



Part of Energy Queensland

Substation Standard

Standard for Selection of Surge Arresters

These standards created and made available are for the construction of Energy Queensland infrastructure. These standards ensure meeting of Energy Queensland's requirements. External companies should not use these standards to construct non-Energy Queensland assets.

If this standard is a printed version, to ensure compliance, reference must be made to the Energy Queensland internet site www.energyq.com.au to obtain the latest version.

Approver	Carmelo Noel General Manager Asset Standards
If RPEQ sign off required insert details below.	
Certified Person name and Position	Registration Number
John Lansley Manager Substation Standards	RPEQ 6371

Abstract: The aim of this document is to establish procedures for selecting gapless metal-oxide surge arresters connected between phase and earth for alternating current systems with the objective of providing protection for electrical plant against voltage surges due to lightning and circuit switching.

Keywords: Surge arrester, protection, standard, substation

CONTENTS

1.1	Purpose	5
1.2	Scope	5
2	References	5
2.1	Legislation, Regulations, Rules, and Codes	5
2.2	Controlled Documents.....	5
2.3	Other Documents	6
3	Definitions and Abbreviations	6
3.1	Definitions	6
3.2	Abbreviations	9
4	Background.....	9
5	General procedure for selection of gapless surge arresters	11
6	Selection of surge arrester ratings.....	12
6.1	Step 1: Obtain system parameters	12
6.2	Step 2: Check for abnormal service conditions.....	12
6.3	Step 3: Determine Continuous Voltage (U_c)	12
6.4	Step 4: Determine Temporary Overvoltage capability and Rated Voltage (U_r)	13
6.5	Step 5: Determine nominal discharge current, I_n	16
6.6	Step 6: Determine energy withstand capability and specific energy	16
6.7	Step 7: Arrester class.....	18
6.8	Step 8: Determination of protective characteristics.....	18
6.9	Step 9: Pressure relief (applicable to porcelain housed SA only)	18
6.10	Step 10: External insulation levels.....	19
6.11	Step 11: Mechanical characteristics	19
6.12	Step 12: Pollution performance	19
7	Determination of protective levels of an arrester	20
7.1	Evaluating insulation co-ordination.....	20
7.2	Arresters at terminals of protected equipment.....	21
7.3	Arresters at some distance away from protected equipment	21
8	Evaluation of alternatives	22
9	Documentation required	22
Annex A	23
Coefficient of earthing (COE) and earth fault factor (k_e).....		23
Coefficient of earthing		23
Earth fault factor (k_e)		23
Annex B	24

Standard for Selection of Surge Arresters

Pollution severity levels and referenced unified specific creepage distance	24
Annex C	26
How to use EQL Selection of Surge Arresters Workbook:	26
Title	26
Useful Information	26
Useful Formulae	26
Input Data	26
Summary of SA Performance	27
Supplier Data	28
Lookup Tables	28
Example analysis	28

FIGURES

Figure 1: Typical voltage-current characteristic for ZnO arresters (AS 60099.5). (Do not use for applications)	11
Figure 2: An example of a TOV capability expressed in p.u. Ur	15
Figure 3: Load diagram (SESWG/A-2310, 1990-05)	16
Figure 4: Typical volt-time curve for coordination of arrester's protective levels with insulation withstand strength for liquid filled transformers.	21
Figure 5: Colour code for cells in the Input Data and Summary of SA Performance sheets.	26
Figure 6: Example Analysis 1	28
Figure 7: Example Analysis 2	29
Figure 8: Example Analysis 3	29
Figure 9: Example Analysis 4	29
Figure 10: Example Analysis 5	30
Figure 11: Example Analysis 6	30

TABLES

Table 1: Recommended Continuous Voltage	13
Table 2: Recommendations for coefficient of earthing k_e (ABB Buyer's Guide, 2010)	14
Table 3: Preferred values of rated voltages (AS 60099.4).	15
Table 4: Line switching surge impedances	17
Table 5: Arrester class selection characteristics. Note: L = low, M = medium, H = high.	18
Table 6: Acceptable Protective Ratios and Margins	21
Table 7: Corona damping constant K_{co}	22
Table 8: Equations for calculating the coefficient of earthing	23
Table 9: Table 3 and Table 4 from SA TS 60815.1	24
Table 10: Table 5 from SA TS 60815.1	24
Table 11: Maximum lead length based on the nominal voltage and lightning impulse withstand voltage of the equipment	27

EQUATIONS

Equation 1: Continuous Voltage (U_c).....	13
Equation 2: TOV	14
Equation 3: U_r	15
Equation 4: Example TOV	15
Equation 5: Example U_r	15
Equation 6: Arrester Energy – known characteristic	17
Equation 7: Arrester Energy – unknown characteristic	17
Equation 8: Specific energy	18
Equation 9: Pressure relief current	18
Equation 10: Wind pressure	19
Equation 11: Wind force	19
Equation 12: Bending moment	19
Equation 13: Protective level including distance effect	21
Equation 14: Steepness of incoming surge	22
Equation 15: Earth Fault Factor	23

Standard for Selection of Surge Arresters

1 Overview

1.1 Purpose

This document defines methods, parameters, and procedure in selecting gapless metal-oxide surge arrester connected between phase and earth for alternating current systems for the protection of electrical plant against voltage surges due to lightning and circuit switching.

This document does not cover specific aspects of the application of surge arresters and the required mechanical strength.

1.2 Scope

This document specifies the requirements and guidance for the selection of gapless metal-oxide surge arresters connected between phase and earth for use in alternating current (AC) power systems. It covers the electrical characteristics, selection parameters, and selection procedure necessary to ensure adequate protection of electrical plant against overvoltages resulting from lightning impulses and switching operations.

The scope includes considerations related to system voltage conditions, temporary overvoltages, rated and continuous operating voltages, energy capability, and protective characteristics relevant to the electrical performance of surge arresters.

2 References

2.1 Legislation, Regulations, Rules, and Codes

Document	Type
<i>Electricity Act 1994 (Qld)</i>	Legislation
Electricity Regulation 2006 (Qld)	Regulation
<i>Electrical Safety Act 2002 (Qld)</i>	Legislation
Electrical Safety Code of Practice – Works, 2020 (Queensland Government)	Code
Electrical Safety Regulation 2013 (Qld)	Regulation
Environmental Protection Act, 1994 (Queensland Government)	Legislation
<i>Queensland WH&S Regulation 2011</i>	Legislation

2.2 Controlled Documents

Document	Alternative Doc ID
Standard for Insulation Co-ordination - 3058912	STNW3034

2.3 Other Documents

AS 60099.4 - Surge Arresters – Metal-oxide surge arresters without gaps for A.C. systems

AS 60099.5 - Surge Arresters – Selection and application recommendations

SA TS 60815.1 - Selection and dimensioning of high-voltage insulators intended for use in polluted conditions - Definitions, information and general principles

SA TS IEC 60815.2 - Selection and dimensioning of high-voltage insulators intended for use in polluted conditions - Ceramic and glass insulators for A.C. systems

SA TS 60815.3 - Selection and dimensioning of high-voltage insulators intended for use in polluted conditions - Polymer insulators for A.C. systems

IEC 60071-2 - Insulation co-ordination - Part 2: Application guidelines

ABB Buyer's Guide, Edition 5, 2003 – 2010 - High Voltage Surge Arresters Buyer's Guide, Industrial Technical Publication

SESWG/A-2310 E Edition 2, 1995-2010 - Application guidelines for station protection, ABB, Industrial Technical Publication

3 Definitions and Abbreviations

3.1 Definitions

For the purposes of this standard, the following definitions apply.

Actual continuous operating voltage (U_{ca})	The maximum r.m.s power frequency voltage which is applied continuously (≥ 2 hours) between the arrester terminals.
Arrester or Surge Arrester (SA)	A protective device for limiting surge voltages on equipment by diverting surge current and returning the device to its original status. It is capable of repeating these functions as specified.
Arrester protective characteristic	A combination of its residual voltages for different current impulses. For good protection the arrester characteristic should lie well below the protected equipment insulation withstand characteristic at all points.
Coefficient of earthing (COE) or Coefficient of grounding (COG)	The ratio U_{LE}/U_{LL} (express as percentage) of the highest r.m.s line-to-ground power frequency voltage U_{LE} on a sound phase, at a selected location, during a fault to ground affecting one or more phases to the line-to-line power frequency voltage U_{LL} that would be obtained at the selected location with the fault removed. COE is equal to Earth fault factor multiplied by $100/\sqrt{3}$.
Continuous current (I_c)	The current flowing through the arrester when energised at continuous operating voltage.
Continuous operating voltage (U_c)	(Often abbreviated as COV or MCOV) is the designated permissible r.m.s value of power frequency voltage may be applied continuously between the arrester terminals. Thus $U_c > U_{ca}$.
Critical flashover voltage (CFO)	The amplitude of voltage of a given waveshape that, under specified conditions, causes flashover through the surrounding medium on 50% of the voltage applications

Standard for Selection of Surge Arresters

Discharge current	The impulse current which flows through the arrester.	
Discharge voltage	Refer to Residual voltage.	
Disruptive discharge	Phenomenon associated with the failure of insulation under electric stress, which include a collapse of voltage and the passage of current (AS 60099.5)	
Duty cycle voltage	Refer to Rated voltage.	
Earth fault factor (ke)	At a selected location of a three-phase system is the ratio of the highest r.m.s phase-to-earth power frequency voltage on a sound phase during a fault to earth (affecting one or more phases at any point) to the r.m.s phase-to-earth power frequency voltage which would be obtained at the selected location with the fault removed. If $ke \leq 1.4$ the system at that location is referred as effectively earthed, otherwise non-effectively earthed. In a system with a resonant earthed neutral or isolated neutral $ke = 1.73$.	
Equipment insulation withstand characteristic	Is a general term for the equipment insulation withstand voltage and comprises?	
	Withstand level	Voltage waveshape
	Chopped (steep) wave withstand level (CWW)	
	Lightning impulse withstand level (LIWL or BIL)	1.2/50
	Switching impulse withstand level (SIWL)	250/2500
	Power frequency withstand level (PFWL)	50 or 60 Hz sinusoidal
Impulse	A surge of unidirectional polarity.	
Impulse (of current or voltage)	Impulse is a unidirectional wave, which rises rapidly to a maximum and falls, a little less rapidly, to zero. Its waveshape is expressed by two numbers (T1/T2). T1 refers to the virtual front time and T2 to the virtual time to half value of the tail; both expressed in microseconds. Some important current impulses are:	
	Impulse	Waveshape (T1/T2)
	Steep current impulse	T1 = 1 μ s T2 \leq 20 μ s
	Lightning current impulse	T1 = 8 μ s T2 = 20 μ s
	Switching current impulse	T1 \geq 30 μ s T2 \geq 60 μ s
	High current impulse	T1 = 4 μ s T2 = 10 μ s
	A special impulse is the rectangular current impulse, which is the shape of a rectangle. A common duration is 2000 μ s.	
Insulation ordination	co- The selection of the dielectric strength of equipment in relation to the voltages, which can appear on the system for which the equipment is intended and taking into account the service environment and the characteristics of the available protective devices.	

Standard for Selection of Surge Arresters

Lightning impulse	current	An 8/20 μ s current impulse.
Lightning protection level (LPL)	impulse	The LPL of an arrester is the residual voltage for the nominal discharge current.
Lightning withstand (LIWV) or Basic insulation level (BIL)	impulse voltage	Standard rated lightning impulse withstand voltage of an equipment or insulation configuration (AS 60099.5)
Nominal current (I_n)	discharge	The peak value of lightning current impulse which is used to classify an arrester.
Pressure capability	relief	The ability of an arrester, in the event of its overloading due to any reason, to conduct the resulting system short circuit current through it without a violent explosion. After the operation of the pressure relief, the arrester must be removed
Prior duty		In order to test if an arrester is capable of functioning during and after successive faults, prior duty testing is conducted where the thermal energy W_{th} is injected into the arrester over a nominated duration (typically 3 minutes) before residual voltage tests are conducted (AS 60099-4). Residual voltages after application of prior duty are typically 5-10% lower than those without prior duty.
Protective margin		The protective ratio minus one and expressed as percentage.
Protective ratio		The ratio of the equipment insulation withstand level to the corresponding protection level of its arrester.
Rated voltage (U_r)		The maximum permissible r.m.s value of power frequency voltage between its terminals at which it is designed to operate correctly under temporary overvoltage conditions as established in the operating duty tests. Note: As per AS 60099.4 the maximum permissible 10 s power frequency r.m.s overvoltage that can be applied between the arrester, as verified in the TOV test and the operating duty cycle.
Residual voltage (U_{res})		The peak value of voltage that appears between the terminals of an arrester during the passage of discharge current.
Surge impedance (Z)		The surge impedance of a conductor is a mathematical constant, approximately equal to the square root of the quotient of the inductance of the conductor and the capacitance between the conductor and ground).
Switching withstand (SIWV) or Basic switching insulation level (BSL)	impulse voltage	The maximum residual voltage of the arrester for the switching impulse discharge current specified for its class (AS 60099-4).

Temporary overvoltages (TOV)	Temporary overvoltages as differentiated from surge overvoltages, are oscillatory overvoltages of relatively long duration and which are undamped or only weakly damped.
Temporary overvoltage withstand factor (T_r or T_c)	The TOV capability of the arrester expressed in multiple of U_r or U_c .
Virtual front time of a current impulse (T_1)	The time in microseconds equal to 1.25 multiplied by the time in microseconds for the current to increase from 10% to 90% of its peak value.

3.2 Abbreviations

This list does not include well-known unambiguous abbreviations, or abbreviations defined at their first occurrence within the text.

CFO	Critical flashover voltage
COE/ COG	Coefficient of earthing/ coefficient of grounding
EQL	Energy Queensland Limited
I_c	Continuous current
I_n	Nominal discharge current
k_e	Earth fault factor
LIWV/ BIL	Lightning impulse withstand voltage/ basic insulation level
LPL	Lightning impulse protection level
U_{res}	Residual voltage
SA	Surge arrester
SIWV/ BSL	Switching impulse withstand voltage/ Switching insulation level
TOV	Temporary overvoltage
T_r	Temporary overvoltage withstand factor
U_c	Continuous operating voltage
U_{ca}	Actual continuous operating voltage
U_r	Rated voltage
Z	Surge impedance

4 Background

Two broad categories of surge arresters have been used in the network:

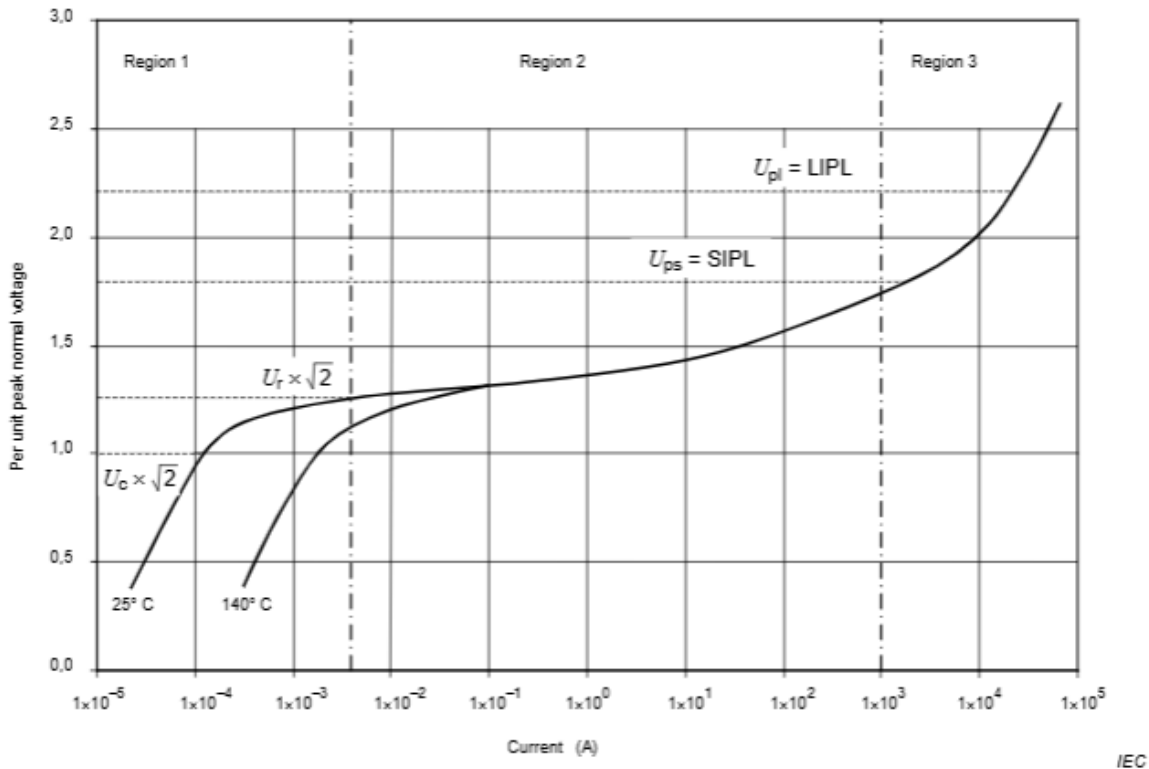
- Metal-oxide surge arresters (MOSA) consisting of highly non-linear stable zinc oxide (ZnO) value blocks.

- Gap type arresters consisting of a series connection of a spark gap and a non-linear resistor made of silicon carbide (no longer purchased but exist on the network).

Metal oxide arresters fall into three broad design types, namely: gapless arresters, shunt-gapped arresters, and series-gapped arresters. Gap-less arresters are purchased by Energy Queensland.

The principle of operation of the gapless SA could be briefly explained as follows. The volt-ampere characteristic exhibits a very non-linear behaviour that may be approximately by the relationship $I = kV^\alpha$. Alpha (α) values will normally vary from 10 to 50, depending on the metal-oxide formulation and current range being studied. Typically, at higher current values and wider ranges will yield lower values of α . For example, α may be 50 over a current range of 1-600 A and may average 26 over a wide range of 1-10 000 A. Figure 1 shows a typical voltage-current characteristic of a gapless arrester. In service there is a permanent current flow through the valve blocks. At the continuous operating voltage this current is small. As soon as the applied voltage exceeds 1.1 times the continuous rating there will be a significant increase in the current flow.

Additionally, the arrester discharge voltage is a function of the rate of rise of the current surge, with higher voltage occurring for faster rates of rise and vice versa. Typically, for the same current magnitude, the voltage occurring for a current cresting in 1 μ s is 8-12% higher than occurring for a standard 8/20 μ s lightning current wave. The voltage occurring for a current cresting in 45-60 μ s is 2-4% lower than that for the 8/20 μ s wave.



Legend

- Region 1: **pre-breakdown** region is the low current region associated with steady state operation
- Region 2: **breakdown** region is the highly non-linear region normally associated with TOV and slow-front (switching) surges
- Region 3: **high current** region is the region associated with currents > 1 kA, normally Fast-front (lightning) surges

NOTE 1 U_c : Arrester continuous operating voltage normally equal to highest voltage of the system $1.05 \times U_{\xi}/\sqrt{3}$.

NOTE 2 U_r : Arrester rated voltage.

NOTE 3 $LIPL=U_{pl}$: Arrester lightning impulse protective level i.e. the maximum residual voltage at the nominal discharge current I_n .

NOTE 4 $SIPL=U_{ps}$: Arrester switching protective level i.e. the maximum residual level at the specified switching impulse currents.

NOTE 5 The currents at $U_c \times \sqrt{2}$, $U_r \times \sqrt{2}$, LIPL and SIPL are only given as examples.

Figure 1: Typical voltage-current characteristic for ZnO arresters (AS 60099.5). (Do not use for applications)

5 General Procedure for Selection of Gapless Surge Arresters

The general procedure for the selection of arresters in relation to the insulation to be protected comprises in a series of steps, which are elaborated in subsequent clauses.

- Select surge arrester ratings
- Determine protective levels of arrester
- Determine equipment insulation strength

- Evaluate insulation coordination
- In the event that (□) indicates that adequate protection cannot be achieved, evaluate alternatives, a re-evaluation may be required.

6 Selection of Surge Arrester Ratings

Characteristics and performance of a SA are determined by the following parameters:

- Continuous voltage (U_c)
- Rated voltage (U_r)
- Nominal discharge current (I_n)
- Specific energy
- Line discharge class
- Pressure relief class (porcelain housing only)
- External insulation level
- Pollution performance

6.1 Step 1: Obtain System Parameters

The following data are required to determine arrester parameters:

- System nominal voltage, U_n and maximum voltage, U_m
- Earthing of system neutral
- Positive and zero sequence impedances at the SA location
- Possible causes of overvoltages
- Length of the longest line to which SA will be connected
- Line surge impedance, Z , and/or line capacitance, C
- Prospective fault levels at arrester location

6.2 Step 2: Check for Abnormal Service Conditions

Abnormal service conditions are listed in Annex A of AS 60099.4. Some of the most important conditions that may lead to selection of higher U_c and/or U_r are:

- Temperatures below -10°C or above $+50^{\circ}\text{C}$
- Frequencies under 48 Hz or above 52 Hz (for 50 Hz systems)
- Presence of heat sources near the arresters
- High system capacitance or electrical proximity to capacitor banks, long cables and long or over-insulated transmission lines.

6.3 Step 3: Determine Continuous Voltage (U_c)

In a 3-phase system, for arresters connected phase-earth, actual continuous voltage is:

$$U_c = U_m / \sqrt{3}$$

Equation 1: Continuous Voltage (U_c)

This applies for effectively earthed and non-effectively earthed systems where the clearing time for phase to ground faults is less than 10 seconds.

6.3.1 Recommended Continuous Voltage

The following **minimum** values of U_c in **normal** conditions are recommended.

Table 1: Recommended Continuous Voltage

Nominal, U_n	System voltage (kV)						
	11	22	33	66	110	132	220
Highest voltage, U_m	12	24	36	72.5	123	145	245
System earthing	SA continuous operating voltage, U_c (kV)						
Effectively and non-effectively earthed	8	15	22	44	75	88	150

6.4 Step 4: Determine Temporary Overvoltage Capability and Rated Voltage (U_r)

6.4.1 Check for Maximum TOV

It is essential that the arrester itself is stable under all system operating conditions. The system behaviour must be known, especially under TOV conditions. The TOV level has become a determining parameter for the rated voltage of the SA. The SA must be selected with a sufficient safety margin.

The main causes of TOV are:

- Single-phase faults
- Single-phase open circuit
- Loss of neutral earth in a normally earthed system
- Sudden loss of load or generator overspeed or both
- Loss of load at the end of transmission line
- Ferro-resonance
- Accident contact with conductors of a higher voltage system

Generally, the TOV arising at earth faults and at load rejection are of interest. Certain network configurations can give resonance overvoltages, which should be avoided by system design and should not be the basis for selection of the arrester TOV capability.

6.4.2 Earth Fault Conditions

The most commonly known TOV is that at single-phase faults. During a single-phase fault, the sound phases exhibit significant voltage rises. The magnitude of the voltage rise on the sound phase during a phase to ground fault is dependent on:

- Positive sequence impedance
- Zero sequence impedance

- Fault resistance

The calculations used to determine the voltage rise, coefficient of earthing and earth fault factor can be found in Annex A. These calculations can be used in site specific assessments for surge arrester ratings.

6.4.3 Other Cases

In some cases, efforts are made to reduce the earth fault current by selectively earthing the neutrals of only a few transformers yet maintaining an effectively earthed system overall. However, there is a possibility that some parts of the system may become non-effectively earthed for some periods when one or more of the earthed neutral transformers taken out of services. An earth fault during this period may lead to higher TOV and arrester failure if this contingency is not taken into account. Since such occurrence is rare, it may be justified to accept risk of arrester failure instead of selecting an arrester with higher TOV capability and thus a higher protective level. This is also equally applicable to the case of accidental contact with conductors of higher voltage systems.

6.4.4 Select Suitable TOV Capability and Rated Voltage (U_r)

The following procedure is used in general cases for selecting SA with sufficient TOV capability.

Known make and type

- Determine the k_e , fault duration and prior energy/duty requirements from Table 1 depending on the U_m and earthing of the system.

Table 2: Recommendations for coefficient of earthing k_e (ABB Buyer's Guide, 2010)

Assumptions	Directly earthed neutral systems		Resonant earth and isolated neutral systems
	$U_m \leq 123 \text{ kV}$	$U_m > 123 \text{ kV}$	
TOV in p.u of $U_m / \sqrt{3}$	1.4 ¹	1.4 ¹	1.73 ¹
Fault duration	1 s	1 s	10 s and 2 h ²
Prior energy ³	Rated	Rated	Rated

Note 1: These values are to be used for general cases. For site specific values, calculated values for TOV from 7.4.2 may be used.

Note 2: 10 seconds is the assumed maximum duration for earth faults in the EQL network.

Note 3: TOV is calculated using the rated prior energy curves to account for multiple faults.

Using this information, calculate TOV using Equation 2:

$$\text{TOV} = k_e \times U_m / \sqrt{3}$$

Equation 2: TOV

- Using the TOV capability curve of the arrester and the TOV value calculated, determine the corresponding T_r . Figure 2 shows the TOV capability curve of Siemens 3EL arresters.

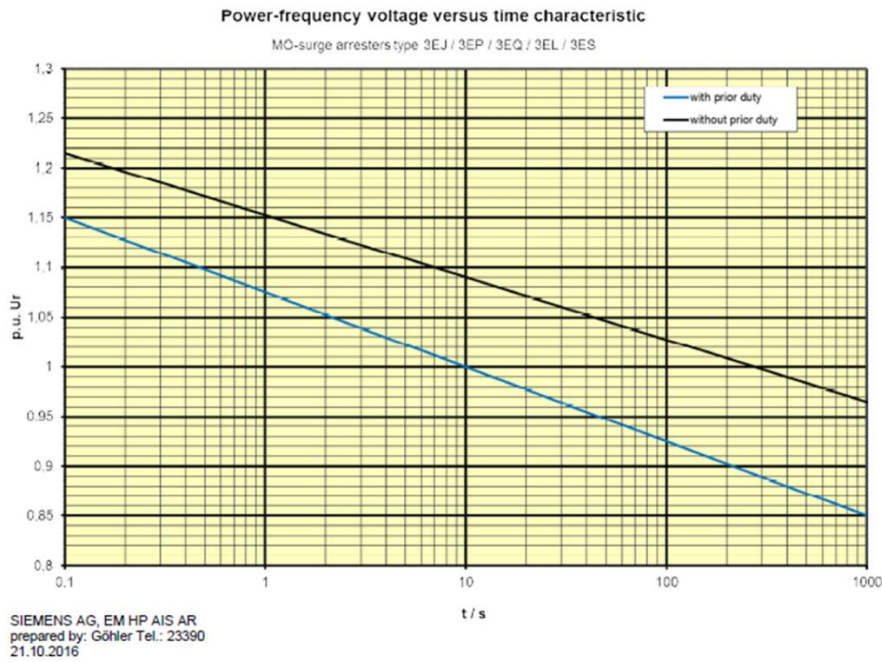


Figure 2: An example of a TOV capability expressed in p.u. Ur.

- Finally determine the rated voltage using Equation 3 and round the result up to the next highest standard rating according to Table 2.

$$U_r = TOV / T_r$$

Equation 3: U_r

Table 3: Preferred values of rated voltages (AS 60099.4).

Range of rated voltage kV r.m.s.	Steps of rated voltage kV r.m.s.
3 to 30	1
30 to 54	3
54 to 96	6
96 to 288	12
288 to 396	18
396 to 900	24

Example – the system highest voltage is 72.5 kV and neutral is directly earthed.

$$TOV = 1.4 \times 72.5 \div \sqrt{3} = 58.60 \text{ kV for } 1 \text{ s}$$

Equation 4: Example TOV

Assuming the arrester has TOV capability shown in Figure 2. At 1 s with prior rated energy, the curve gives $T_r = 1.07$ then

$$U_r \geq 58.60 \div 1.07 \geq 54.77 \text{ kV}$$

Equation 5: Example U_r

The next higher standard rating is $U_r = 57 \text{ kV}$.

Unknown make and type

It is recommended that the **rated voltage, U_r at least 1.25 times U_c** should be selected when possible. If this is a non-standard rating, choose the next highest rating.

6.5 Step 5: Determine Nominal Discharge Current, I_n

Standard I_n values stipulated by AS 60099.4 are 2 500A, 5 000 A, 10 000 A and 20 000 A.

It is recommended a **minimum nominal discharge current of 10 kA** should be used for protection of equipment in substations. This corresponds to Substation SL & SM class in AS 60099.4.

6.6 Step 6: Determine Energy Withstand Capability and Specific Energy

6.6.1 General

Switching overvoltage represents the most severe stress for arresters because of the very large energies involved. The most onerous case is the stress caused by switching-in against a trapped charge on a transmission line on arresters installed at the open far end of the line.

The current through the arrester and its residual voltage at this current are given by the intersection of the arrester volt-ampere characteristic and the load line and can be determined by plotting the load diagram as in Figure 3.

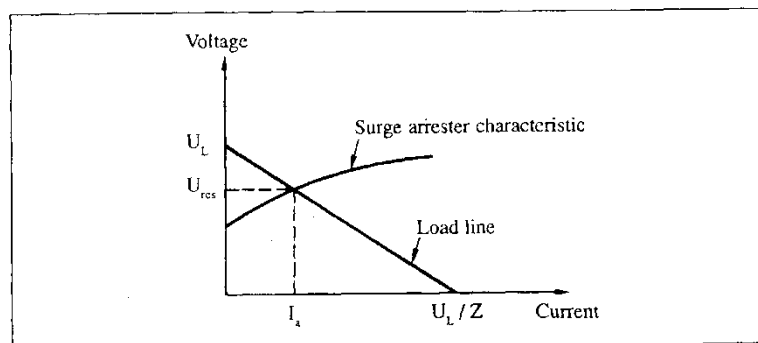


Figure 3: Load diagram (SESWG/A-2310, 1990-05)

- U_L = Prospective overvoltage
- Z = Line surge impedance
- I_a = Surge arrester current
- U_{res} = Surge arrester residual voltage

TOV will always occur on switching-in a capacitor bank but will only occur on switching-out if restrikes occur in the switching device. Arresters installed in a substation to protect transformers and other equipment from overvoltages may be subjected to severe energy absorption during capacitor switching because of large energy ($CV^2/2$) stored in the capacitor bank. In this case the arrester energy should also be checked.

6.6.2 Line Switching Parameters

In the absence of site-specific information, the following switching parameters can be used (SESWG/A-2310, 1990-05).

Table 4: Line switching surge impedances.

System max voltage U_m (kV)	OH Line Surge impedance Z (ohm)	UG Cable Surge impedance Z (ohm)	Prospective overvoltage without arresstor U_L (p.u)
Under 145	450	20	3.0
145 to 345	400	20	3.0
362 to 525	350	20	2.6

6.6.3 Calculate the Arrester Energy

Known surge arrester volt-ampere characteristics

The discharge energy (W), given in kilojoule (kj), absorbed by the arrester is given by the equation:

$$W = [(U_L - U_{res}) / Z] \times U_{res} \times 2l / v \times n$$

Equation 6: Arrester Energy – known characteristic

Where:

- U_L = Prospective switching surge overvoltage or line changing overvoltage (kV)
- U_{res} = Switching residual voltage of the arrester (kV), determined from load characteristic
- Z = Line surge impedance (ohm)
- l = Length of line (km)
- v = Velocity of propagation (km/ms)
300 km/ms for aerial lines and GIS bus
For cables much lower around 150 km/ms dependent on cable insulation
- n = Number of consecutive discharges

Arrester volt-ampere characteristic not known

The energy W in (kJ) can also be calculated from the following equation:

$$W = 1/2 C [(a \cdot U_m)^2 - (\sqrt{2} \cdot U_c)^2] / 10^3$$

Equation 7: Arrester Energy – unknown characteristic

Where:

- a = per unit switching overvoltage factor (taken as 3 for $U_m \leq 345$ kV) times $\sqrt{2}/\sqrt{3}$
= 2.45
- C = line capacitance (μF)
- U_m = system highest voltage (kV)
- U_c = continuous operating voltage of arrester (kV)

6.6.4 Determine Specific Energy

$$\text{Specific energy } W' = \text{Arrester Energy} \div \text{Arrester } U_r \quad (\text{kJ} \div \text{kVrated})$$

Equation 8: Specific energy

6.7 Step 7: Arrester Class

6.7.1 Determine Arrester Class

Following AS 60099-4, the class of surge arrester must be selected by considering the I_n and specific energy required for system safety. The specific energy can be calculated using Equation 4, Equation 5 and Equation 6 and Table 4 used to select the correct class of arrester.

Table 5: Arrester class selection characteristics. Note: L = low, M = medium, H = high.

Arrester class		I_n (kA)	Switching impulse discharge current (kA)	Q_{rs} (C)	W_{th} (kJ/kV)	Q_{th} (C)
Substation	SL	10	0.5	≥ 1	≥ 4	Substation
	SM	10	1	≥ 1.6	≥ 7	NA
	SH	20	2	≥ 2.4	≥ 10	NA
Distribution	DL	2.5	NA	≥ 0.1	NA	Distribution
	DM	5	NA	≥ 0.2	NA	≥ 0.7
	DH	10	NA	≥ 0.4	NA	≥ 1.1

6.7.2 Recommended Minimum Class

In general, it is recommended that **SM** class should be selected for substation applications, however **SL** class may be acceptable for voltages up to 66kV.

6.8 Step 8: Determination of Protective Characteristics

Refer to Section 8.

6.9 Step 9: Pressure Relief (Applicable to Porcelain Housed SA Only)

6.9.1 Pressure Relief Current

Pressure relief current limits should exceed the system's available short circuit current and duration at the arrester location. The device is chosen on the basis of the prospective symmetrical short circuit current in the system at the arrester location or calculated from the formula:

$$I = Pk \div (\sqrt{3} \times U_m)$$

Equation 9: Pressure relief current

I = Prospective symmetrical short circuit current (kA)

Pk = Prospective 3-phase short circuit power at the arrester location (MVA)

U_m = The maximum system voltage (kV)

A minimum level of **40 kA** is recommended.

6.9.2 Pressure Relief Class

It is recommended that pressure relief class **NS** should be selected.

6.10 Step 10: External Insulation Levels

According to AS 1307.2, the arrester housing shall withstand the following voltages:

LIWV = 1.3 x lightning impulse protection level of the arrester

PFVV = 1.06 / $\sqrt{2}$ x switching impulse protection level for a duration of 1 minute

SIWV = 1.25 x switching impulse protection level for arresters having $U_r \geq 200$ kV.

6.11 Step 11: Mechanical Characteristics

Strong wind and pull of conductor increase the horizontal loading on the arrester. Wind pressure can be calculated from wind velocity.

$$q = 0.36 \times V^2 \text{ on cylindrical surface}$$

Equation 10: Wind pressure

Where:

q = wind pressure (Pa)

V = wind velocity (m/s)

The wind force acting on the arrester is:

$$F_w = q \times l \times d$$

Equation 11: Wind force

Where:

F_w = force due to wind on arrester (N)

l = length of arrester (m)

d = mean diameter of arrester (m)

Assuming this force acts at the middle of the arrester, bending moment (N.m) at the arrester base will be:

$$M_w = l \times F_w \div 2$$

Equation 12: Bending moment

The cantilever strength (bending moment) of the arrester must be sufficient for pull of conductor and wind force. Wind speed up to 72 m/s should be allowed for.

6.12 Step 12: Pollution Performance

Refer to Table 3, Table 4 and Table 5 of SA TS 60815.1 for site pollution severity levels (SPS) and relation between the pollution level and its typical environment. Once the SPS class is known, refer to Figure 1 of SA TS IEC 60815.2 for the corresponding reference unified specific creepage distance.

It is recommended that **Class D – High** and corresponding minimum reference unified specific creepage distance of **43.3 mm/kVrated or higher** should be selected, where kVrated is the r.m.s. value of the highest operating voltage across the insulator. Where surge arresters are being used in highly polluted areas, consideration is given to using Class E as a special purchase.

7 Determination of Protective Levels of an Arrester

The following protective levels should be considered.

- Steep (or front of wave) current impulse residual voltage (FOW)
- Lightning impulse protection level (LPL)
- Switching impulse protection level (SPL)

If arrester parameters are not available, refer to Table F.1 of AS 60099.5 (for arresters with $I_n = 10$ kA)

When the make and type of the arrester is known, refer to the manufacturers data and use a coordinating current of 10 kApk.

7.1 Evaluating Insulation Co-ordination

Insulation coordination is evaluated on the basis of the margin between the insulation strength of the surge voltage at the equipment terminals.

In general, there are two methods of portraying insulation coordination

- The tabulation of protective ratios or margins, and
- The graphical presentation of coordination.

Regardless of the method, the same minimum protective ratios and margins apply. The graphical presentation is shown in Figure 4.

The graphical method requires the test results of the equipment as well as the protective levels of the arrester.

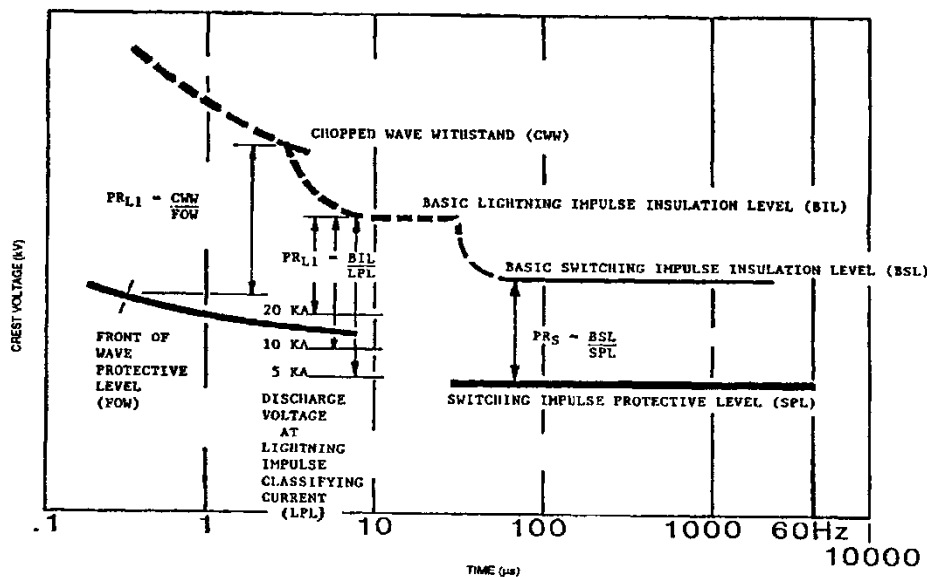


Figure 4: Typical volt-time curve for coordination of arrester’s protective levels with insulation withstand strength for liquid filled transformers.

For more information refer to Standard for Insulation Coordination - 3058912 (STNW3034).

7.2 Arresters at Terminals of Protected Equipment

For arresters installed at the terminals of the protected equipment, the effect of separation distance will be negligible, depending on the equipment highest voltage range the acceptable protective ratios and margins should be as follows:

Table 6: Acceptable Protective Ratios and Margins

Protective ratios	Protective margins
$PR_{L1} = CWW \div FOW \geq 1.2$	$PM_{L1} = (PR_{L1} - 1)100\% \geq 20\%$
$PR_{L2} = LIWV(or\ BIL) \div LPL$ $\geq 1.4\ for\ Range\ A$ $\geq 1.2\ for\ Range\ B\ \&\ C$	$PM_{L2} = (PR_{L2} - 1)100\%$ $\geq 40\%\ for\ Range\ A$ $\geq 20\%\ for\ Range\ B\ \&\ C$
$PR_s = SIWV\ (or\ BSL) \div SPL \geq 1.15$	$PM_s = (PR_s - 1)100\% \geq 15\%$

Range A: above 1 kV to less than 52 kV

Range B: from 52 kV to less than 300 kV

Range C: 300 kV and above.

7.3 Arresters at Some Distance Away From Protected Equipment

For arresters installed at some distance away from the protected equipment, the voltage at the equipment V_T should be calculated by the simplified method.

In this method separation distance and incoming surge steepness are used.

When there are connection leads and a distance between arrester and plant, the protected plant will be subjected to a higher overvoltage. Voltage increase due to distance effects is given in the formula:

$$U = U_{res} + (2 \times S \times D) \div v$$

Equation 13: Protective level including distance effect

Where:

U = voltage at protected plant (kVpk)

U_{res} = residual voltage of the arrester (kVpk)

S = rate of rise or steepness of the incoming voltage wave (kV/ μ s)

D = distance between arrester and protected plant including connection leads, arrester tail to the earth grid, and arrester height (m)

v = velocity of wave propagation (m/ μ s)

(Approximately equal to velocity of light 300 m/ μ s, except for cables for which 150 m/ μ s may be used)

The steepness of the incoming surge at the substation shall be determined based on the reduced steepness resulting from propagation along the overhead line. Considering that surge steepness decreases inversely with the travel distance, the steepness **S** of the impinging surge may be approximated by:

$$S = \frac{1}{n K_{co} X}$$

Equation 14: Steepness of incoming surge

where **n** is the number of overhead lines connected to the substation (divided by two for multi-circuit towers with double-system back flashovers), **K_{co}** is the corona damping constant, and **X** is the distance between the lightning strike point and the substation.

The acceptable protective ratios and margins are as same as those for arresters at terminals of protected equipment.

Table 7: Corona damping constant K_{co}

Conductor Configuration	K _{co}
Single conductor	1.5 x 10 ⁻⁶
Double conductor bundle	1.0 x 10 ⁻⁶
Three or four conductor bundle	0.6 x 10 ⁻⁶
Six or eight conductor bundle	0.4 x 10 ⁻⁶

8 Evaluation of Alternatives

If acceptable coordination cannot be achieved, the following measures may be evaluated;

- Increase the equipment LIWV and SIWV
- Decrease the separation distance.
- Add additional arresters
- Use arrester with lower protective characteristics.

9 Documentation Required

Documentation on the selection of SA shall take the form of a design report and is to include, but not be limited to the following:

- Values for the design inputs such as system voltage, system impedances, system earthing, etc. Refer to section 6.1.
- Calculations to determine SA ratings
- Evaluation of protective ratios / margins
- Insulation coordination studies
- Evaluation of alternatives (as applied).

Annex A

Normative

Coefficient of Earthing (COE) and Earth Fault Factor (ke)

A.1 Coefficient of Earthing

Table 8: Equations for calculating the coefficient of earthing.

Fault resistance not included	Fault resistance (R_f) included
Applicable when $Z_1 = Z_2$	Fault resistance tends to reduce COE
Single phase-to-earth fault (P-E) at phase a: $COE (phase\ b) = -[\sqrt{3}(3k) \div (2 + k) + j1] \div 2$ $COE (phase\ c) = -[\sqrt{3}(3k) \div (2 + k) + j1] \div 2$	For P-E fault: $k = (R_0 + R_f + jX_0) \div (R_1 + R_f + jX_1)$
Double phase-to-earth fault (P-P-E) on phase b and c: $COE (phase\ a) = \sqrt{(3k)} \div (1 + 2k)$	For P-P-E fault: $k = (R_0 + 2R_f + jX_0) \div (R_1 + 2R_f + jX_1)$
Where: $k = Z_0 \div Z_1 = (R_0 + jX_0) \div (R_1 + jX_1)$	

A.2 Earth Fault Factor (ke)

$$k_e = \sqrt{3}COE \text{ Earth fault factor (ke)}$$

Equation 15: Earth Fault Factor

The network is defined as effectively earthed when $COE < 1.4$.

Annex B

Informative

Pollution Severity Levels and Referenced Unified Specific Creepage Distance

Table 9: Table 3 and Table 4 from SA TS 60815.1

Table 3 – Directional dust deposit gauge pollution index in relation to SPS class

Directional dust deposit gauge pollution index, PI ($\mu\text{S}/\text{cm}$) (take whichever is the highest) ^a		Site pollution severity class	
Average monthly value over one year	Monthly maximum over one year		
< 25	< 50	a	Very light
25 to 75	50 to 175	b	Light
76 to 200	176 to 500	c	Medium
201 to 350	501 to 850	d	Heavy
> 350	> 850	e	Very heavy

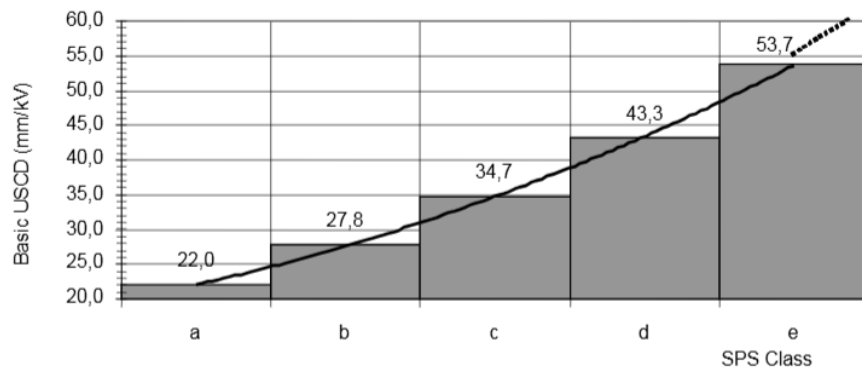
^a If weather data for the site in question is available, then the directional dust deposit gauge pollution index can be adjusted to take into account climatic influences – see Annex E.

Table 4 – Correction of site pollution severity class as a function of DDDG NSD levels

Directional dust deposit gauge NSD (grams) (take whichever is the highest)		Site pollution severity class correction
Average monthly value over one year	Monthly maximum over one year	
< 0,5	< 1,5	None
0,5 to 1,0	1,5 to 2,5	Increase by one class
> 1,0	> 2,5	Increase by one or two classes and consider mitigation (see 9.5.5)

Table 10: Table 5 from SA TS 60815.1

Standard for Selection of Surge Arresters



IEC 1967/08

Figure 1 – RUSCD as a function of SPS class

Annex C

Informative

How to use EQL Selection of Surge Arresters Workbook:

To assist with the selection of appropriate surge arresters, a selection tool has been created based on the information in this standard. The tool is made up of seven sheets containing useful information and formulas, prefilled data, input data and calculations. In order to complete SA evaluation, only the two green coloured sheets need to be accessed as these contain the input data and calculated answers. A brief description of each sheet will be provided below.

Title

The title sheet contains the revision history of the document and a table of contents describing each sheet of the workbook.

Useful Information

This sheet provides information about the standards used to develop the spreadsheet and a number of other pieces of background information which were used in the calculations in sheets 4 and 5. These include descriptions of appropriate insulation levels for different voltages, surge arrester characteristics, insulation coordination, system overvoltage, pollution levels and other miscellaneous information.

Useful Formulae

The useful formulae sheet contains several formulae that have been used to calculate results in sheets 4 and 5 as well as some that were not used but could be useful if further calculations were required to select an appropriate SA. These formulae include impedance, velocity of surge propagation, coefficient of earthing, phase-to-earth faults, earth fault factor and the energy generated in an arrester.

Input Data

This sheet contains linked cells for the input of key pieces of information about the SA's and the systems they will be used in. Any cells which are coloured pink are to be used to select a value, dark-yellow cells are for values to be entered into, and the light-yellow and light-green cells are linked cells which auto-populate based on the pink and dark-yellow cells (fig. 7). Many cells also contain prompts based on standard values about what to enter if you do not know some specifications of the system you are designing for. For example, the lead lengths from the line terminal to the connection point and from the earth terminal to earth have been suggested to be 1 m and 4 m respectively while the lead length from the connection point to the protected equipment varies significantly based on the nominal voltage and space so a table of maximum lengths has been included in Table 11.

Input cell **Linked input cell** **Cell with formula** **Selected value**

Figure 5: Colour code for cells in the Input Data and Summary of SA Performance sheets.

Standard for Selection of Surge Arresters

Table 11: Maximum lead length based on the nominal voltage and lightning impulse withstand voltage of the equipment.

Nominal voltage, Un (kV)	LIWV equipment rating (kVpk)	Maximum lead length, D (m)	
		Effectively earthed	Non-effectively earthed
11	60	24.24	-0.13
	75	42.54	12.05
	95	66.89	28.25
22	95	12.15	-10.37
	125	31.36	1.78
	150	47.33	11.91
33	145	9.89	0.11
	170	20.02	8.54
	200	32.15	18.71
66	325	27.65	
110	450	20.30	
	550	35.01	
132	450	7.10	
	550	18.93	
	650	30.70	
220	650	3.25	
	750	11.22	
	850	19.20	
	950	27.22	
	1050	35.20	

The tab colour of this sheet as been set to green as it contains important information which must be entered in order to evaluate the SA's.

Summary of SA Performance

This sheet contains the calculations used to evaluate the SA's performance against required system minimums. The parameters evaluated include continuous operating voltage, rated voltage, nominal discharge current, class, specific energy, protective ratio, creepage distance, LIWV and cantilever strength. It should be noted that EQL have recently specified that all SA's must be evaluated to a

Standard for Selection of Surge Arresters

level four/very heavy pollution level. Although no values need to be entered in this sheet, it contains the summarised SA evaluation, so its tab colour has also been set to green.

Supplier Data

The supplier data sheet contains information relevant to the selection of SA's under the current contract 883 with Siemens. This includes data like the arrester class, U_r , U_c , I_n , residual voltages, specific energy and arrester dimensions which was obtained from a variety of documents provided during the contract evaluation process. It also includes the TOV curves for each type of arrester in the contract with this information being used to assist in evaluating the suitability of the arresters U_r .

Lookup Tables

The final sheet contains information which is used in sheet 4 to create the drop-down menus in the pink cells. It does not need to be accessed unless changes need to be made to the spreadsheet or there is an issue with what is being displayed.

Example analysis

In order to explain the new changes to the spreadsheet, an example analysis has been performed on a 33 kV, non-effectively earthed system with a longest overhead line connection of 100 km and the SA's located on the transformers to be protected.

First, the U_n , 33 kV, was entered via a drop-down menu. This resulted in the U_m automatically updating to 36 kV. Next, 'NON-EFFECTIVELY EARTHED' was selected as the system neutral earthing as the impedances of the system were not known. If they were known, these should be entered in the appropriate cells, and the blank option should be selected from the drop-down menu in row 18. If the future fault level is known this should also be entered.

7	INPUT DATA			
8	Input cell	Linked input cell	Cell with formula	Selected value
9				
10	System			
11	System nominal voltage (also Base voltage), U_n (or U_{base}) =			33
12	System/equipment highest voltage, U_m			36 kV
13	System Impedances at arrester location in pu/ohm. Select			Ohm
14	Leave blank if unknown	$Z_0 =$	+ j	ohm
15		$Z_1 =$	+ j	ohm
16	If impedances are in pu, enter base MVA, otherwise leave blank			
17	System neutral earthing (if impedances are known)			
18	If impedances are unknown, select			
19	Possible future fault level			15 MVA
20				

Figure 6: Example Analysis 1

Following this, the protected equipment section was filled in with the location of the arresters selected from the drop-down menu in row 22. In order to select an appropriate LIWV/BIL, the light-green cells in row 24 automatically populate according to the LIWV/BIL values that correspond to the U_n value selected above. From the values provided, choose the appropriate value for the equipment being protected and type into the dark-yellow cell in row 25.

Standard for Selection of Surge Arresters

21	Protected Equipment						
22	Location of arresters		Transform				
23	Note: SA installed at line entrance mainly protect VT, CT & open CB on the feeder						
24	Potential protected equipment LIWV/BIL based on Un	145	170	200	NA	NA	kVpk
25	Protected equipment LIWV/BIL. Select appropriate value above	200					
26							

Figure 7: Example Analysis 2

The incoming transmission line option was then selected from the drop-down menu with this selection automatically populating the surge impedance and surge speed of propagation. The length of the longest line, 100 km, was then input along with the number of consecutive discharges, 2. This is nominally set to two as during switching surges, twice the surge energy is seen by the SA so the system should be designed for this occurrence.

27	Transmission line / Cable					
28	Incoming overhead line or cable. Select		Line			
29	Surge impedance, Z		450	ohm		
30	Length of connected longest line/cable, l		100	km		
31	Surge speed of propagation, v		300	km/ms		
32	Number of consecutive discharges, n		2			
33	Note: n = 2 is required to design for switching surges					
34						

Figure 8: Example Analysis 3

In this section no values were selected or input as they are linked to the system earthing and Um values. If the system was effectively earthed and Um below 123 kV, the TOV would be 1.4 and the fault duration 1 s. If the Um was above 123 kV the TOV would be 1.4 with a fault duration of 1 s. All the systems should be rated for prior energy, so this is taken into account during calculations involving TOV.

35	Temporary Overvoltage (TOV) conditions					
36	These TOV values are in p.u. of Um/sqrt(3).					
37	TOV for effectively earthed, Um ≤ 123 kV		NA			
38	Rated for prior energy		NA	Fault duration	NA	s
39	TOV for effectively earthed, Um > 123 kV		NA			
40	Rated for prior energy		NA	Fault duration	NA	s
41	TOV for non-effectively earthed		1.73			
42	Rated for prior energy		Yes	Fault duration	10	s
43						

Figure 9: Example Analysis 4

Using the system parameters selected above as a guide, the SA that was estimated to be the most appropriate was selected using the drop-down menu in row 46. This selection automatically populated the light-yellow cells in rows 47 to 69 with data that is located in the Supplier Data sheet.

Standard for Selection of Surge Arresters

44	Surge arrester from current contract				
45	(For checking performance of an existing arrester or selecting arrester with known make & type)				
46	Contract item			33 kV NEI	
47	Make			Siemens	
48	Type			3EL 1 036-1PE31-4XA1	
49	Standard. (AS is same as IEC)			IEC	
50	Class (IEC std)			SL	
51	Rated Voltage/Duty cycle voltage, Ur			36 kV	
52	Continuous operating voltage/MCOV, Uc			28.8 kV	
53	Nominal Discharge Current, In			10 kApk	
54	Is TOV capability curve available?			Yes, figure 1	
55	TOV capability 10s, TOV			36 kV	
56	Residual Voltages				
57	Lightning current	(8/20 μ s)	@ 2.5 kApk	80.5 kVpk	
58			@ 5 kApk	85.4 kVpk	
59			@ 10 kApk	91.8 kVpk	
60	Switching current	(30/60 μ s)	@ 0.5 kApk	61 kVpk	
61			@ 1 kApk	63 kVpk	
62			@ 2 kApk	66 kVpk	
63	Specific Energy, W				6 kJ/kVrated
64	Housing LIWV			170 kVpk	
65	PFVV			123 kV	
66	Creepage distance,				1400 mm
67	Height of SA, lsa				445 mm
68	Mean diameter, dsa				200 mm
69	Cantilever strength, F				1880 N
70					

Figure 10: Example Analysis 5

Finally, the installation and environmental conditions were set according to standard values and Table 2 although other values may be chosen depending on the system and installation environment. EQL has established that the minimum pollution level should be 'IV (Very Heavy)' so this cell should not be changed.

71	Installation Conditions				
72	SA connection			Phase-Earth	
73	Length of lead from SA line terminal to connection point, d'			1 m	
74	Length of lead from SA earth terminal to earth, d"			4 m	
75	Note: Standard lengths of d' (1 m) and d" (4 m) have been used.				
76	Length of lead from SA connection point to protected equipment, D			10.00 m	
77	See maximum length of D in the Manual for the Surge Arrester Selection Tool				
78					
79	Environmental Conditions				
80	Pollution level. IV Very Heavy is minimum			IV (Very Heavy)	
81	Corresponding specific creepage distance			31 mm/kVrated	
82	Pull of conductor at line terminal,			500 N	
83	Wind velocity, V			210 km/h	
84					

Figure 11: Example Analysis 6

Following the completion of the Input Data sheet, the SA selected can be checked against the system requirements using the Summary of SA Performance sheet. In the summary, the continuous operating voltage, rated voltage, nominal discharge current, class, specific energy, protective ratio, creepage distance, LIWV and cantilever strength of the arrester are compared to that required for the system to operate safely. This outcome of this comparison is displayed visually in the suitability column with any unsuitable parameters identified with a red "NOT SUITABLE" cell. If a parameter is unsuitable, some reasons may be that the wrong surge arrester was selected for the system or that the length of the lead from the SA connection point to the protected equipment was incorrectly selected. If the summary still displays an unsuitable value after these changes have been made, then a larger surge arrester may be required.

Standard for Selection of Surge Arresters

Appendix A Revision History

Revision Date	Version Number	Author	Description of Change/Revision
29/06/2003	0.1.0	Qui Dinh	Approved for issue
13/06/2007	0.1.1	Qui Dinh	Header changed. Footer modified Clause 10 – References modified & moved to become clause 2 Clause 2 – Background moved to become clause 4. Clause 1 modified Heading of Clause 5 (now 6) modified Clause 5.4.3 (now 6.4.3) voltage 132 kV corrected to 123 kV Clause 5.5.2.1 Notations of Equation 1 changed. Clause 5.5.2.2 formula for ke added Clause 5.7.1 last para, reference added Appendices A & B swapped
29/04/2008	0.2.0	Qui Dinh	Clause 2. Reference 11 added Clause 6.5.2.1 Equation 3 added Clause 6.5.4.2 modified Clause 6.6 Determination of nominal discharge current, modified. Clauses 6.9 & 6.12 added Clause 6.10.1 Equation 8 added Clause 9.2. Modified by adding sub-headings 9.2.1 & 9.2.2. New clause 9.2.1. Appendix G added
01/06/08	0.2.1	Qui Dinh	Comments from SSG incorporated
26/02/2014	0.2.2	Cassie Caldwell	Copy to new template
05/02/2021	1	Kate Watson	Copy to new dual branded template Section 2.3 References to IEEE standards removed

Standard for Selection of Surge Arresters

			<p>Section 7.3 Equations for continuous voltage changed to reflect the safety factors already in the EQL network</p> <p>Section 7.6.3 Factor of 2 added to the arrester energy equation for arresters with known volt-ampere characteristics</p> <p>Section 7.7.1 Arrester classes changed to reflect the latest changes to IEC 60099-4</p> <p>Sections 8 and 9 regarding insulation coordination removed. Refer to STNW3034.</p> <p>Annex D Added including updated Surge Arrester Selection Guide (EQL SS-1-8.3 Selection of Surge Arresters)</p>
June 2023	2	John Lansley	Updated template.
May 2026	3	John Lansley	Creepage distances referred back to SA TS60815.1 – Class D standard. Steepness calculation incoming surge referenced to IEC60071.2