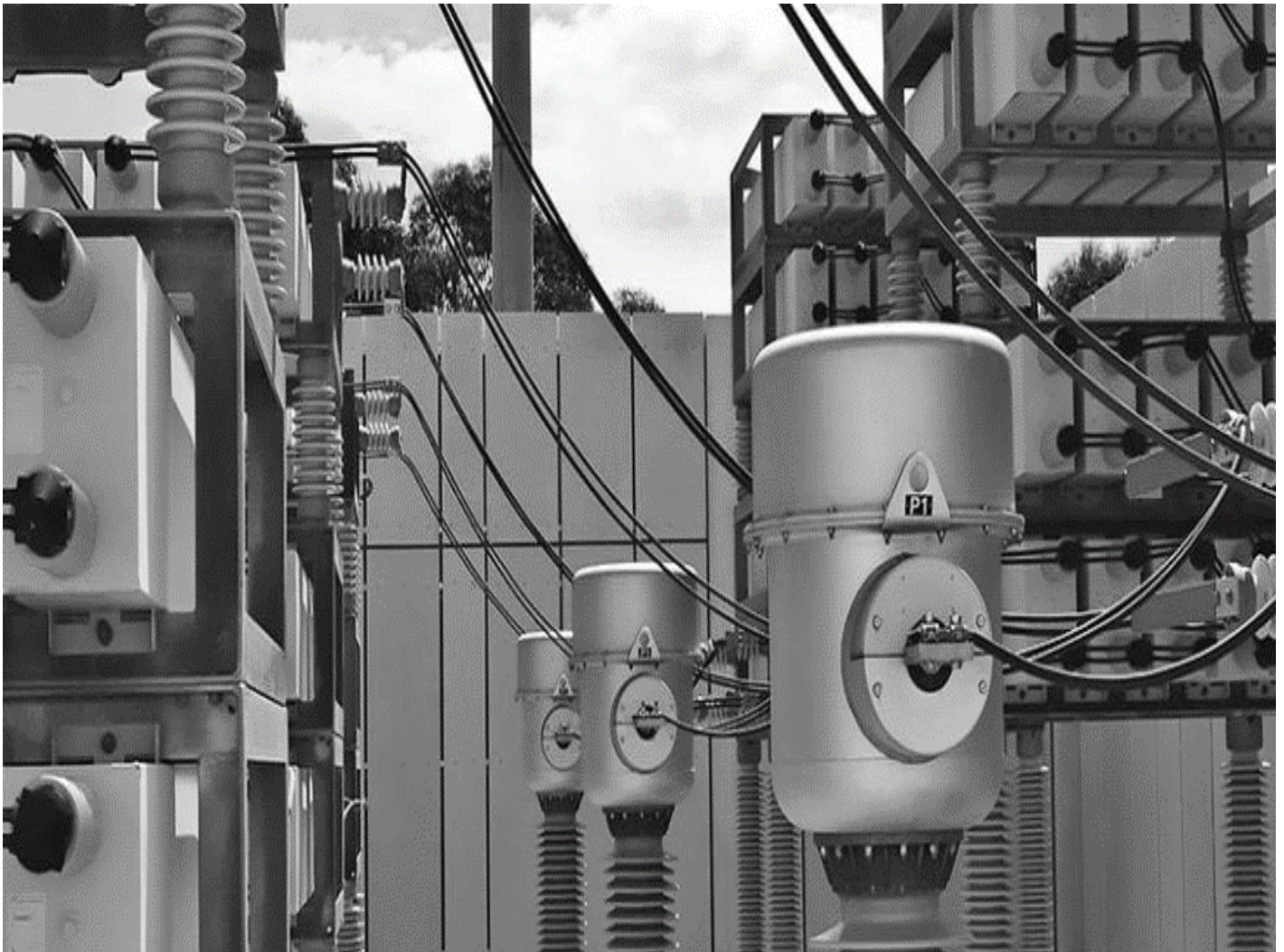


National Grid UK Electricity Transmission plc

NATIONAL SAFETY INSTRUCTION 11

and Guidance



WORK ON OR NEAR TO HIGH VOLTAGE CAPACITORS



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DOCUMENT HISTORY

Issue	Date	Summary of Changes / Reason	Author(s)	Approved By (Title)
1	Sept 2008	Reformatted and re-drafted to follow 3 rd edition Electricity Safety Rules layout. Safety bulletin 147, incorporated.	NSI Working Group	MDE Manager Les Adams 
2	April 2011	Annual review; document amended as detailed below and minor text changes as highlighted in yellow.	NSI Review Group	MDE Manager Les Adams 
3	April 2014	Renamed as "National Safety Instruction and Guidance" which now incorporates and replaces NSI 11 Issue 3 and NSI 11 Guidance Issue 2.	NSI Review Group	ETAM Operations North Manager Mike Dean
4	Oct 2020	Major reformatting & revision. Renamed as "Work on or near to High Voltage Capacitors".	Electricity Transmission Operations Safety Rules Team	Head of ET Operations Matt Staley
5	May 2023	Minor amendments	Electricity Transmission Operations Safety Rules Team	Head of ET Operations Andy Richardson

KEY CHANGES

Section	Amendments
Purpose & Scope	Clarification that NG Personnel (Competent Person & Senior Authorised Person) need to be authorised to this NSI to work on the Equipment but that other Working party members do not.

WORK ON OR NEAR TO HIGH VOLTAGE CAPACITORS

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1 Purpose and Scope

To apply the principles established by the Safety Rules and provide guidance on National Safety Instruction 11 for **Personnel**, working on or near to **High Voltage** Capacitors including the dissipation of stored energy.

National Safety Instruction 11 applies to all Capacitor Banks including those fitted with a *Shorting Switch(es)*. This document describes the safety measures that are required when working on or near to *Capacitor Banks*. Most importantly, *Shorting Switch(es)* do not dissipate the **Charged** energy stored in externally fused capacitors, where the external fuse has operated.

National Safety Instruction 11 applies to Capacitors installed in;

- Mechanically Switched Capacitors (MSCs & MSCDNs)
- Static VAR Compensators (SVCs, RSVCs & DRCs)
- Series Compensators (TCSCs & SSSCs)
- Harmonic Filters

NSI 11 also applies to all the other components of these circuits (i.e. Resistors, Reactors, Surge Arresters, Current Transformers etc) when located in the same discrete or fenced off areas with the Capacitor Banks.

In some applications of Capacitors, implementing safety precautions as detailed in NSI 2 is sufficient to ensure that the Capacitor will be discharged. Examples of such **Equipment** (which do not require **Personnel** to be formally appointed to this NSI) are:-

- Circuit Breaker Grading Capacitors
- Capacitor Voltage Transformers
- Line traps
- 13kV Earthing Capacitors (typically found on 13kV Shunt Reactor circuits)

Guidance on the application of NSI 11 to specific circuit applications can be found in Technical Guidance Note – TGN(E) 320 – Application of NSI 11 to Common HV Capacitor Installations.

National Grid Personnel (Competent Person & Senior Authorised Person) working on or near to High Voltage Capacitors shall be appointed to this NSI, but members of the Working Party do not. For Contractor appointments see Appendix A.

The layout of this guidance note reflects that of legislative codes of practice, where the rule (or mandatory obligation) is identified by a green panel on the left-hand side. The guidance follows the rule and is identified by a blue panel.

Within National Grid, guidance notes hold equivalent status of an Approved Code of Practice (ACOP) in law. If not followed, you will be required to demonstrate that your safe system of work is of an equal or higher standard.

2 Definitions

Terms printed in bold type are as defined in the Safety Rules.

Title	Definition
Capacitor Element	A singular device for the purpose of storing electrical charge, consisting essentially of two electrodes separated by a dielectric.
<i>Capacitor Unit</i>	An assembly of one or more capacitor elements in the same container with terminals brought out by one or more bushings.
<i>Capacitor Rack</i>	An individual framework containing <i>Capacitor Unit(s)</i> which can be connected together.
<i>Capacitor Stack</i>	An assembly of one or more <i>Capacitor Rack(s)</i> connected together. A <i>Capacitor Stack</i> may contain <i>Capacitor Unit(s)</i> from one or more discrete components of the Capacitor Bank.
<i>Capacitor Bank</i>	An assembly of one or more <i>Capacitor Stack(s)</i> as part of an High Voltage Circuit (i.e. MSCDN, SVC, etc). There may be more than one <i>Capacitor Bank</i> in a High Voltage circuit (i.e. Bank A, B, C)
<i>Discharge Stick</i>	A type registered device for the purpose of discharging a <i>Capacitor Unit</i> which may be Charged .
<i>Shorting Switch</i>	A fixed device for short-circuiting and earthing <i>Capacitor Stack(s)</i>
<i>Short-Circuiting Lead</i>	A Type Registered lead used for short-circuiting an individual <i>Capacitor Unit</i> . This can be a clip-on short used during the disconnection of <i>Capacitor Unit</i> or a bolt-on short used during the removal.
<i>Technical Specialist</i>	An individual with detailed specialist technical knowledge to assist when required in the safe installation, preparation for work, maintenance and removal of <i>Capacitor Unit(s)</i> .
<i>Rack Earthing Spigot</i>	A point on a <i>Capacitor Rack</i> for the application of an Earthing Device .
<i>Rack Earth(s)</i>	Portable Drain Earth(s) provided for the purpose of earthing and/or short-circuiting <i>Capacitor Units</i> or groups of units and the <i>Capacitor Rack(s)</i> containing them.
<i>Resistive Discharge Device</i>	A type registered device for the purpose of discharging a DC <i>Capacitor Unit</i> which may be Charged , at a rate which is not detrimental to the Equipment .

Type Registered Portable Earthing Devices are recorded in TRL 2.02.

3 Dangers

The **System Danger(s)** to **Personnel** are electric shock, burns and effects on eyes arising from:-

- a. The discharge of electrical energy retained by the *Capacitor Unit(s)* after they have been **Isolated**
- b. Inadequate precautions to guard against electric shock as a result of any **Charged** conductors or associated fittings
- c. **Charged** capacitors inadequately short circuited
- d. **Equipment** retaining or re-gaining a charge

NSI11
4.1 to 4.3

4 General Requirements for Work

- 4.1 The circuit shall be **Isolated, Point(s) of Isolation** established and **Primary Earth(s)** applied.
- 4.2 *Shorting Switches*, where installed on the *Capacitor Stacks(s)*, shall be closed by a **Senior Authorised Person** under the instruction of a **Control Person (OS) 1**.
- 4.3 A **Permit for Work** or **Sanction for Work** shall be issued.

Guidance
NSI 11
4.2 to 4.3

4 General Requirements for Work

- 4.2 *Shorting Switch(es)* are not normally remotely controlled and as such they shall be operated locally under the instruction of a local **Control Person (OS) 1**, as defined in Management Procedure - NSI 30 Authorisation of Personnel.

The **Senior Authorised Person** shall act as the local **Control Person (OS) 1** to close the *Shorting Switch(es)* prior to the issue of the **Safety Document**. The closed *Shorting Switch(es)* shall be stated on the **Safety Document** and shall form the record of the safety precautions established. This shall be identified in Section 2 of the **Safety Document** "Actions taken to avoid Danger".

Where *Shorting Switch(es)* are to be maintained, they shall be initially closed, but may be opened after the issue of a **Safety Document**, as a precaution that may be varied by the appropriate **Safety Document** holder. An **Earthing Schedule** shall be issued. The *Shorting Switch(es)* closed shall be identified in Section 2 of the **Safety Document** "Actions taken to avoid Danger" The *Shorting Switch(es)* to be opened shall be identified in Section 3 of the **Safety Document** 'Precautions that may be varied'.

- 4.3 Guidance on the application of NSI 11 to specific circuit applications can be found in TGN(E) 320.

SAFETY WARNING - The **Senior Authorised Person** issuing the **Safety Document** shall ensure the time difference between the completion of the isolation of the *Capacitor Bank* (as recorded on the Switching Instruction) and the time of issue of the **Safety Document** to the **Competent Person** shall be a minimum of 20 minutes. This is to allow sufficient time for the *Capacitor Bank* to discharge via the *Capacitor Unit* discharge resistors.

NSI11
5.1 to 5.3

5 Work on or near to AC Capacitor Units

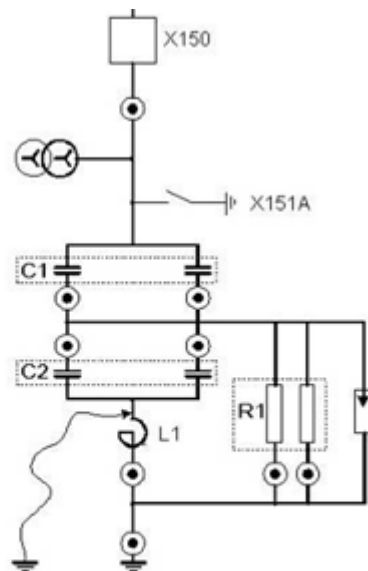
- 5.1 When work is to be carried out on or near to *Capacitor Unit(s)*, in addition to the requirements of 4.1 to 4.3, the **Senior Authorised Person** shall assess the work and decide whether it shall be carried out by one of the following methods;
- By implementing control measures which ensure that **Personnel** and objects maintain a minimum **Safety Distance** of 0.8m from any exposed *Capacitor Unit(s)*.
 - Or, if infringement within 0.8m from any exposed *Capacitor Unit(s)* is required, **Danger** from Capacitors which may remain **Charged** shall be excluded by the application of Section 5.2.
- 5.2 When work is required on a *Capacitor Unit(s)*, An **Earthing Schedule** shall be issued specifying the application of **Drain Earth(s)**, *Rack Earth(s)*, *Discharge Stick(s)* and *Short-Circuiting Lead(s)* as follows;
- *Capacitor Unit(s)* shall first be visually inspected at a distance no less than 0.8m from exposed *Capacitor Unit* terminals, **Charged** *Capacitor Rack(s)*, fuse(s) or associated busbars and connections to identify any abnormal *Capacitor Unit(s)*.
 - When carrying out discharging activities, encroachment is permitted up to a distance no less than 0.4m from exposed *Capacitor Unit* terminals, **Charged** *Capacitor Rack(s)*, fuse(s) or associated busbars and connections. The reduction in distance takes into account the skill of the **Personnel** operating the *Discharge Stick(s)* and practical considerations.
 - Each *Capacitor Stack* to be worked on shall be short-circuited and **Earthed**. Resistors and Reactors shall not be considered as a continuous electrical connection therefore this will typically require the use of a **Drain Earth** between every *Capacitor Stack* and Reactor.
 - *Capacitor Rack(s)* shall where reasonably practicable be discharged by the application of a *Rack Earth* to a *Rack Earthing Spigot*. Where this is not reasonably practicable, *Capacitor Rack(s)* shall be discharged by the temporary application of a *Discharge Stick* whose clip-on end is connected to Earth. This *Discharge Stick* shall remain in situ until all *Capacitor Unit(s)* in that *Capacitor Rack* have been discharged.
 - Once a *Capacitor Rack* has been discharged, apply the clip-on end of a *Discharge Stick(s)* to the rack metalwork and proceed to discharge *Capacitor Unit(s)* within that rack.
 - Repeat above steps on *Capacitor Rack(s)* from ground level up to the rack to be worked on, plus a minimum of one rack above, within the *Capacitor Stack* to be worked on.
 - No conductors within a *Capacitor Stack* shall be disconnected before all *Capacitor Unit(s)* connected to that conductor have been discharged.
- 5.3 *Discharge Stick(s)*, *Short-Circuiting Lead(s)*, *Rack Earth(s)* etc shall be regularly inspected and maintained.

Guidance
NSI 11
5.1 to 5.2

5 Work on or near to AC Capacitor Units

- 5.1 Suitable control measures for ensuring that **Safety Distance** of 0.8m is maintained from **Charged Capacitor Unit(s)** could include the use of demarcation or where appropriate, **Personal Supervision** by a **Senior Authorised Person**.
- 5.2 When considering the requirements for **Drain Earth(s)**, resistors and reactors are not considered to be a 'continuous electrical connection'. Therefore, in order to short circuit and **Earth** all **Capacitor Stack(s)**, it is usually necessary to use a **Drain Earth** between **Capacitor Stack(s)** and reactor(s).

This **Drain Earth** has a secondary purpose in that prevents a **High Voltage** being generated by the resonant circuit formed by the Capacitor Bank and Reactor whilst performing capacitor measurements (refer to Capacitor C2 and Reactor L1 in Figure 5.2A). To apply / remove the **Drain Earth** the **Competent Person** receiving the **Safety Document** shall be authorised to Management Procedure NSI 2 "Earthing High Voltage Equipment" section 5.1.



SINGLE LINE DIAGRAM OF A TYPICAL MECHANICALLY SWITCHED CAPACITOR WITH DAMPING NETWORK (MSCDN)

Figure 5.2A - Location of the Drain Earth Between a Capacitor Stack and Reactor.

A visual inspection is required to identify any capacitors which may have failed and consequently may be presenting a hazard. Signs of bulging and oil leaks may be indicative of a failure. For externally fused **Capacitor Unit(s)**, operated fuses can be identified by their fuse tails hanging down, refer to Figure 5.2B.

Guidance
NSI 11
5.2 (Cont)



Figure 5.2B - Identifying an Externally Fused Capacitor with a Fuse Operated

SAFETY WARNING - Any externally fused *Capacitor Unit(s)* with fuses that have operated shall be treated as **Charged** and dangerous. These *Capacitor Unit(s)* shall be discharged using a *Discharge Stick* by a **Competent Person**, or by a **Person** under the **Personal Supervision** of a **Competent Person**.

Capacitor Rack metalwork is typically connected to one or more of the *Capacitor Unit(s)* which are mounted within it. In the same way that a *Capacitor Unit* could remain **Charged**, the associated rack metalwork may be at a potential with respect to Earth. Before approaching a *Capacitor Rack*, it shall, where reasonably practicable be **Earthed** by the application of a *Rack Earth*. This may be achieved using portable **Earthing Device(s)** in a daisy chain arrangement or by providing each *Capacitor Rack* with an independent portable **Earthing Device**.

Where this is not reasonably practicable (e.g. if no spigot or 'boss' is fitted), the *Capacitor Rack* must first be discharged using a *Discharge Stick* whose 'Clip-On' end is connected to Earth, or to an adjacent **Earthed** *Capacitor Rack* before applying the clip-on end of a *Discharge Stick* to discharge the associated *Capacitor Unit(s)*.

Note: The use of a Discharge Stick with a continuous lead of up to 20m is permissible for this purpose.

Capacitor Unit(s) by design, dissipate stored voltage via a discharge resistor to a value of approximately 75V in around 10 minutes (20 minutes for a *Capacitor Bank*). However, in certain conditions e.g. fuse and discharge resistor failure, there is a potential for the *Capacitor Unit* voltage to remain at a value up to approximately 20 kV, dependent on the *Capacitor Bank* type and rating. The closure of *Shorting Switch(es)*, if fitted, in this instance does not discharge the faulty *Capacitor Unit*. Hence the requirement to use a *Discharge Stick* on all *Capacitor Unit(s)*. A *Capacitor Unit* is made safe by connecting together both terminals to its metal container. In some configurations one of the terminals is inherently at the container and rack potential.

Guidance
NSI 11
5.2 (Cont)

With reference to Figure 5.2C, at no time whilst connecting the clip-on or crook end of a *Discharge Stick* shall any part of the body encroach to within a distance less than 0.4m of the exposed capacitor terminals. It may be necessary to use two *Discharge Sticks*, each connected to the *Capacitor Rack* metalwork to maintain this separation even in the case of a single bushing *Capacitor Unit*.

When the *Capacitor Unit* has a single bushing, the *Discharge Stick* shall be used by first connecting the clip-on end of the *Discharge Stick* to the **Low Voltage** terminal (or relevant common busbar) of the *Capacitor Unit* and applying the “crook” end of the *Discharge Stick* to the *Capacitor Unit High Voltage* terminal, refer to Figure 5.2C & 5.2D.

When the *Capacitor Unit* has two bushings, a second *Discharge Stick* is required for the second terminal. The associated *Capacitor Rack* metalwork must first have been discharged and the *Discharge Stick(s)* shall then be used by connecting the clip-on end(s) to the discharged *Capacitor Rack* metalwork and applying the “crook” ends of the *Discharge Sticks* to the *Capacitor Unit* terminals. Alternatively, a *Discharge Stick* with dual ‘crook’ ends may be used, which uses a common clip-on end but is otherwise operated in the same manner, as shown in Figure 5.2E. Since the terminals of double bushing *Capacitor Units* are usually insulated from the *Capacitor Rack* metalwork, it is imperative that both terminals are shorted together and to the *Capacitor Rack* metalwork simultaneously to successfully discharge the *Capacitor Unit*.

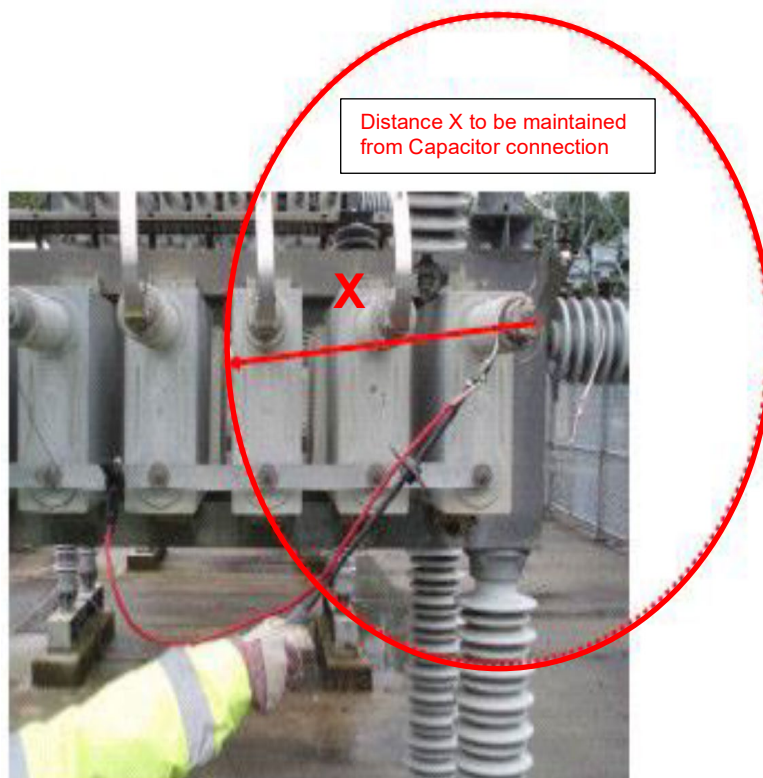


Figure 5.2C - Applying the Discharge Stick to a Capacitor Unit terminal

Guidance
NSI 11
5.2 (Cont) to 5.3



Figure 5.2D – Discharge Stick with single 'crook' end.



Figure 5.2E – Discharge Stick with dual 'crook' ends.

Abnormal *Capacitor Unit(s)* are those that show signs of excessive bulging, major leaks or broken bushings. If any abnormal *Capacitor Unit(s)* are found, especially following a fault, then advice from a *Technical Specialist* may be sought.

- 5.3 NSI 11 Earthing / Discharging equipment shall be visually inspected for damage before and after use. They are required to be stored and managed to the same standard as other Portable **Earthing Devices**.

NSI11
6.1 to 6.2

6 Work on or near to DC Capacitor Units

- 6.1 When work is to be carried out on or near to DC *Capacitor Unit(s)* associated with HV Voltage Source Converters (e.g. within DRC valve sub-modules or SSSC Circuits), in addition to the requirements of 4.1 to 4.3, the **Senior Authorised Person** shall assess the work and decide whether it shall be carried out by one of the following methods;
- By implementing control measures which ensure that **Personnel** and objects maintain a minimum **Safety Distance** of 0.8m from any exposed DC *Capacitor Unit(s)* which may remain **Charged**.
 - Or, if infringement within 0.8m from any exposed DC *Capacitor Unit(s)* is required, **Danger** from Capacitors which may remain **Charged** shall be excluded by the application of Section 6.2.
- 6.2 When work is required on a DC *Capacitor Unit(s)*; an **Earthing Schedule** shall be issued specifying the application of **Drain Earth(s)**, **Rack Earth(s)**, Voltage Testing Devices and **Resistive Discharge Devices** as follows;
- *Capacitor Rack(s)* or conductive enclosures shall where reasonably practicable be **Earthed** by the application of **Earthing Devices**.
 - DC *Capacitor Unit(s)* to be worked on shall be proven to be discharged by the application of an appropriately rated Voltage Testing Device.
 - DC *Capacitor Unit(s)* found to have remained **Charged**, shall be discharged by the application of a **Resistive Discharge Device**, or be allowed additional discharge time. This shall be followed by repeating the voltage measurement to prove discharged.
 - Repeat above steps on *Capacitor Rack(s)* from ground level up to the *rack* to be worked on, plus a minimum of one *rack* above the point of work.

General Requirements when carrying out discharging activities

- DC *Capacitor Unit(s)* shall be visually inspected at a distance no less than 0.8m from exposed terminals, **Charged Capacitor Rack(s)**, fuse(s) or associated busbars and connections in order to identify any abnormal DC *Capacitor Unit(s)*. Where the DC *Capacitor Unit(s)* are housed within an **Earthed** enclosure, the distance of 0.8m may be reduced accordingly, however the inspection shall take place from outside of the enclosure (i.e. through open doors, inspection panels etc).
- The DC *Capacitor Unit(s)* shall be discharged or proven discharged using a Voltage Testing Device and / or **Resistive Discharge Device** which have been assessed as being compatible with the **Equipment**. The insulation of the equipment used in this activity, when used correctly, is sufficient to avoid **Danger** from exposed **Charged** capacitor terminals, **Charged Capacitor Rack(s)**.

Guidance
NSI 11
6.1 to 6.2

6.1 DC *Capacitor Unit(s)* may exhibit very high energy levels, as such a different approach in discharging the units to avoid injury and damage to **Equipment** and **Earthing Device(s)** may be required. With the exception of the discharge procedure, the philosophy and requirements of NSI 11 are otherwise applicable to DC *Capacitor Unit(s)*. In some cases, the DC *Capacitor Unit(s)* may be integral to the Insulated-Gate Bipolar Transistor (IGBT) valve sub-modules (VSM). In this instance the manufacturers procedures for safely discharging and measuring the voltage of the DC *Capacitor Unit(s)* shall be followed.

Where the DC *Capacitor Unit(s)* are located within an enclosure, approach within 0.8m is permitted so long as no access is gained to the enclosure. (Access is permitted within the enclosure when 0.8m **Safety Distance** is maintained)

The *Voltage Testing Device* (Fig 6.1A) and *Resistive Discharge Device* (Fig 6.1B) are required to be compatible with the operating parameters of the exact installation for which its use is intended.

When using a Voltage Testing Device, reference to manufacturer's instructions shall be made to determine the minimum measurement which can be considered to be safe. The Voltage Testing Device must be proven to be working on a known voltage source before and after use.



Figure 6.1A: An example Voltage Testing Device rated at 7 kV DC.

The correct *Resistive Discharge Device* will ensure that DC *Capacitor Unit(s)* will be safely discharged at a rate which will not cause damage to the **Equipment**. It shall be utilised in accordance with the manufacturer's instructions; noting that its thermal rating may be relevant if carrying out successive discharge operations. Where appropriate, the exact position and sequence of application shall be specified, e.g. if one end of the device needs to be connected first.

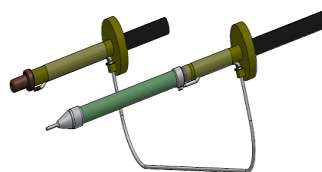


Figure 6.1B: An example Resistive Discharge Device

It may be necessary to prove a number of DC *Capacitor Unit(s)* are discharged before proceeding to discharge other *Capacitor Rack(s)*. (e.g. those on a higher level).

The exact discharge sequence shall be clearly specified in an **Earthing Schedule**.

6.2 Owing to a large variation in the arrangements and operating parameters of DC *Capacitor Unit(s)*, no minimum distance is specified. (Any distance given may be impractical for one installation and inadequate for another).

By selecting the correctly rated Voltage Testing Device and / or *Resistive Discharge Device*, **Danger** is excluded during discharging activities by the insulation properties of the device.

NSI 11
7.1 to 7.2

7 Performing Capacitance Measurements

- 7.1 Before performing capacitance measurements, the *Capacitor Unit* or *Capacitor Unit(s)* in a parallel group shall be discharged by a **Competent Person**, or by a **Person** under the **Personal Supervision** of a **Competent Person**.
- 7.2 When measuring using a test instrument which applies a voltage greater than 75V, the requirements of 7.1 shall be repeated after every measurement performed.

Guidance
NSI 11
7.1 to 7.2

7 Performing Capacitance Measurements

- 7.1 Refer to Section 4 Guidance for discharging *Capacitor Unit(s)*.
- It is preferable, though not mandatory, to utilise modern Capacitance Measurement devices which exhibit low energy levels (i.e. a test voltage of less than 75V)
- 7.2 If using conventional Capacitance Bridge Test Equipment;
- Connect the capacitance bridge to a series group of *Capacitor Unit(s)* starting at the **Low Voltage** end of the *Capacitor Stack*.
 - Perform capacitance measurements on *Capacitor Unit(s)*, as required in that series group.
 - Continue capacitor measurements, testing the next series group of *Capacitor Unit(s)* progressing towards the **High Voltage** end of the *Capacitor Stack*.
 - In exceptional circumstances an individual may be used for technical expertise e.g. third party SVC technical specialists. A **Competent Person** shall provide **Personal Supervision** to the individual.

NSI 11
8.1 to 8.5

8 Handling, Storage and Transport of Capacitor Units

- 8.1 Where there is potential for a *Capacitor Unit* to become **Charged** they shall not be handled unless a *Short-Circuiting Lead* has been securely applied across all terminals and to the *Capacitor Unit* container.
- 8.2 Before the application of a *Short-Circuiting Lead* to a *Capacitor Unit*, it shall be discharged as defined in Sections 5 or 6.
- 8.3 The application of *Short-Circuiting Lead(s)* shall be by a **Competent Person**, or a **Person** under the **Personal Supervision** of a **Competent Person**. Application of all *Short Circuiting Lead(s)*, including the sequence, number and location, shall be specified on an **Earthing Schedule**.
- 8.4 Before a *Capacitor Unit* is removed from a *Capacitor Rack*, the clip-on *Short-Circuiting Lead* shall be replaced by a bolt-on *Short-Circuiting Lead* or shorted by non-insulated copper wire.
- 8.5 Failed *Capacitor Unit(s)* when stored and transported shall remain short-circuited.

Guidance
NSI 11
8.1 to 8.5

8 Handling, Storage and Transport of Capacitor Units

- 8.1 SAFETY WARNING** – Where there is a potential for a *Capacitor Unit* to become **Charged** e.g. within a **High Voltage** compound they shall not be handled unless it is short-circuited by a *Short-Circuiting Lead*, refer to Figure 8.1A & 8.1B.



Figure 8.1A
Clip-on *Short-Circuiting Lead*



Figure 8.1B
Bolt-on *Short-Circuiting Lead*

- 8.3 The *Capacitor Unit* shall be short-circuited by connecting a clip-on *Short-Circuiting Lead* between the capacitor low voltage terminal and the bushing. If the capacitor unit has two bushings, a second *Short-Circuiting Lead* shall also be connected between the second bushing terminal and the *Capacitor Unit* container.



Figure 8.3A – Applying the Clip-on *Short-Circuiting Lead*

- 8.4 *Capacitor Unit(s)* shall be short-circuited using a bolt-on *Short-Circuiting Lead* or at least two complete turns of copper wire. When using copper wire, an assessment shall be made as to which diameter represents the best balance of mechanical strength versus the ability to make good electrical contact (which may be in the pitch of terminal threads). Typically, copper wire with a diameter in the range of 0.6mm² to 1mm² are suitable. Care must also be taken to select wire which is bare or tinned; since insulated wire will not be effective.

Capacitor Unit(s) with one bushing terminal and a terminal connected to the container shall have one short-circuit connection between those two terminals.

Capacitor Unit(s) with two bushing terminals insulated from the container shall be short-circuited by two connections, one between the two bushing terminals and an additional connection between one of the bushing terminals and the container.

- 8.5 A failed *Capacitor Unit(s)* shall remain shorted due to the potential for the bushing to become **Charged**. This is due to the possibility of a trapped internal charge within the failed unit re-connecting to the bushing during movement.

Appendix A - Authorisation Matrix for Contractors Personnel

Contractor Personnel	Person	Competent Person	Authorised Person	Senior Authorised Person
Sections	N/A	N/A	N/A	N/A

Contractors Personnel

Contractors by law have a duty to provide a safe system of work for their employees.

National Grid have a duty in law to employ competent Contractors to undertake work on capacitor banks and provide them with National Grid's safe system of work to enable them to develop their own safe systems of work.

National Grid Supply Chain Management processes ensure competent Contractors are selected.

Once a competent Contractor is selected, National Grid has a duty to ensure the Contractor understands **Danger(s)** associated with undertaking work within a **High Voltage** compound, permit systems, demarcation and safe access and egress, including movement of objects and vehicles etc. This is accomplished by Contractors employees being authorised to National Grid Safety Rules and to NSI 6 and 8, via Management Procedure - NSI 30 "Appointment of Persons".

The Contractor selected shall be an expert in the area of High Voltage Capacitors and therefore no requirement for authorisation under NSI 11 is necessary.

Before a **Safety Document** is issued the **Senior Authorised Person** shall be authorised to NSI 11 and shall ensure the Contractors risk assessment and method statements cover the **Danger(s)** identified in NSI 11.

The National Grid Senior **Authorised Person** will issue a **Safety Document** to a Contractors **Competent Person** authorised to NSI 6 & 8.

Note: If the work involves the application of **Drain Earth(s)** the Contractors **Competent Person** shall be authorised to Management Procedure - NSI 2 "Earthing High Voltage Equipment", or the **Senior Authorised Person** shall manage the **Drain Earth(s)** via the **Safety Document** transfer process.