this paper is written from the perspective of practicing engineers sharing experiential knowledge. While the paper draws on established codes and standards, it does not claim to provide exhaustive technical specifications. Readers are strongly advised to consult the latest editions of all referenced codes and regulations before undertaking any electrical installation work.

## Construction of Temporary Transformer Room

### Rationale for Temporary Transformer Rooms

Tower cranes, concrete batching plants, dewatering pumps, welding equipment, site offices and lighting all need a lot of electricity on large construction sites, especially for infrastructure projects like railway extensions, tunnel constructions and major building developments. A standard low-voltage feeder (like a 400A three-phase) is not always enough for these needs. In this case, the power company provides a small 11kV transformer, usually rated between 200 kVA and 300 kVA, that lowers the voltage from high to low (380V/415V) for distribution across the site.

To keep the transformer and its medium-voltage (MV) panel safe from rain, dust, unauthorised access, and accidental contact, they must be kept in a weatherproof, secure enclosure. This is the temporary room for the transformer. The authors note that the installations done by CLP Power and the equipment made by Merlin Gerin (now part of Schneider Electric) are typical, but there is a lot of variation between suppliers.

### Structural Design and Materials

The authors say that the temporary transformer room is usually made of painted mild steel to keep it from rusting. The building needs to be strong enough to handle wind loads, hits from construction vehicles by accident, and normal site activities.



Figure 1: Typical temporary outdoor transformer room

Figure 1 shows a typical temporary outdoor transformer room. The room is big enough for a small oil-type transformer (like a 200 kVA, 11kV) and an MV panel. It's important to note that control circuit instruments are often housed in a separate cabinet outside the transformer room, on the right side of transformer room. The authors say that this separation makes it less necessary for people to go into the transformer room to keep an eye on things and control them, which makes things safer.

The manuscript talks about pictures that are not in the text that is available. Future editions ought to include these images to enhance the descriptive material.

### Plinth and Oil Containment

The transformer room needs to be built on a concrete base that is at least one foot (about 300 mm) above the ground. This elevation has two purposes: first, it keeps water from getting into the ground during heavy rain; second, it gives the heavy transformer a stable, level base.

A very important safety feature is the four-inch (about 100 mm) high curb that goes around the outside of the plinth. This way, the oil does not spill onto the pavement outside. If oil-filled transformers leak, they can be bad for the environment because they hold a lot of insulating oil. The kerb serves as a secondary containment bund, stopping spilt oil from getting to the ground or drainage systems around it. This design feature is in line with environmental protection rules that say you cannot dump oil into stormwater drains or natural bodies of water.

### Weatherproofing and Ventilation

Because construction sites are outside, temporary transformer rooms need to be very weatherproof. The roof is made of metal sheets, and the eaves go beyond the room's footprint. This overhang keeps rainwater from falling directly into the room.

The roof metal sheet eave of the transformer room goes out from the top of the room to keep rainwater from dripping down from the roof into the transformer room (see Figure 2).



Figure 2: Concrete plinth provided with 4 inches high kerb

Ventilation is necessary to get rid of the heat that the transformer makes while it is working. There are ventilation fans on the roof, but they need to be protected from rain. The authors talk about a certain design solution:

The dog house has a top canopy that covers the fan, so rainwater cannot get into the transformer room through the fan from above. Ventilation air goes out from the side. This design lets hot air out while keeping rainwater from coming in directly. Here are some more weatherproof features:

1. Ventilation louvres on all sides, with fine wire mesh to keep out bugs, birds, and other things.
2. Doors that can be locked on all sides of the room so that workers can get to all sides of the transformer and MV panel (keeping in mind that the space inside is limited).
3. Doors that swing open and closed with locks, metal louvres, and fine-hole wire mesh to keep rain from getting in from the side.

The dog house ventilation design is a cheap but effective way to solve a common problem with outdoor electrical enclosures. Engineers who are designing similar installations in tropical or subtropical areas should think about using or changing this method.

### Security and Access Control

There are live high-voltage and medium-voltage equipment in the transformer room. To keep people from getting in without permission, all doors must be locked.



Figure 3: Control panel is mounted outside of transformer room

The control panel is often mounted outside (see Figure 3) so that it can be monitored and operated without having to go into the transformer room. The fused switches and moulded case circuit breakers (MCCBs) that carry heavy currents, on the other hand, must stay in the locked room. These outgoing power supply switches are heavy current rating and are live and must be installed inside transformer room and all doors are locked against unauthorized entry. This setup strikes a good balance between ease of use and security needs.

### Site Context and Integration

Figure 1 shows a large construction site that is well-organised and has hoarding structures supported by I-beams on concrete plinths. There are noise barrier cloths set up high all around the site, and the boundary hoarding has walking platforms with company advertisement canvases on them. This picture puts the transformer room in the context of the whole construction site, which shows how important it is to connect it to safety and security measures on the site.

The authors give a very useful piece of advice "Good site formation". The transformer room must be placed carefully within the site layout, considering how easy it will be to get to for delivery, maintenance, emergency

response, and eventual removal. Bad placement can cause problems with operations, higher costs, and safety risks.

## Cable Sizing According to EMSD Wiring Code

### Overview of the Cable Sizing Process

For electrical safety and system performance, it is very important to get the right size cable. Cables that are too small can overheat, which can damage the insulation, cause copper losses, lower the voltage, and even start a fire. Oversized cables are safe, but they cost too much and are hard to install and end.

The most recent version of the EMSD (2025) Wiring Code gives a clear way to size cables that must be followed for all permanent and temporary installations. There are three main steps in the process:

- (1) estimating the load and calculating the maximum demand,
- (2) applying correction factors, and
- (3) checking the current-carrying capacity and voltage drop.

### Step 1: Maximum Demand Calculation

The maximum demand current of the circuit is the first thing to think about when sizing a cable. The designer must figure out the expected steady-state operating current for a final circuit that will power a specific load, like a tower crane, a welding set, or a lighting distribution board. When choosing a protection device, you need to keep in mind that starting currents for motor loads can be much higher than running currents. This is because cables can handle short bursts of overload without being damaged.

### Step 2: Application of Correction Factors

The designer needs to divide the maximum demand current ( $I_b$ ) by the product of the relevant correction factors to get a "reference current" ( $I_t$ ) for choosing the cable. The correction factors consider the installation conditions that make the cable less able to carry current.

The EMSD Wiring Code says that the following correction factors are needed:

1. Grouping factor ( $C_g$ ): Cables that are close together (like those that are bunched up trunking or buried together) cannot get rid of heat as well as cables that are alone.
2. Thermal insulation factor ( $C_i$ ): Cables that are buried in thermal insulation, like in insulated walls, don't let heat escape as easily.
3. Ambient temperature factor ( $C_a$ ): The higher the ambient temperature, the less current the cable can carry.
4. Soil thermal resistivity factor ( $C_s$ ): The type of soil that buried cables are in affects how well they can get rid of heat.

If you multiply the three correction factors together, you get 0.8. The final circuit's maximum demand is 20A, so  $20A/0.8 = 30A$ . This means that the cable must be able to carry at least 30A in normal conditions, like when the temperature is 30°C and the air is free.

### Step 3: Cable Selection from Tables

The designer uses the calculated reference current ( $I_t$ ) to look up the right table in the EMSD (2025) Wiring Code.

1. The type of insulation on the cable (PVC or XLPE, which stands for cross-linked polyethylene)  
The material of the conductor (copper or aluminium)
2. How many phases are there (one or three)?

### 3. How to install it (surface mounted, in conduit, in trunking, buried direct, etc.)

The cable you choose must have an Itab that is equal to or greater than the It that is needed. For example, if you choose a 4 sq mm cable, the current capacity is greater than 30A.

#### Step 4: Voltage Drop Verification

If the voltage drops between the supply point and the load is too high, a cable that meets current-carrying requirements may still not be acceptable. The EMSD Wiring Code usually says that the voltage drop for lighting circuits can be no more than 4% of the nominal supply voltage and for other power circuits, it can be no more than 6%. However, the exact limits depend on the type of installation.

The calculation for the voltage drops depends on:

1. Length of the cable
2. Current (Ib)
3. Cross-sectional area of the conductor
4. Material for the conductor
5. The load's power factor

The EMSD Wiring Code has tables and formulas for how much voltage drops per ampere per metre. There is a formula in the code to figure out the voltage drop. If the cable size meets both the current capacity and the voltage drop, confirm that you want to use that size. If not, choose the next bigger size cable. Check the voltage drop and current capacity again.

#### Practical Implications for Temporary Installations

When sizing cables for temporary construction sites, you also need to think about:

1. Requirements for mechanical protection (cables can be run on the ground, but they must be able to handle vehicle traffic)
2. Moving temporary distribution boards around a lot
3. Bad weather (UV rays, moisture, and dust)

The basic calculations are the same as for permanent installations, but the correction factors and installation methods may be very different. The authors stress that having a temporary status does not mean that installations are not required to fully follow the EMSD (2025) Wiring Code.

### Cap. 610 Energy Efficiency, and the Role of the Registered Energy Assessor (REA)

#### Overview of Cap. 610 and the Building Energy Code (BEC)

Cap. 610 of the Laws of Hong Kong (2013), formally titled the Building Energy Efficiency Regulation, came into effect after 2010. This regulation mandates that certain building services installations comply with the prescribed Building Energy Code (BEC). The BEC sets minimum energy efficiency standards for four key systems:

- Electrical installations (EE-EL form)
- Air conditioning installations (EE-AC form)
- Lighting installations (EE-LG form)
- Lift and escalator installations (EE-LE form)

For new building installations, and for certain "material change" or addition and alteration (A&A) works, the owner must engage a Registered Energy Assessor (REA) to verify compliance with the BEC. The REA is a professional (typically an electrical or mechanical engineer) registered with the Electrical and Mechanical Services Department (EMSD) to carry out energy assessments.

### **The Copper Loss Requirement**

One of the most important things that the building energy code (BEC) electrical section requires is that copper losses in electrical circuits be kept to a minimum. Copper loss ( $I^2R$  loss) is the heat that conductors give off because they resist electricity. Too much copper loss wastes energy, makes the cooling loads heavier, and lowers the overall efficiency of the system.

There are rules for limiting copper loss, usually less than 1% is okay for the final circuit, submain, and riser. The exact percentage may change depending on the type of circuit and the use, but the basic idea is that designers must choose cable sizes that keep resistive losses within set limits. Nowadays, usually excel sheets calculate the copper loss, meaning that compliance calculations are usually done with spreadsheet tools that use the BEC formulas (Electrical and Mechanical Services Department, 2024). But the manuscript does not say which formulas or which version of the BEC to use, which makes it hard for readers who want to do the calculation again.

### **The REA's Role and Common Compliance Failures**

The registered energy assessor (REA) oversees checking the design (usually before construction starts) and making sure that the installation is up to building energy code (BEC) standards. The manuscript stresses how important it is to get involved in REA early:

You must get REA involved to check the design before construction starts. I saw a case in Kwun Tong where the owner of a whole floor of shops was unhappy with BEC. All the shops could not be rented out to tenants, and the owner lost a lot of money every day because they did not have any rent income.

This case shows an important point: under Cap. 610, the owner is legally responsible for BEC compliance. If the REA does not find a problem with compliance, or if the owner tries to get around the REA process, the building or property cannot be rented or occupied. This means big money losses for businesses that own commercial real estate.

### **Exempted Items: A Lesson in Code Interpretation**

The authors talked about the Kwun Tong case, which had to do with a finding of non-compliance with lighting power density. I learned that the reason is that advertising lights have too much power and do not meet the code's lighting power density requirement. I told the owner that the advertisement light power was for commercial use, like a window display light, and that it was not subject to BEC. Then it passed BEC. The technical guide for BEC has a list of exempt items with pictures and very clear instructions. Not clear what REA is or if it is an exempt item; lighting power density must be higher than Code requirements; cannot pass BEC.

This example shows how important it is for REAs and designers to be very familiar with the BEC Technical Guide (EMSD, 2024a), especially the list of items that are not subject to the rules. Lighting for advertising (like shop window displays and illuminated signs) is often not included because it is used for branding rather than general lighting. But if the REA does not know about this exemption, they might incorrectly mark a compliant installation as non-compliant, which would slow down the project's completion.

The manuscript does not say which version of the BEC Technical Guide it uses or gives the exact clause numbers for the advertising lighting exemption. Revisions in the future should have exact references.

## Financial Implications of Non-Compliance

The manuscript gives a clear warning about the financial effects of not following BEC:

Whole floor shops cannot be rented out, which means a big loss of rental income. It loses million a month, so hiring experienced ICE to check is not a good idea. It is not only dangerous, but it is also a big financial loss. Engaging ICE is very cheap, but if you do not, the penalty for an accident is very high (a fatal accident means the owner goes to jail for three years and pays a fine of 20 million dollars). You must go bankrupt right away and go to jail.

While the author talks about "ICE" (the Institution of Civil Engineers), they probably mean "experienced consulting engineer" in this case. The main point is that hiring experienced advisors is a false economy. Hiring a qualified REA or consulting engineer is very cheap compared to the possible losses from delays in finishing a project, not being able to rent out space, or fines from the government after an accident.

## Limitations of the Regulatory Discussion

The original manuscript has a long and emotional discussion of dishonest employees, bad accountants, and court cases. Although these observations are framed as aspects of the author's personal experience, they lack direct relevance to the technical subject of temporary transformer rooms and electrical installations. For the sake of this academic revision, we only note the author's claim that internal malpractice can make regulatory risks worse. A more thorough examination would necessitate documented case evidence instead of anecdotal claims. Because of this, the revised article does not include this material because it is not relevant to a technical engineering paper.

## Testing and Commissioning (T&C) of Electrical Installations

### Overview of T&C Requirements

Testing and commissioning (T&C) is the process of making sure that electrical installations are safe, work, and meet design and regulatory standards. T&C must be done before the installation is powered up for normal operation and again during regular inspections (WR2) for temporary transformer rooms and their distribution systems. The manuscript enumerates the following critical T&C tests, each of which is analysed comprehensively below.

### Visual Inspection

People often do not check the actual items installed match what is shown in the drawings and specifications. The engineer must check with their eyes that:

- All the equipment, like cables, switchgear, transformers, and distribution boards, meets the approved plans and specs.
- The equipment is set up correctly, supported correctly, and is not physically damaged.
- Clearances and work areas follow safety rules.
- There are labels and ID tags that can be read.

Visual inspection can find problems that electrical testing alone might not, like the wrong type of equipment, missing parts, or obvious mistakes made during installation.

### Insulation Resistance Test (Megger Test)

Insulation resistance testing, often called the "Megger test" (Juris et al., 2024) after a well-known maker of insulation testers, checks the resistance of insulation between conductors and between conductors and the ground. Low insulation resistance means that moisture has gotten in, the material has been damaged, or there are problems with how it was made that could cause leakage currents or short circuits.

To do the test, you apply a DC voltage (usually 500V, 1000V, or 2500V, depending on the system voltage) and then measure the current that comes out. The EMSD (2025) Wiring Code says what values are okay. The manuscript lacks specific acceptable values, presenting a limitation; readers are required to refer directly to the Code.

### **Continuity Test**

Continuity testing checks that all the conductors make a complete, low-resistance path from one end point to the next. This test is very important for protective earth (PE) and bonding conductors because high resistance could stop overcurrent protection devices from working properly during a fault.

### **Polarity Test**

Polarity testing (Hora, 2024) shows that single-pole switching, and protective devices are connected to the line conductor (not the neutral) and that socket outlets and other termination points are wired correctly (with the line, neutral and earth in the right places). If the polarity is wrong, equipment can still be powered on even when it is turned off, which is very dangerous.

### **Earth Fault Loop Impedance Test**

The earth fault loop impedance ( $Z_s$ ) (Neamt, Neamt & Chiver, 2021) is the resistance of the path that fault current takes from the point of fault back to the source (transformer) through the protective earth conductor. This impedance must be low enough that, even when there is a fault, enough current flows to turn on the overcurrent protective device in the time required to disconnect.

The test consists of measuring the loop impedance and making sure it doesn't go over the maximum value set for the protective device (which is usually based on the device's time-current characteristic curve).

### **Earth Electrode Test**

It is necessary to measure the resistance to earth for installations that use earth electrodes, such as earth rods or foundation earth electrodes. The EMSD (2025) Wiring Code says what the highest acceptable values for earth resistance are. High earth resistance can stop fault currents from spreading out properly and make touch voltages dangerous.

### **Secondary Current Injection of Relays**

To make sure that protection relays (like overcurrent relays and earth fault relays) work correctly at the current and time settings they are set to, they must be tested. Secondary injection testing means taking the relay off its current transformers (CTs) and sending test currents directly into the relay's input terminals.

All relays must be pulled out and tested with a portable big tester that can make current and measure the time it takes for the relay to start and stop. Make sure that the current plug setting multiplier and time multiplier match the graph on the relay for checking the tripping time.

Primary current injection (testing with full fault current through the CTs) is typically performed at the factory due to the high currents required. Factory workers also do high-voltage pressure tests, like 2 kV.

### **Ductor Test of Busbar Joints (Micro Resistance)**

To stop localised heating, busbar joints (the places where different sections of busbar connect) must have very low resistance. A ductor tester (micro-ohmmeter) sends a high-test current (usually 50A to 600A) through the joint and measures the voltage drop across it to figure out the resistance. A high resistance means that the joint is loose or dirty and needs to be re-torqued or cleaned.

## **Tightness Torque Test of Bolts on Busbar**

Bolted connections on busbars and cable terminations need to be tightened to the torque that the manufacturer says to. If you tighten too much, the threads can strip or the conductors can break. If you do not tighten enough, the resistance will be high, and the heat will build up. You can use a torque wrench to make sure that each bolt is tightened to the right amount.

## **Cable Termination Verification**

The manuscript stresses a simple but important principle to check and make sure that the ends of the cable and wire are connected correctly, not wrong. Misconnections, like swapping phases, connecting neutral to earth, or rotating three-phase motors the wrong way, can break equipment, make things unsafe, and cause problems with how things work.

## **Functional Testing**

Functional testing checks that all of the equipment works as it should turn off the MCCBs, fuse-switches, and air circuit breakers (ACBs), take out the withdrawable units and look for any screws that are loose or parts that are missing, make sure that the mechanisms work smoothly, and turn it back on and restore it.

This testing requires coordination with the power utility to turn off their supply at their transformer room to turn off the main switchboard and check the ACBs at the main switchboard. The functional testing must cover all the floor subboards.

## **Generator Testing and Lift Coordination**

The manuscript delineates a particular scenario concerning emergency generator testing. To start the emergency generator, you need to turn off the main power supply. The lift will stop when the main power is turned off.

This process makes sure that no one gets stuck in a lift when the main power goes out. The emergency generator turns on by itself when the main power goes out. The generator runs for a long enough time (like 20 minutes) to show that it works properly. The generator turns off by itself when the main power comes back on.

The 20-minute run time mentioned in the manuscript seems to be a requirement for that site. The EMSD (2025) Wiring Code and relevant generator standards (like ISO 8528 (ISO, 2018)) set minimum run times for different types of tests. Readers should check the requirements that apply to their own installations.

## **Temporary Lighting for WR2**

The manuscript mentions a useful detail that is often missed. It needs to bring a portable diesel generator to give temporary light because WR2 must do it at night and get the power back before morning.

WR2 testing (periodic inspection) usually happens at night or other times when people are not in the building to avoid bothering them. But this means that the building will be without power for a few hours. For safety and to let workers do the testing, there must be temporary lighting powered by a portable generator.

## **Post-Completion Activities**

The manuscript outlines two final tasks after all testing has been finished and confirmed. Debris from installation, like copper shavings, dust, and drilling swarf, can cause tracking, short circuits, and equipment to fail before its time. Cleaning well is very important. A schematic diagram (also called a single-line diagram) must be shown in the switch room so that operators and maintenance workers know how the system is set up.

## Application to Data Centres

The manuscript states that the same basic T&C procedures apply to more complicated setups like data centers. These are the basic electrical tests and T&C on the main switchboard, switches, UPS, changeover switches, power panel units and other parts of the Data Centre. They also include simulating a fault to check the security of the power supply.

In addition to other tests, data centers also test their uninterruptible power supplies (UPS), automatic transfer switches (ATS), and standby generators by simulating fault conditions to make sure they work properly without cutting off power to important loads.

## WR2: Periodic Inspection and Testing

### Definition and Regulatory Basis

WR2 stands for the regular checking, testing, and certification of low-voltage fixed electrical installations in Hong Kong. The "R" stands for "regulation," and the "W" stands for "wiring." The Electricity Ordinance (Cap. 406) (Laws of Hong Kong, 2020) and the Electricity (Wiring) Regulations say that WR2 inspections must be done.

How often WR2 inspections happen depends on the kind of building:

- Every five years for hotels, hospitals, and public entertainment venues
- Every five years for factories and industrial buildings
- Buildings for business: every five years
- For common areas in residential buildings, every ten years

If there are two transformers and one of them is more than 2500A, it must hire a REW(C0) to do WR2. REW B can only work up to 2500A. There are different grades for Registered Electrical Workers (REWs). REW(B) can work on installations with up to 2500A. REW(C0) is able to work on installations with more than 2500A, even if they have two or more transformers

### WR2 Procedure Based on the Author's Experience

The manuscript offers a firsthand narrative of WR2 procedures derived from the author's experiences at Lohas Park and a supermarket in Tsuen Wan:

1. Working with the power company: The company turns off the power at their transformer room.
2. Night-time execution: WR2 must be done at night, and power must be restored before morning to cause the least amount of disruption.
3. Temporary lighting: A portable diesel generator lights up the area while testing is going on.
4. Systematic testing: All relays are taken out and tested with secondary injection.
5. The order for switching: The power company should turn off their supply in the transformer room first and then do WR2. After WR2 is done (the supposed incoming ACB and all downstream boards are off power), the power company turns the power back on, then turns on the incoming ACB, and finally turns on each downstream subboard.

### Critical Safety Warning

The manuscript gives a strong warning about the risks of turning on. It is not dangerous to turn off the switch; it is dangerous to turn it on. Before turning on the main switch, make sure that all of the downstream circuit breakers are open. This warning is based on a basic rule of electrical safety: when you turn off a system, the load is gradually disconnected, which means that the circuit breaker opens when the current is low or zero.

When you turn on the circuit breaker, it must close against the full inrush current of all the downstream loads, such as transformers, motors, and capacitors. If there is a fault downstream, the circuit breaker will close on a short circuit, which is dangerous because it can cause an arc flash.

### **Mandatory Testing Before Switching On**

The manuscript states a crucial requirement prior to activation following maintenance or testing.

You need to check the megger test for all phases, from line to line, line to neutral and all insulated parts before turning it on.

Before turning on any circuit that has been worked on, the insulation resistance must be checked. This proves that no connections or damage were caused by accident while the work was being done.

### **Discrimination of Circuit Breakers**

#### **Definition and Importance**

Discrimination, which is also known as selectivity or coordination, is the process of setting up overcurrent protective devices (circuit breakers, fuses, relays) so that if there is a fault in the electrical system, the protective device right before the fault clears it while all the other devices stay closed and power continues to flow to healthy circuits.

It is very important when a fault happens, the far downstream breaker must trip before the nearer circuit breaker. If the right discrimination is not used, a fault on a final circuit could trip the main incoming circuit breaker instead of just the local sub-circuit breaker. This would cause the whole building to go dark and stop all operations. This is especially important for places like data centers, hospitals, and air traffic control centers where power must never go out.

#### **Practical Experience: Discrimination Verification at CAD Headquarters**

The manuscript talks about a project at CAD Headquarters, which is close to Hong Kong International Airport and keeps an eye on air traffic. At CAD H/Q near the airport, I worked on a project with well-known contractor RNB to make sure that all the main switchboards' relay settings were correct and that the right discrimination was used when tripping.

As part of this project, we had to make sure that all the relay settings (current plug setting multiplier and time multiplier) were working together correctly so that relays that are downstream trip faster than relays that are upstream. The time-current characteristics of all devices in series do not overlap in a way that causes unwanted upstream tripping.

#### **Output of Discrimination Studies**

It is necessary to make a report to CAD after checking. It means the discrimination verification was done.

A full report on discrimination research usually has:

- A diagram of the electrical system on one line
- Time-current characteristic curves for all safety devices
- Tables of relay settings, such as plug setting, time multiplier, and instantaneous settings
- Checking that the calculated fault current at each bus is less than the breaking capacity of all devices
- A statement that the work follows the EMSD (2025) Wiring Code and other engineering standards such as CIBSE (2004), IET (2018).

## Methods for Achieving Discrimination

The manuscript talks about different kinds of starters that change starting currents and, as a result, discrimination. DOL and assisted starters, like the star-delta starter, the auto transformer starter, the variable frequency (variable speed starter), and the variable speed drive, are all soft starters that do not cause a sudden jump in starting current.

1. Direct-On-Line (DOL) starters send full voltage to the motor, which causes a high inrush current (usually 6–8 times full load current). This can make it hard to tell the difference because the high starting current may be close to the setting of upstream protective devices.
2. Star-delta starters cut the starting current down to about 33% of the DOL starting current.
3. Auto-transformer starters let you choose the starting voltage (for example, 50%, 65%, or 80% of line voltage) and lower the starting current at the same time.
4. Variable Frequency Drives (VFDs), also known as variable speed drives, frequency inverters, or soft starters, slowly speed up the motor and only use a little more than full load current when starting.

## VFDs and Energy Saving

The manuscript offers an intriguing operational perspective on variable frequency drives (VFDs) in heating, ventilation, and air conditioning (HVAC) contexts. Instead of stopping the fan coil when the room temperature is cool enough, let it run at a variable speed at a low speed. Proved saves more energy than frequently stopping and starting the fan coil. This observation goes against the common belief that turning off a motor completely saves the most energy. In fact, starting and stopping a lot:

1. Pulls a lot of current at the start each time
2. Puts thermal cycling stress on the motor windings
3. It might use more energy than running at a constant low speed.

VFDs let motors run at the lowest speed needed to keep setpoint conditions, which saves energy. VFD energy savings can diminish due to installation errors and system overrides (Riskiawan et al., 2026). But the manuscript does not give any numbers or references to back up the claimed energy savings, which is a problem.

## Safety Precautions for Working on Live Electrical Installations

### General Principles

The manuscript ends with important safety tips for working with electricity. The main idea is easy to understand, but it must be followed strictly. Before you work on electrical installations, you need to turn off the power. But there are times when you have to work on live parts, like when you need to test or measure something. In these situations, extra care is needed.

### Personal Protective Equipment (PPE)

#### The manuscript suggests:

1. Wearing insulated gloves—rated for the voltage in the area.
2. Do not wear metal glasses, wear plastic glasses instead. Metal frames can conduct electricity and cause a shock or arc flash hazard.
3. Put an insulated mat on the floor while working on live parts, like the main switchboard, to make the resistance to earth higher so that the current is lower if it flows on you.

The manuscript does not say what the voltage rating or testing frequency should be for insulated mats and gloves. For more information, readers should look up the EMSD (2025) Wiring Code and the appropriate safety standards, such as IEC 61111 for mats (IEC, 2009) and IEC 60903 for gloves (IEC, 2014).

## Voltage Detection

The worker must make sure that the conductor is not live before touching it. Touch any parts that live with a pen lamp, which will light up if the surface is live. This is a voltage pen or voltstick that lights up or beeps when it gets close to a live conductor. The manuscript says that non-contact testers are good for initial checks, but a two-pole voltage tester should be used to confirm before touching.

## Lock-out/Tag-out (LOTO)

The manuscript stresses a key LOTO principle to put a hand lock on the switch so that no one can accidentally turn it on while you have turned off the power.

The isolating switch should have a personal lock and tag on it, and the worker should keep the key. This stops someone else from turning the circuit back on while work is going on. The manuscript also says that each worker must put their own lock and tag on the isolating switch.

## Permit-to-Work System

EMSD specifies the Permit to Work system in the EMSD Wiring Code when workers are working in an area where there may be live electricity, such as inside a false ceiling.

A Permit-to-Work (PTW) is a written document that:

1. Tells you what work needs to be done
2. Tells where and how long it will be
3. Lists the safety measures and isolation points
4. Is signed by someone who has the right to do so, like a responsible engineer or supervisor
5. The worker knows about it

Before work starts, PTW makes sure that everyone knows about the risks and safety measures.

## Limitations of the Study

Readers should be aware of the limitations of this paper, which is based on real-life experiences from construction sites in Hong Kong.

- (a) No photographic proof -- The original manuscript mentions several pictures (Photo 1, Photo 1b, Photo 1c, Photo 3, and Photo 4) that are not included in the text that is available. These pictures would have been helpful for showing how to build transformer rooms, plinths, ventilation systems, and control panels. These pictures should be included in future revisions, or if they aren't available, they should be replaced with schematic diagrams.
- (b) No quantitative data -- The paper provides qualitative observations and procedural descriptions; however, it lacks quantitative data, including measured insulation resistance values, earth fault loop impedance results, ductor test readings, or comparative energy consumption figures for variable frequency drive (VFD) versus stop-start operation. There are no measurements or references to back up the claim that "continuous low-speed VFD operation proved save more energy than stop and start".
- (c) Anecdotal case evidence -- The Kwun Tong case study demonstrating the repercussions of BEC non-compliance is offered as a solitary anecdote, lacking supporting documentation such as correspondence, regulatory notices, or financial records. The narrative is informative, but it fails to satisfy the evidentiary criteria of formal case study research.
- (d) References to rules that are not complete -- The paper talks about the EMSD Wiring Code, Cap. 610, the Building Energy Code (BEC), and the BEC Technical Guide, but it doesn't say which edition, clause, or

publication date they are. Since these documents are updated from time to time, readers can't tell which version of the requirements applies without checking on their own.

- (e) Geographic scope -- The paper is only about Hong Kong's rules and building methods. The technical principles (cable sizing, discrimination, testing procedures) are generally applicable; however, the specific regulatory requirements (REA registration, WR2 frequencies, REW grading) are jurisdiction-specific and should not be presumed to apply universally.
- (f) No distinction between temporary and permanent -- The paper does not clearly separate the rules that apply only to temporary transformer rooms on construction sites from those that apply to permanent installations. For instance, are the WR2 inspection frequencies and REA requirements the same for both temporary and permanent installations? This lack of clarity makes the paper less useful for people who only work with temporary installations.
- (g) No Discussion of transformer removal and decommissioning -- The paper talks about building, testing, and using the temporary transformer room, but it doesn't say anything about how it will be taken down and removed. This is a big problem because restoring the site and safely removing electrical infrastructure are important steps in finishing the project.

## CONCLUSION

This paper has attempted to connect the gap between theoretical electrical engineering concepts and the real-world challenges of building temporary transformer rooms on large construction sites in Hong Kong. The authors have used decades of combined field experience to write down the design features (weatherproofing, oil containment, ventilation, security), technical procedures (cable sizing, T&C, WR2, discrimination), and regulatory compliance requirements (Cap. 610, REA, BEC) that are necessary for a project to go smoothly.

The main point of this paper is that paying attention to details can save lives and money. Hiring qualified professionals like REAs, REWs, and consulting engineers is very cheap compared to the money that could be lost if a project takes too long to finish, if the property can't be rented out, if fines are imposed by the government, or, worst of all, if someone dies and goes to jail and goes bankrupt. Also, the time spent on systematic testing (insulation resistance, earth loop impedance, secondary injection, ductor testing) and formal verification (discrimination studies, torque checks, polarity verification) stops failures from happening during operation, which can have terrible effects.

There are still rules that apply to temporary electrical installations. The same safety rules, WR2 inspection frequencies, and EMSD Wiring Code, Cap. 610 rules apply. The "temporary" label affects how the building is built (making it weatherproof, easy to move, and easy to take down), but it doesn't change the rules or safety standards.

The authors want people to think of this paper as a useful addition to the official codes and standards, not a replacement for them. Every installation is different, and professional judgement based on the conditions at the site must always come first. The principles documented here, from the 100 mm oil containment kerb to the pre-energization insulation resistance test, are still the best practices that have been proven to work in the field over many years.

As Hong Kong keeps building new areas, extending railways, and digging tunnels, the need for temporary high-voltage electrical installations will only grow. The authors hope that this paper will help create a culture of safety, compliance, and engineering excellence in the local construction industry. They also hope that future professionals will build on and improve the practices described in this paper.

## Recommendations for Future Work

Due to the limitations mentioned above, the following suggestions are made for future research and practice.

## For Professionals

1. Get qualified professionals involved early. The costs of not following BEC rules or safety rules are much higher than the costs of hiring experienced REA and consulting engineers. Getting involved early, before site construction and during design, is very important.
2. Keep a record of all test results in an organised way. Keep logs of insulation resistance, earth loop impedance, ductor tests, and relay injection results with the date on them. This paperwork shows that the rules were followed and helps with finding faults.
3. Set up official LOTO and PTW processes. Even for short-term installations, strict lock-out/tag-out and permit-to-work systems are necessary to keep workers safe. The EMSD Wiring Code sets the rules.
4. Check for discrimination by looking at the time-current curve. Do not think that overcurrent devices will work together just because they have different ratings. Formal discrimination studies with plotted characteristic curves are necessary.
5. Think about using VFDs for motor loads. In addition to the benefits of soft starting, VFDs save energy by running continuously at low speeds in variable-torque applications like fans and pumps. However, it is important to look at the costs of higher capital and the need to reduce harmonics.

## For future studies

1. A study that compares numbers. A formal study that looks at insulation resistance values, earth fault loop impedance, and ductor test results from several temporary transformer room installations would set empirical benchmarks and find common ways that things go wrong.
2. A comparison of temporary and permanent requirements. A methodical comparison of regulatory requirements (EMSD Wiring Code, Cap. 610, WR2) concerning temporary and permanent installations would elucidate ambiguities within the existing framework.
3. How to measure how much energy VFDs save when they are only used for a short time. Field measures that compare how much energy VFD-controlled fans and pumps use to DOL-controlled fans and pumps on construction sites would back up the claimed savings.
4. Best practices for decommissioning and removing things. Research shows that documents safely to take down temporary transformer rooms, such as draining oil, removing equipment, pulling cables, and restoring the site, would fill a gap in the current literature.
5. Comparison across jurisdictions. A comparative analysis of temporary high-voltage electrical installation regulations across various jurisdictions (Hong Kong, Singapore, UK, Australia) would elucidate best practices and potential avenues for regulatory harmonisation.

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