TECHNICAL BULLETIN

TB 0171

EARTHING OF METALLIC ITEMS IN MAJOR SUBSTATIONS

Background

During the earth grid continuity testing it is found that some metallic items in major substation buildings have a high resistance to the earth grid either deliberately or mistakenly. It has been recommended that these un-bonded non-fault current carrying metallic items be bonded to the earth grid. The cost for carrying out such bonding may be disproportionate to the benefit received.

Table 5-3 of EDI 516 has listed example equipment connectivity requirements for the following three categories of metallic items.

1. fault carrying connections (N-1) connectivity,
2. non fault current carrying connections (N connectivity) and
3. no connection required

The earth bonding requirement for some of the category 2 items can be considered to be impractical to achieve.

Action

Table 5-3 of EDI 516 establishes examples of typical connectivity requirements for substations. However, some of the non-fault current carrying connections may not be required based on a risk assessment performed by the earthing designer.

Where the assessment shows the connection to be of low risk, when considering the practicality of making the connection, then the non-fault current carrying connection is not required. The following are required to be included as a part of the analysis:

- The likelihood of foreseeable energisation.
- The mesh voltage in the area.
- Where the requirement to bond a metallic item is ambiguous the risk assessment methodology of Annexure 1 shall be used.
- Where a bond is identified in the field as being impractical the earthing designer shall provide advice.
- The un-bonded metallic items and recommended actions to these items are recorded in the design report.
- Where an item is to be un-bonded, the measured value of touch voltage from design verification current injection is required to be recorded in the earthing commissioning report.

All equipment at risk of becoming a part of the primary fault current path shall have N-1 connectivity as stated in Table 5-3 of EDI 516. Secondary equipment, such as fire alarms, shall be earthed in accordance with AS3000, SDI 529 and SDI 511.

Application Examples

The following examples give guidance on where specific bonds are required.

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Example 1: Items required N-1 connectivity- lightning arresters and air break switches

Example 2: Wet area inside substation building-N connectivity requirement determined by risk assessment

Example 3: Kitchen sinks inside substation building N connectivity requirement determined by risk assessment

Example 4: Indoor substation yard handrails and light column N connectivity requirement determined by risk assessment


Example 5: Handrails of a substation building N connectivity requirement determined by risk assessment


Annexure 1: Detailed risk assessment

Where the decision of whether to bond or not bond non-fault carrying metallic equipment inside the substation yard is ambiguous the following methodology shall be applied to make the decision.

Un-bonded non-fault current carrying metallic structures should be bonded to earth if individual probability of fatality risk not as low as reasonably practical or other important requirement is found by the earthing remediation designer. Risk scenarios for unearthed metallic items in substation buildings and yards of indoor substations can be summarised as follows:

- Electricity Worker wearing shoes standing on reinforced concrete floor or crushed rock layer and touching metallic items. Applicable safety risk scenario is touch voltage.
- Electricity Worker wearing shoes standing on reinforced concrete floor or crushed rock layer and touching unbonded items with one hand and touching a bonded or un-bonded item with the other hand. Applicable safety risk scenario is hand to hand voltage.
- Electricity Worker in barefoot and wet body standing on wet reinforced concrete floor and touching metallic taps or metallic parts of deluge shower. Applicable safety risk scenario is touch voltage.
- Electricity Worker in barefoot and wet body standing on wet reinforced concrete floor and touching metallic taps or metallic parts of deluge shower with one hand and touching an bonded or un-bonded metallic items with the other hand. Applicable safety risk scenario is hand to hand voltage.

Applicable contact frequency and duration is 100 contacts/year with 4 sec duration of each contact (equivalent to individual Urban Interface).
Resistivity of concrete: 5 Ωm for wet and 50 Ωm for dry.
Faults in this substation and the faults in other substations bonded to earthing system of this substation are to be considered for fault rate determination.

Example of an acceptable risk evaluation for wet conditions:

Items	Resistivity of wet Concrete (Ωm)	Fault Clearing Time (Sec)/ System	Contact Scenario	Fault Rate Per annum	EG(1) Allowable (V)	Design Max Touch Voltage - unearthed	EG(0) Risk calculated From 'Argon'
-Deluge shower -Shower tap	5	0.150/33kV	Touch /wet	0.1	418	100	$1.7e^{-9}$
	5	0.52/11kV	Touch /wet	1.6	224	94	$2.1e^{-7}$
	N/A	0.150/33kV	H-H	0.1	405	100*	$2.0e^{-10}$
	N/A	0.52/11kV	H-H	1.6	218	94*	$3.3e^{-9}$
						Total	$2.1e^{-7}$

Example of an acceptable risk evaluation for dry conditions:

Items	Resistivity of wet Concrete (Ωm)	Fault Clearing Time(Sec)/ System	Contact Scenario	Fault Rate Per annum	EG(1) Allowable (V)	Design Max Touch Voltage - unearthed	EG(0) Risk calculated From 'Argon'
-Stainless Kitchen zinc -Zinc metallic drain pipes -Exposed copper water or gas pipes -Hot water system -Steel cabinets including doors -Metallic handrails -Steel racks	50	0.150/33kV	Touch /wet	0.1	418	100	$1.6e^{-9}$
	50	0.52/11kV	Touch /wet	1.6	224	94	$1.4e^{-7}$
	N/A	0.150/33kV	H-H	0.1	405	100	$1.7e^{-10}$
	N/A	0.52/11kV	H-H	1.6	218	94	$2.4e^{-9}$
						Total	$1.4e^{-7}$