Power Supply Requirements for ICT rooms

Best Practice Document

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Executive Summary

The installation of standby power generators is recommended in all institutions with essential ICT rooms.

A centralised on-line UPS should be installed to supply ICT rooms. The necessary UPS battery life should be assessed as part of a risk analysis if no standby power generator is to be installed. The UPS should be electrically isolated both during normal inverter operation and in static bypass operation mode.

The minimum requirement for main electrical panels for normal power supply, emergency supply and uninterruptible power supply is that they shall be located in separate cabinets. Main electrical panels supplying essential ICT rooms shall be constructed according to Form 4-b in the EU low-voltage switchgear and controlgear assembly norm NEK EN 60439-1.

The need for overvoltage protection of the distribution grids must be assessed. If overvoltage protection is present in the main distribution grid, at least equivalent overvoltage protection shall be installed in the secondary distribution system for ICT rooms.

The creation of a single earth potential in ICT rooms is considered to be very important for maintaining the necessary accessibility and uptime. All conductive structural elements and equipment surfaces shall be at the same earth potential.

Introduction

This document provides a specification of the Norwegian HE sector’s recommended requirements for power supply for ICT rooms.

The document is a revision of version 3, dated 22 December 2009. A revision log will be found in Chapter 13.

The target group comprises IT managers and IT operations personnel in the HE sector. The purpose of the document is to improve the quality of power supply for ICT rooms in the sector and it is intended that the recommendations in this document will form the basis of expansion, renovation and new building projects, and that they will be applied in everyday work contexts.

1 Definition of Power Supply Types and Supply Integrity

1.1 Power supply types

In this document the following definitions of electric power supplies are used:

1. Normal power supply: Electric power supplied by an electricity company through the local grid

2. Standby power supply: Electric power produced by one or more diesel generators

3. Uninterruptible power supply: Electrical power supply by a UPS (Uninterruptible Power Supply) which under normal circumstances is supplied by the normal power supply and in the event of failure of this supply is initially supplied by its own batteries before subsequently switching to the standby power supply.

Such terms as “emergency power”, “essential power” and “non-essential power” have been deliberately omitted, since “emergency power” is defined in NEK 400 and applies to power supply to installations which are crucial to health and safety. The terms “essential power” and “non-essential power” can lead to undesirable associations and perceptions in some user groups and should therefore be avoided. Figure 1 shows the principles of power supply to ICT rooms.

1.2 Supply integrity

NVE issues annual service interruption statistics compiled from figures submitted by Norwegian power grid operators. Previously, these statistics consisted mainly of non-supplied energy (NSE) and service interruption statistics from reporting points, but since 2005 the statistics have also included interruption statistics applying to end users.

Since 2006, short-term interruptions (less than 3 minutes) have also been reported. Such short-term interruptions amount to a significant number of faults in the course of a year.

The statistics make use of, among other things, the following terms for prolonged interruptions, as defined in IEEE 1366 “Guide for electric power distribution reliability indices”:

CAIDI (Customer average interruption duration index):
The sum of all end user interruption durations divided by the total number of end user interruptions during the year in question.
Meaning: CAIDI represents the average duration of interruptions before the supply is restored over the course of a reporting year.

CTAIDI (Customer total average interruption duration index):
The sum of all end user interruption durations divided by the total number of end users interrupted during the year in question.
Meaning: CTAIDI represents the average duration of interruptions experienced by customers who have actually been without power supply during the reporting year.

SAIDI (System average interruption duration index):
The total duration of interruptions during the year divided by the number of customers on the last day of the year.
Meaning: SAIDI indicates the total duration of interruptions experienced by the average customer during the reporting year.

SAIFI (System average interruption frequency index):
The total number of interruptions during the year divided by the number of customers on the last day of the year.
Meaning: SAIFI indicates how often the average end user has experienced interruption in power supply during the reporting year.

Interruption statistics reported to NVE and published in the report "Interruption Statistics 2007" are shown in the table below:

Prolonged interruptions (> 3 min)	SAIFI (Number of inter-ruptions per end user)	SAIDI (hours per end user)	CAIDI (hours per / interruption)	CTAIDI (hours per end user)
2005	1.9	2.3	1.2	2.9
2006	2.1	2.6	1.3	4.6
2007	2.0	2.4	1.2	3.6
Average 2005-2007	2.0	2.4	1.2	3.7

Short-term interruptions (< 3 min)	SAIFI (Number of interruptions per end user)	SAIDI (minutes per end user)	CAIDI (minutes per end user)	CTAIDI (minutes per end user)
2006	1.8	1.4	0.8	3.0
2007	1.9	1.4	0.8	3.0
Average 2005-2007	1.9	1.4	0.8	3.0

The figures in the table above apply to the whole of Norway and to both planned and unplanned interruptions. On NVE's website and at www.fasit.no (this website in Norwegian only), it is also possible to obtain figures at the level of individual power grid operators. There is some variation among the Norwegian counties; both because of meteorological phenomena in the year to which the statistics apply and because of topographical conditions, but the greatest variation over time will probably be between urban areas with underground supply grids and rural areas with overhead supply lines. Underground supply grids result in significantly higher supply security. The figures in the table must therefore only be used for guidance and an assessment of supply security should be carried out in each individual case. However, the interruption statistics show that both short-term faults (less than 3 minutes) and prolonged faults (greater than 3 minutes) occur so frequently that an uninterruptible power supply is essential to avoid time-consuming and expensive server downtime. Moreover, the interruption durations (CTAIDI) are so great that a standby power generator is necessary to avoid impracticably large battery installations in UPS units.

2 General Requirements

When constructing power supplies for ICT rooms, a risk and vulnerability (RAV) analysis should be performed and used as a basis for selection of a system. The RAV analysis should encompass all parts of the power supply which by definition are important for each ICT room, single or duplicate supply, the size of UPS or batteries, the size of diesel generators, installation requirements, etc.

1. All buildings in large campuses containing essential ICT rooms (server rooms, backup rooms, entrance rooms, etc.) with a significant number of servers and other infrastructure components should have duplicated supply of normal power from the local power supplier (ring structure) combined with a local standby power supply. For more details, reference should be made to the design recommendations for power supply in TIA-942 “Telecommunication Infrastructure Standard for Data Centres”.

2. Main distribution panels for normal, standby and uninterruptible power supplies shall be in separate cabinets.

3. All large or essential ICT rooms shall have their own secondary distribution systems supplied directly from the building’s main distribution system. Alternatively, several small ICT rooms may use a shared secondary distribution system. It is not recommended that essential ICT rooms share secondary distribution systems with equipment or areas which are not IT-related. Less important ICT rooms (e.g. telecommunications rooms) may use general secondary distribution systems. (Experience at Uninett’s operational centre shows that institutions in which equipment in ICT rooms shares power supply with other equipment are subject to disproportionate supply interruption.)

4. Main switchboards supplying essential ICT rooms shall be constructed according to Form 4a in the panel norm NEK EN 60439-1. This means that each circuit breaker is installed in a separate case, isolated from the bus bar, and the cable connections for each circuit breaker should be isolated from each other. This will prevent arcing, and so on, in a circuit breaker cell from spreading to the rest of the panel.

5. Switchboards shall be equipped with plug-in circuit breakers which enable the addition of new circuits without interrupting the power supply to equipment served by the switchboard. Moreover, all new switchboards shall be provided with 10 % spare circuits and 30 % free space for new circuit breakers.

6. Essential ICT rooms should receive their power supply from at least two separate main distribution systems (for example separate distribution systems for standby and uninterruptible power supplies).

3 Requirements for Normal Power Supply

1. In cases where the quality of the normal power supply from the grid is poor (owing to power outages, noise and spikes, low voltage, and so on), improvements should be demanded in the form of new supply lines, separate transformers and so on. Alternatively, purchasing isolating transformers, overvoltage protection, and so on, should be considered. Requirements for normal power supply are stipulated in the Norwegian Energy Act and its appurtenant regulations, cf. Section 1.2 “Supply reliability”. Information and statistics regarding supply reliability may also be obtained (in Norwegian) at www.nve.no.

2. The main distribution grid should be fitted with a panel meter of multi-instrument type with a power analyser which should be able to communicate with the building management system. The panel meter should be capable of measuring voltage and current in all phases, including any neutral conductor (N), as well as the power, power factor, Total Harmonic Distortion (THD – the ratio of the power of the harmonic components to the power of the fundamental frequency, expressed as a percentage) and single harmonics of current and voltage, energy (kWh), maximum and minimum current and voltage, and so on. The measurements should be based on the true RMS values of current and voltage.

3. The need for overvoltage protection must be considered in each individual case, but if the building is supplied by overhead lines, overvoltage protection must be fitted to the main distribution system supplying essential ICT rooms.

4. If the building is equipped with lightning protection, the main distribution panel shall be fitted with Class B overvoltage protection.

5. If overvoltage protection is installed in the main distribution system, such protection should also be installed in secondary distribution systems supplying essential ICT rooms because of the possibility of voltage reflections.

4 Requirements for Standby Power Supply

1. All major institutions with essential ICT rooms should be equipped with diesel generators to provide standby power. Standby power shall be fed to UPS, ventilation and cooling installations used in essential ICT rooms. In the case of some critical systems it may be necessary to supply cooling equipment from UPS units. The generator shall also power all the systems necessary to maintain its own functions, such as electrical fuel pumps, cooling, operation of ventilation flaps, emergency lighting in engine compartments (via a UPS or separate battery installation) and so on.

   Installations must be considered in relation to costs. It may be less expensive to acquire a UPS unit with a small battery bank and a diesel generator than only a UPS with a large battery bank in order to satisfy the requirements for time under battery operation as defined in the institution's own risk analysis.

2. Diesel generators shall have an output (in kVA) of at least 1.5 to 2 times the calculated load (UPS, battery charging, ventilation and cooling). If the generator is to supply other systems, this must be allowed for in the calculations.

3. It must be taken into account that the load may be capacitive and that it should be possible to bypass the UPS. The capacitive output of the generator must be suited to the load.

4. The requirement for start-up time following a detected supply failure (normal supply) must be assessed according to the requirements of each individual installation. An example of a factor which will influence the requirement is if the generator is to supply emergency light fittings or medical areas (both for humans and animals) in addition to ICT rooms. Upon restoration of the grid supply after failure, the generator shall continue to run long enough to ensure that the grid supply is stable. No detectable voltage fluctuation shall occur on switching from generator operation to grid operation.

5. Routines shall be created for monthly testing and maintenance running of the diesel generator. Test and maintenance operation of a generator shall be performed at full load, based on the supplier's recommended maintenance routines. MOM documentation shall be supplied with the generator.

4.1 Technical requirements for standby power generators

The following technical requirements apply to standby power generators:

1. Generator specification: TN-S 400/230V
2. Indoor daily service tank according to generator size
3. Outdoor diesel tank with at least 72 hours' capacity The location and design of the tank shall be in accordance with official regulations with regard to environmental issues (exhaust), fire precautions and fuel storage. If necessary, the size of the tank should be considered based on the ease of filling by the diesel supplier.
4. Engine cooling system: water
5. Generator cooling system: air
6. Insulated exhaust pipes
7. Noise: according to EU environmental directive OND 2000/14EC
8. Emission requirements: EU
9. The generator shall have radio interference suppression according to VDE G and N standards
10. Permitted frequency variation on load-change directly from idle to full load (and vice versa): ± 2%
11. Voltage drop at PF 0.7-1:
    a. Stationary with load increase from idle to full load: ± 2%
    b. Transient with load increase from idle to full load: ± 10%
12. Forced excitation: Minimum 250% of rated current for 10 seconds on shorting of generator terminals.

5 Requirements for Uninterruptible Power Supply (UPS)

1. All UPS units shall be of “on-line” type, i.e. providing continuous UPS power and with no switching time in the event of supply grid failure.

2. Battery capacity must be evaluated on the basis of the reliability of the power supply, the type of equipment to be supplied with power, SLA conditions and the risk of data loss. The following battery capacities are recommended:
   a. UPS units supplied with both normal and standby power: 15-20 minutes
   b. If no standby power generator is used, a separate risk analysis must be carried out to determine the necessary battery capacity. Standby power generators are recommended, cf. Section 4.1 above. In an installation without standby power generators for use during prolonged power interruptions, one will normally have to accept power supply failure, cf. Section 1.2 above.

3. A centralised UPS with its own main distribution system is recommended. “Centralised UPS” means a UPS which supplies all ICT rooms. It should also be noted that 48 V direct current systems supplied by batteries may be appropriate, cf. Chapter 9. A 48 V system will provide 4.8 times higher current than the corresponding power supplied at 230 V, and such systems should therefore be installed locally to limit the amount of wiring.

4. For especially important functions, redundant UPS systems should be considered.

5. A UPS shall be equipped with manual bypass switching between normal and bypass power supply to enable service and maintenance, as well as replacement of the UPS.

6. A UPS shall be equipped with static bypass switching which should preferably be used during normal power grid operation to improve the degree of efficiency of the installation. If the UPS is not able to operate in bypass mode during normal operations, it shall be equipped with static bypass for automatic overriding of the UPS in the event of extreme overloading and short-circuiting.

7. The battery supply shall be according to NEK EN 50272-2 “Safety requirements for secondary batteries and battery installations – Part 2: Stationary batteries”.

8. Valve-regulated, maintenance-free lead-acid (VRLA) batteries are used, which do not require forced room ventilation. Battery packs shall be supplied by the UPS supplier. The lifetime of

batteries in each installation shall be specified by the supplier based on, among other things, the temperature requirements in the room and the charging cycle of the UPS. The batteries shall be selected so as to minimise lifetime costs.

9. It is recommended that batteries for large UPS units be arranged in an “n+1” system which facilitates quick and convenient replacement of batteries while the system is in operation.

10. Single-core cables shall be used between the battery installation and the UPS, and cables for each polarity shall be laid separately. The poles of the battery switch shall be separate and each shall be located in a separate cabinet.

11. UPS rooms normally require cooling to maintain the necessary working temperature.

12. Note that no UPSs are suitable for 3-phase 230 V power supply systems and that an isolating transformer is required to convert from 230 V IT/TT to 400 TN-S before, and from 400 V TN-S to 230 V IT/TT after the UPS. This applies mainly at power levels greater than 7 kVA, since smaller UPSs are single-phase 230 V (IT = Isolated Terra, electrical supply system isolated from earth).

13. UPS units should preferably supply computing equipment but may also be used for necessary supplementary systems such as work lighting, access control systems, cooling systems, and so on.

14. VoIP requires a UPS in the telecommunications room if the same uptime requirements as for traditional PABX systems are to be maintained.

15. A UPS shall be equipped with an Ethernet interface with an SNMP module for monitoring and control. It should be possible to initiate a controlled run-down after a given time (e.g. 6 minutes) or in the event of low battery voltage. It should be possible to transmit alarm signals, consumption monitoring, signals for controlled run-down of equipment, and so on, to an external system by means of SNMP. Moreover, a UPS should be equipped with a display giving full alarm, capacity and consumption status, and so on. The next version of NAV will be developed to handle alarm signals from UPSs.

16. MOM documentation shall be supplied with the UPS and shall include proposals for routines for maintenance and inspection of UPS and battery installations.

5.1 Technical requirements for UPS systems

The following technical requirements apply to UPS systems:

1. Capacity at least 30 kVA
2. Soft start
3. Surge suppressor
4. Static bypass for use in the event of overload if it cannot be used in a normal operating situation
5. Manual bypass for maintenance
6. Battery monitoring
7. Protection against deep discharge of batteries
8. Facility for parallel operation
9. Degree of efficiency: > 94% in on-line operation
10. Maximum load crest factor: > 3
11. Noise level: < 50 dBA

12. MTBF (system) minimum: 17 years
13. Guarantee from start-up: 1 year
14. SNMP interface
15. Run-down of Windows and UNIX machines.

Input:

1. Voltage fluctuation: ± 20%
   a. THDI: < 5%
   b. Power factor: > 0.99

Output:

1. Must tolerate capacitive loads from server racks. Working area, for example: 0.8 cap < PF < 0.8 ind.

Overloading:

1. 120%: 1-5 min
2. 150%: 1 s
3. High fault triggering in inverter operation mode. Shall be selective to type B (16 A) automatic circuit breakers.

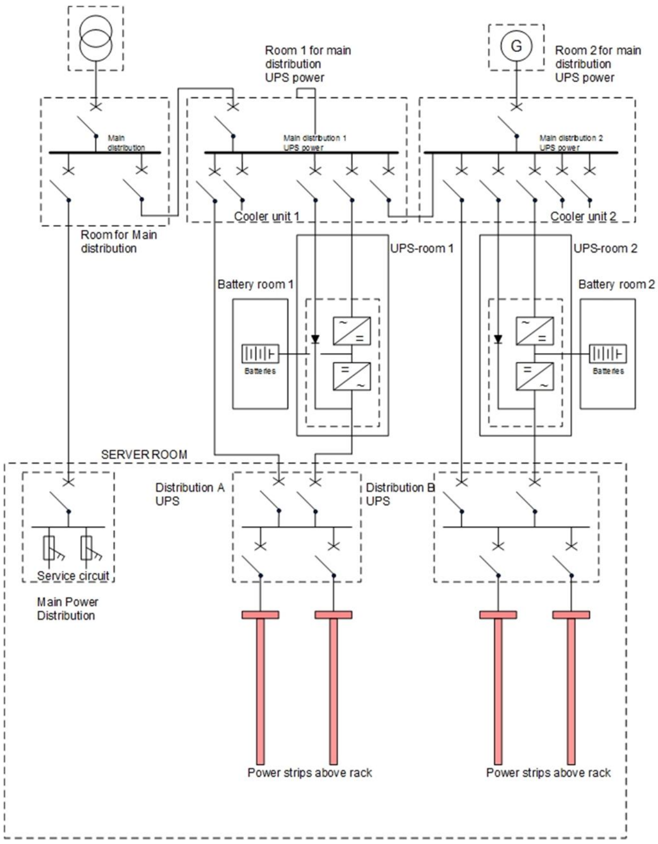

Figure 1: Principles of power supply to ICT rooms.

6 Requirements for 48 V Rectifier Installations

Because of their simplicity, 48 V rectifiers have high MTBF and are therefore typically used for power supply to telecommunications equipment, telephone exchanges, routers and similar devices demanding high uptime. Such installations are especially relevant in connection with larger PoE systems.

In critical installations, duplicated systems are often used.

Because of their low voltage and high cable losses, the use of such installations is restricted to a single ICT room.

The positive conductor of the rectifier is connected to earth, providing a negative potential of 48 V. Fuses are installed in the negative conductor.

The rectifier normally consists of an integral cabinet with a monitoring unit and fuses for appropriate equipment units, as well as plug-in rectifier modules depending on the existing capacity requirements and anticipated future requirements.

The capacity of the rectifier must be at least equivalent to the power consumption plus the charging current for fully discharged batteries. Depending on the load, protection against deep discharge and age, it will be impossible to exploit more than about 70 % of the battery capacity.

Separate battery rooms should preferably be used, even with VRLA batteries.

6.1 Technical requirements for rectifier and battery installations

1. Power at least 1.2 times the expected consumption
2. Rectifiers and batteries shall fit into 19-inch racks, or if necessary separate racks for larger installations
3. It should be possible to strap together units to attain 230 V single-phase (IT and TN), three-phase IT (230 V) and three-phase 400 V with neutral conductor (TN-S)
4. Battery protection
5. Equipment fuses

Specify number and values of fuses based on planned requirements plus spare. Maximum Type C characteristics

6. Protection against deep discharge (LVBD – Low Voltage Battery Disconnect, normally at 40.5 V)
7. Cutting of non-priority circuits (Low Voltage Load Disconnect) based on time or voltage.
8. Temperature-compensated charging
9. Noise: Maximum 55 dBA
10. Power factor > 0.99 at 50% or higher load
11. Efficiency at least 0.92
12. Input protection fuse and varistor for transient protection
13. Output overload protection and short-circuit protection with temperature protection
14. Monitoring module with display and SNMP
15. Battery symmetry monitoring
16. Batteries (VRLA for computer rooms)
17. Battery capacity: at least 8 hours
18. Battery lifetime: at least 6 years.

7 Requirements for power bars and PDUs

Traditional or intelligent power bars or Power Distribution Units (PDUs) are often used to supply power to rack-mounted equipment. A number of different types and makes are available, from the most simple, with no “intelligence” to advanced, “intelligent” PDUs which enable remote monitoring of each individual power outlet. In many cases, the use of intelligent PDUs can provide operational advantages which in turn may result in increased uptime and accessibility. If PDUs are to be purchased, one should ensure that they are suitable for the requirement.

PDUs may have the following inputs:

- 400 V/16 A, three-phase, 3P+N+PE
- 400 V/32 A, three-phase, 3P+N+PE
- 230 V/16 A, three-phase, 2P+PE
- 230 V/32 A, three-phase, 3P+PE

PDUs may have the following outlets:

- 10-40 outlets rated at 230 V/10-16 A, consisting of socket types C13 and C19. The length of these necessitates vertical installation on the rear edge of the rack.
- 4-8 outlets rated at 230 V/10-16 A, consisting of socket types C13 and C19. This type of power bar can often be installed either horizontally or vertically.

Intelligent PDUs will often provide the following functions:

- Display for monitoring of power consumption of individual outlets (e.g. to ensure that UPS A and UPS B are not unevenly loaded)
- Setting of threshold values for alarms to avoid overload, fuse tripping, etc.
- Facilities for remote control/monitoring of outlets
- Monitoring of environmental alarms (for temperature, air humidity, doors, water, etc.)
- Local fuses for improved selectivity
- Management via Ethernet, web, SNMP, Telnet, SSH, etc.
- Server/client software for remote operation may also be appropriate.

When selecting PDUs it is important to ensure that the input ratings are in harmony with the outlet ratings, and that they have the required functions. UNINETT recommends intelligent PDUs which facilitate monitoring of the power supply to equipment, i.e. to detect failure, unbalanced loading of circuits, power consumption, switching in and out, etc.

8 Circuit breaker coordination

8.1 General

All protective devices and circuit breakers must be compatible with any upstream and downstream protective devices to ensure discrimination. As a general rule there shall be total discrimination between all protective devices in an installation. The minimum requirement is that there shall be total discrimination where the probability of short-circuit arising is greatest, i.e. close to the load and in the last part (roughly 20%) of the cable adjacent to the load.

8.2 Uninterruptible power supply

To simplify the tripping of automatic cut-outs in the event of a short-circuit, as well as when the UPS is supplied from its own batteries, the MCB (miniature circuit breakers) used should not be of a too slow-acting type. The maximum short-term current from the UPS should be greater than the instantaneous tripping current for the cut-outs, I5. I5 for a Type B cut-out is 5×In, for Type C it is 10×In and for Type D, 20×In, cf. Figure 3, below. In addition, allowance must be made for the fact that loads in the other circuits will absorb some of the available short-circuit current, but this is normally of small magnitude since the voltage drops significantly on short-circuiting. The amount of current which the fault-free circuits will absorb depends on the voltage characteristics of the loads. If the UPS cannot provide sufficient short-circuit current to trip the MCB in the faulty circuit instantaneously, all the connected loads will be affected and the UPS may disconnect because of overloading after a very short time (a few hundred ms). In the case of large circuit breakers, for example in rising mains, one must normally accept that the UPS must be supplied with short-circuit current through a static bypass in order to trip the circuit breaker.

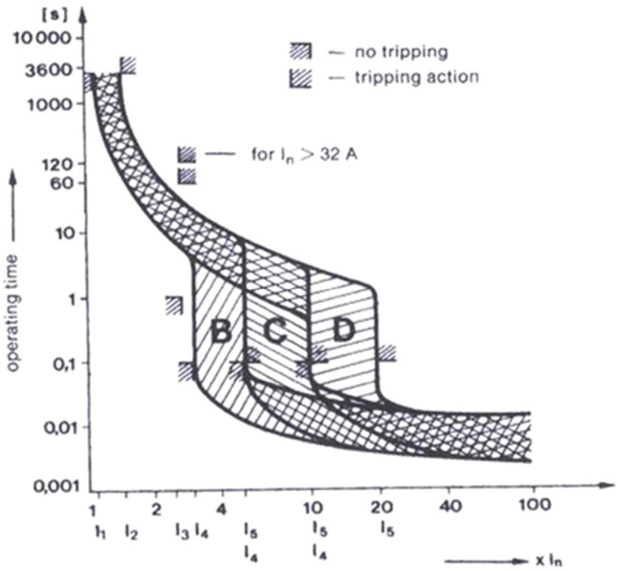

Figure 3. Tripping characteristics of Type B, C and D automatic cut-outs according to NEK EN 60898.

9 Earthing

The principles of and requirements for earthing are specified in the standards NEK 400 “Low-voltage electrical installations” and NEK EN 50310 “Application of equipotential bonding and earthing in buildings with information technology equipment”. In addition, reference should be made to TIA-942 “Telecommunication Infrastructure Standard for Data Centres” and IEEE 1100-2005, “IEEE Recommended Practice for Powering and Grounding Electronic Equipment”.

It is considered very important that sound and correctly installed earthing be provided in the various ICT rooms. Inadequate earthing may lead to damage to equipment and reduced availability and uptime. Generally, all conductive structural and equipment surfaces in ICT rooms, such as racks, cabinets, chassis, ventilation installations, room cooling units, pipes, cable racks, computer room floors, and so on, shall have the same earth potential.

In achieving this, distinction is often made between large or essential rooms (server rooms, backup rooms, etc.) and less important ICT rooms (ERs, TRs, entrance rooms, etc.). In large or important ICT rooms, it is recommended that a dedicated mesh earth bonding network be created which provides the same earth potential in the entire room. Among other things the mesh network provides effective protection against high-frequent noise. All conductive structural and equipment surfaces shall be connected to the mesh network using the shortest possible cables. See Figure 4.

Requirements for mesh earth bonding networks (large and important ICT rooms):

1. Can be installed on cable racks beneath raised floors (recommended) or under ceilings.
2. The mesh network shall cover the entire ICT room, ideally extending 1.8 m beyond the racks.
3. The recommended maximum mesh size is approximately 2×2 m.
4. Connections shall be provided up to each individual rack, room cooling unit, ventilation unit, etc. The connections to racks shall terminate in the earth rail.
5. All connecting cables to the mesh network shall be as short as possible (to give the lowest possible impedance at high frequencies).
6. The mesh network shall be terminated in a dedicated ICT room earth rail with multiple earth cables.

7. The ICT room earth rail shall be connected to the building's main earth rail.

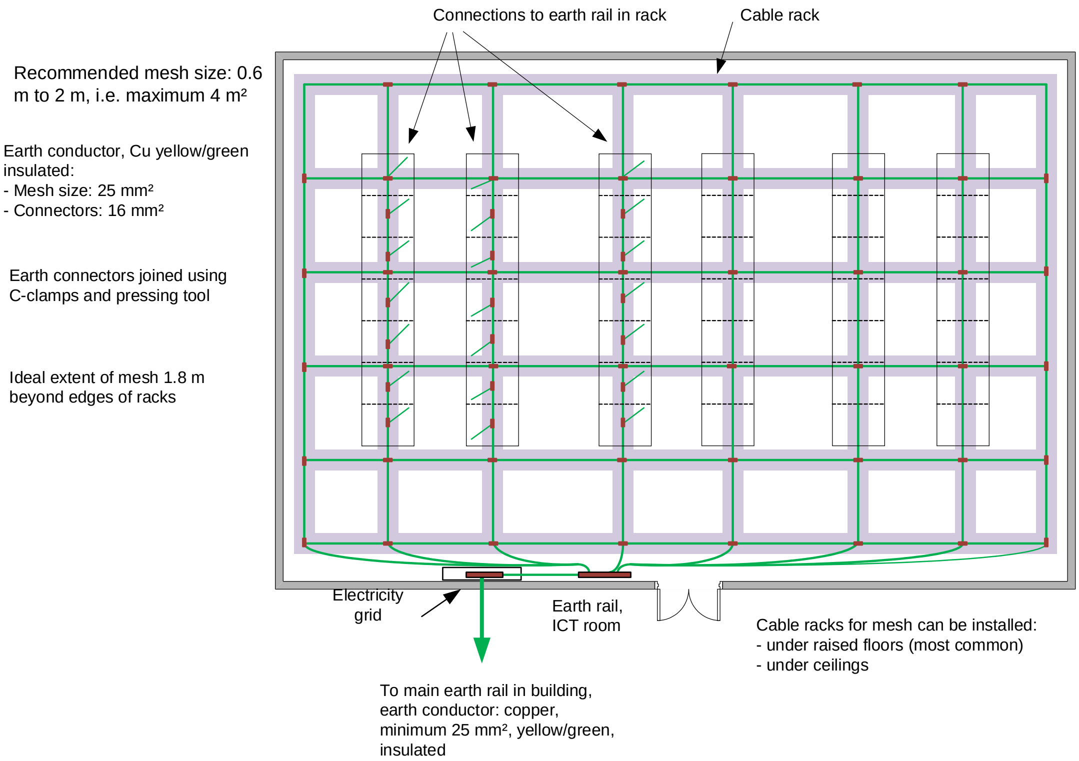

Figure 4. Example of mesh earth bonding network

In small ICT rooms where no mesh earth bonding network is provided, an insulated earth cable should be provided for connection to earth rails in electrical power supply cable racks, cf. Figures 5 and 6. Earthing of rack-mounted equipment is illustrated in Figures 5 and 6. The principles are the same if the racks are installed in rooms with or without earth bonding network.

The following general requirements apply to the earthing installations:

1. All ICT rooms shall have their own earth rail for connecting the various conductive structural and equipment surfaces. The following shall be connected to the ICT room earth rails:

    a. The main earth rail in the main distribution system: copper, minimum 25 mm², yellow/green, insulated

    b. Mesh earth bonding network (large or essential ICT rooms) and earth conductor for connecting rack earth rails in smaller ICT rooms: copper, minimum 25 mm², yellow/green, insulated

    c. Room coolers and ventilation installations: copper, minimum 16 mm², yellow/green, insulated

    d. Cable racks, rising mains and wire racks (pathways): copper, minimum 16 mm², yellow/green, insulated Through-going cable racks should be cut when intersecting with walls. Outdoor cable racks should not be connected to the earth rail in ICT rooms.

    e. Water pipes, cooling pipes, drainpipes and so on: copper, minimum 16 mm², yellow/green, insulated. To avoid condensation, through-going water pipes may be insulated. In such cases, earthing can be dispensed with.

f. Raised floors: copper, minimum 16 mm², yellow/green, insulated. One computer room floor pedestal per 1.5-3.2 m² shall be earthed (every second or third pedestal in each direction with a pedestal spacing of 0.6 m). Raised floors in themselves may represent an earthed mesh, but will be no substitute for a mesh earth bonding network, cf. Figure 4.

2. Earth cables shall be joined using C-clamps and pressing tools to provide good electrical continuity.

3. Earth cables which are to be connected to earth rails shall be fitted with cable lugs, which shall be attached to the earth rails using a pressing tool to give good electrical continuity.

4. Each rack shall be fitted with its own earth rail in good electrical continuity with the rack. Any insulating paint shall be removed before an earth rail is screwed onto a rack using spring washers. Earth rails in racks shall be connected to a mesh earth bonding network or earth cables in a cable rack – copper, 25 mm² (minimum 16 mm ²), yellow/green, insulated.

5. Earthing of patch panels should be carried out based on the manufacturer's instructions. The following alternatives may be encountered:
   a. Earthing by means of screws and spring washers attaching panels to racks. Insulating paint should be removed before connecting.
   b. Earthing by means of pre-fabricated earth cables with cable lugs. Cable lugs should be screwed to racks using spring washers. Insulating paint should be removed before connecting.
   c. Earthing by means of a separate isolated earth rail for patch panels. Isolated earth rails simplify disconnection during fault-finding. This method is preferable when using shielded horizontal cable (STP).
      i. Earth conductor between patch panels and isolated earth rails: copper, minimum 2.5 mm², yellow/green, insulated
      ii. Earth conductor between isolated earth rails and earth rails in racks: copper, minimum 16 mm², yellow/green, insulated.

6. Earthing of active equipment shall be carried out based on the manufacturer's instructions. For example, larger units may require duplicated connections to the earth rail in a rack. The use of insulated copper earth conductor, minimum 16 mm², yellow/green, is recommended.

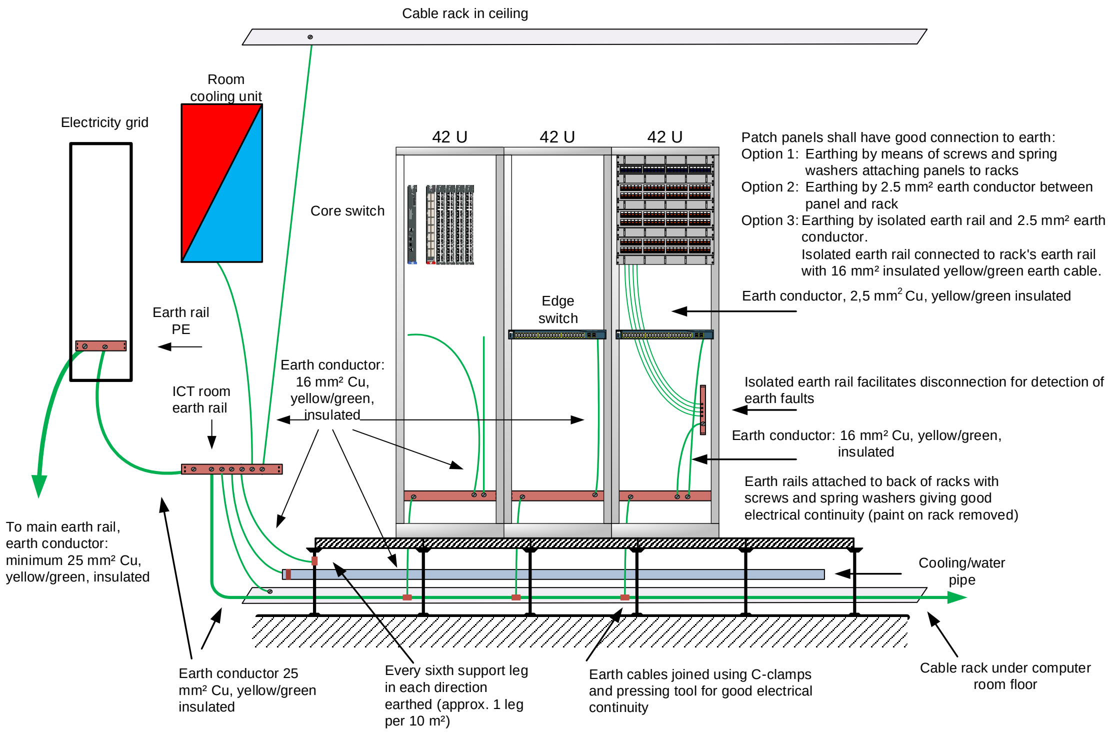

Figure 5. Principles of earthing of smaller ICT rooms with raised floors (server rooms, ERs, TRs, etc.)

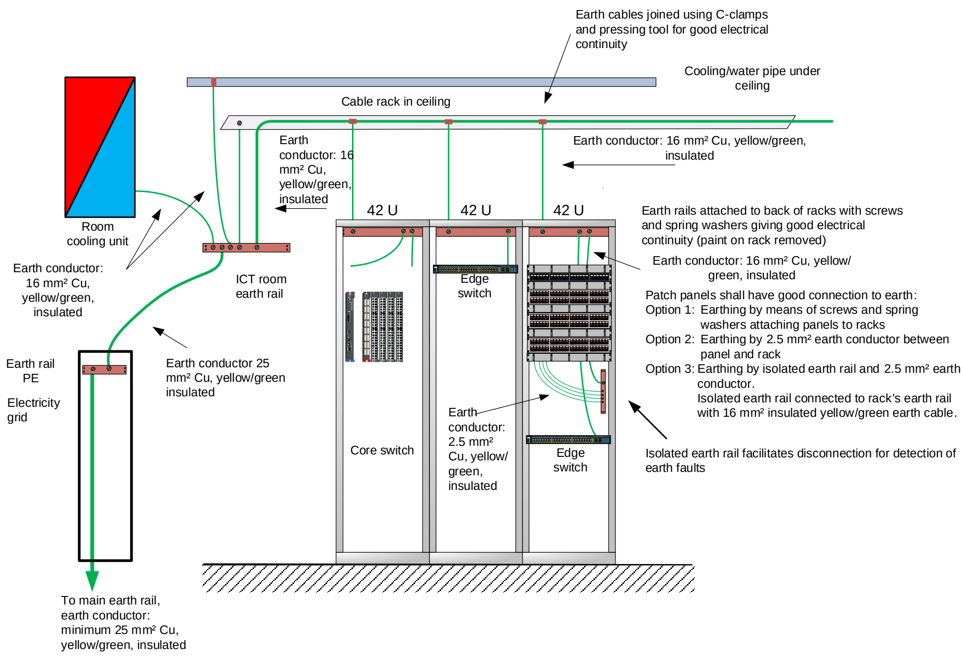

Figure 6. Principles of earthing of smaller ICT rooms without raised floors (server rooms, ERs, TRs, etc.)

10 Design

1. As the basic configuration of racks with mixed content (network electronics, servers, backup systems, etc.) two 230 V, 16 A circuits are recommended for normal power supply and two 230 V, 16 A circuits for uninterruptible power supply. Each circuit should be equipped with double outlet sockets installed on brackets on cable racks. Equipment should be fitted with duplicated power supply and be connected to a minimum of two power circuits (normal power and standby power). In normal operational mode, the load should not exceed 50% on any of the power circuits. If this level is exceeded, the number of circuits should be increased in pairs (normal power and standby power).

2. Power bars or Power Distribution Units (PDUs) are normally installed in equipment racks which are connected to power sockets on the cable racks. Alternatively Power Distribution Units (PDUs) may be installed in equipment racks. A PDU is installed vertically in the rack and has many more outlets than traditional power bars. PDUs can be supplied with various power ratings, for example: 7.3 kVA (32 A) with switches and SNMP interface for monitoring.

3. The trend is toward the use of more compact server racks with higher power requirements. In such cases, the supplier’s requirements for power supply should be adhered to. In order to allow for the installation of pure server racks and similar, it is recommended to install some circuits rated at 230 V, 32 A and/or 400 V, 32 A. As an example, server rooms in a hospital with a capacity of 54 racks are equipped with 108 UPS circuits rated at 230 V, 16 A (two circuits per rack), twelve 230 V, 32 A circuits and fourteen 400 V, 32 A circuits.

   In large computer rooms it is common to use power rails with outlet boxes to supply PDUs. The outlet boxes are fitted with sockets for connecting PDUs which usually have a capacity of 230 V, 32 A and 400 V, 32 A (single phase or three-phase, 5 wire).

   The number and type of outlets must be considered in the light of requirements.

4. All ICT rooms should be equipped with one or more switches for emergency shut-down (normal/standby power and UPS). The switches shall be protected to prevent unintentional disconnection.

5. If there is a high content of third harmonic (> 15 %) in the current load in 4 or 5-conductor cables, a reduction factor must be used to calculate the cables’ current-bearing properties. If the neutral conductor current is expected to be higher than the phase current, the cross-sectional area of the conductors of the cable should be determined on the basis of the neutral conductor current. See Annex 52 C in NEK 400 for more details.

11 Documentation and Labelling

In general, all electrical installations in ICT rooms shall be labelled. Each circuit should be labelled with its circuit number in junction boxes and on power sockets. Documentation (single-line diagrams, etc.) shall be kept up-to-date and easily accessible, for example in the junction boxes.

Colour-coded labels shall be used to distinguish between the different power supply types:

1. White = normal power supply
2. Yellow = standby power supply (diesel generator)
3. Red = uninterruptible power supply

Institutions without their own labelling systems are recommended to label electrical installations according to Statsbygg's multidisciplinary labelling system, cf. http://statsbygg.no/Dokumenter/TFM (in Norwegian).

12 Testing

Regular testing of power supplies and fuses is recommended, by connecting and disconnecting loads such as UPSs, PABXs, and so on.

Note that the dimensioning and design of power supply installations are governed by law. It is therefore recommended that suitably qualified personnel be involved as required.

References

Laws:

1. Act No. 50 of 29 June 1990 relating to the generation, conversion, transmission, trading, distribution and use of energy etc. (the Energy Act) http://www.ub.uio.no/ujur/ulovdata/lov-19900629-050-eng.pdf (unofficial translation)

2. Act No. 4 of 24 May, 1929 relating to the supervision of electrical installations (the Electrical Inspection Act).

Regulations:

1. A number of regulations are associated with the Norwegian Energy Act. A full overview of these (in Norwegian) is available in the following document: (http://www.lovdata.no/for/sf/sf-19900629-050.html).

2. The following regulations are particularly relevant: Regulations relating to the supply quality of power systems: http://www.lovdata.no/for/sf/oe/oe-20041130-1557.html (in Norwegian).

3. DSB Forskrift om elektriske lavspenningsanlegg (FEL) [Regulations relating to low tension electrical installations] (in Norwegian)

4. DSB, Forskrift om sikkerhet ved arbeid i og drift av elektriske anlegg (FSE) [Regulations relating to safety in connection with work on and operation of electrical installations] (in Norwegian)

New NVE regulations are currently undergoing consultative treatment: ///Supply quality in power supply systems, proposal for regulations, cf. http://www.nve.no/FileArchive/262/Leveringskvalitet_forskrift_offentlig%20h%F8ring_28mai2004.pdf.

Norms and standards:

1. IEEE 1100-2005: IEEE Recommended Practice for Powering and Grounding Electronic Equipment

2. IEEE 1366: Guide for electric power distribution reliability indices

3. TIA standard TIA-942: Telecommunication Infrastructure Standard for Data Centers

4. Norwegian electrotechnical standard NEK 400 Elektriske lavspenningsinstallasjoner, 2006 [Low-voltage electrical installations] (in Norwegian)

5. Norwegian electrotechnical standard, NEK EN 60439-1 Lavspennings koblings- og kontrollanlegg – Del 1: Krav til typeprøvede og delvis typeprøvede anlegg [Low-voltage connection and control installations – Part 1: Requirements for type-tested and partially type-tested installations] (in Norwegian)

Revisions

The following revisions have taken place in relation to the version dated 22 December 2009:

1. General text adjustments and revisions based on the experiences of institutions in the sector.
2. New Chapter 7 dealing with requirements for PDUs.

Glossary

CAIDI	Customer Average Interruption Duration Index
CTAIDI	Customer Total Average Interruption Duration Index
DSB	The Norwegian Directorate for Civil Protection and Emergency Planning
MOM	Management, Operation and Maintenance
ER	Equipment Room
IEEE	The Institute of Electrical and Electronics Engineers
NSE	Non-supplied Energy
IT	Isolated Terra – Electrical potential system which is isolated from earth or connected to earth via a sufficiently high impedance, either at a neutral point or at an artificial neutral point in a transformer, generator, or similar.
TR	Telecommunications Room
kVA	KiloVolt Ampere – unit of power for alternating current equipment
kWh	Kilowatt-hour
LVBD	Low Voltage Battery Disconnect
MTBF	Mean Time Between Failures
NAV	Network Administration Visualized, an ICT management system developed by the HE sector under the direction of UNINETT
NEK EN	Norwegian Electrotechnical Committee European Norm
NVE	The Norwegian Water Resources and Energy Directorate
PABX	Public Automatic Branch Exchange
PDU	Power Distribution Unit
POE	Power over Ethernet, IEEE 802.3af / at
RMS	Root Mean Square
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SNMP	Simple Network Management Protocol
SLA	Service Level Agreement
THD	Total Harmonic Distortion

TIA	Telecommunications Industry Association
TN	Power supply system which has one point directly earthed at the power source, with the vulnerable components connected to this point via protective conductors. Three types of TN systems are defined, depending on the arrangement of the N conductor and protective conductors.
TN-C	In this system, the N conductor and protective conductor are combined into one conductor in the entire supply system.
TN-S	In this system, a separate protective conductor is used all the way from the power source and throughout the entire installation.