TATA STEEL

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Tata Steel Technical Standard

S2173201 Power systems, earthing and protection facilities for low-voltage installations

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1 SUBJECT AND SCOPE

This standard applies to power supply systems, earthing facilities and protection by local equipotential bonding and is aimed at low voltage electrical installations. It shall clarify the requirements set out in the existing standards and provide additional requirements.

This standard applies to all new electrical installations to be built and is mandatory for all Tata Steel business units at the IJmuiden site.

The requirements for grounding foundations will be included in a, to be manufactured, separate standard for foundation grounding.

Outside the scope of this standard are additional requirements for earthing of:

- installations with hazardous substances (e.g. PGS blades) for storage and piping systems
- environments to which the ATEX Directive applies

1.1 Normative reference

Application of the latest editions of relevant Dutch, European and international standards is mandatory. The following Dutch and international standards are of extra significance because they are inextricably linked to this standard.

- NEN 1010 Elektrische installaties voor laagspanning
- IEC 60364 Low-voltage electrical installations

1.2 Terms and definitions

Unless otherwise specified, the terms and definitions are used in accordance with the NEN 1010 standard

Additional names:

Main distribution	Distribution device that has at least one direct power supply of a transformer or generator.
Sub distribution	Distribution equipment that is supplied exclusively from other distribution equipment
Conductor	Conductor of copper, unless another material is indicated.

1.2.1 Code Power Supply Systems

The various power systems are indicated by two or more capital letters.
The **first** letter indicates whether an active part of the power source is connected to earth, namely:

T (Terre)	earthed directly
I (Isolé)	not earthed or earthed by high impedance

The **second** letter indicates how the metal frames are connected to earth, namely:

N (Neutre)	directly connected to the earth point of the power source by use of a protection line,

The **third** letter indicates how the Neutral and Protective Earth lines are constructed:

S (Separé)	Neutral (N) and Protective Earth (PE) are separated,
C (Combiné)	Neutral (N) and Protective Earth (PE) are combined in one conductor (PEN)

1.2.2 Definitions of protective measures

Main earth rail / main earth terminal
Earth rail or earth clamp which forms part of an earthing facility of an installation and which allows the electrical connection for earthing between several conductors.
(see NEN 1010 2.13.15)

Earth electrode
Conductive part that can lie in the ground or in a certain conductive medium, for example concrete or coke, and which is in electrical contact with the earth.
(see NEN 1010 2.13.05)

NEN 1010 542.2.1: For earth electrodes may be used:

- earth rods and earth pipes
- band-shaped and wire-shaped earth pipes
- earth plates
- foundation-built electrodes
- reinforcement rods of concrete structures in the ground

Earth wire
Conductor that creates a conductive path or part of a conductive path between a certain point in a system, an installation or equipment and an earth electrode or earth grid
(see NEN 1010 2.13.12).

Protective Earth (PE)
Conductor fitted for safety, for example for protection against electric shock.
(see NEN 1010 2.13.22)

PEN conductor
Conductor that has both the function of safety conductor (PE) and Neutral.
(see NEN 1010 2.13.25)

(Potential) bonding
Provision of electrical connections between conductive parts intended to achieve potential equality.
(see NEN 1010 2.13.19)

Protective bonding
Protective guidance for protective (equipotential) bonding (see NEN 1010 2.13.24)

2 POWER SYSTEMS AND VOLTAGES

2.1 Power Systems

2.1.1 T Permitted schemes

For distribution networks:

- TN-S systems

Special applications:

- IT systems

The application of the TN-C and TN-C-S systems is only permitted in the case of extensions to such existing systems and requires the agreement of involved Tata Steel Installation responsible person. The consent must be recorded in advance in writing.

2.1.2 Permitted voltages for power grids

- 400 V
- 500 V
- 690 V

The application of different voltages is only permitted with the agreement of the Tata Steel Installation responsible person. The consent must be recorded in advance in writing.

2.2 Embodiment of TN systems

2.2.1 TN-S system with one power source

(NEN1010 paragraph 312.2.1.1)

a) A direct connection to earth with a neutral point from a transformer or star point of a generator is not allowed.

b) The conductor, which must be connected from the star point of the transformer or generator to the N-rail of the main distribution, is insulated and must be of at least the same cross-section as the phase conductor.

c) The N-rail in the main distribution is designed separately and only connected to the PE rail at one point by means of a detachable connection.
The PE rail in the main distribution is connected in two places (preferably both ends) to the main earth rail of the building (see paragraph 4.1.2.a).

d) Additional earthing of the PE can be provided in the installation.
* Local earthing of metal frames for potential equalization.

e) Earthing of transformer housing according to paragraph 6.1.5, Figure 5: Principle scheme protection measures main distribution.

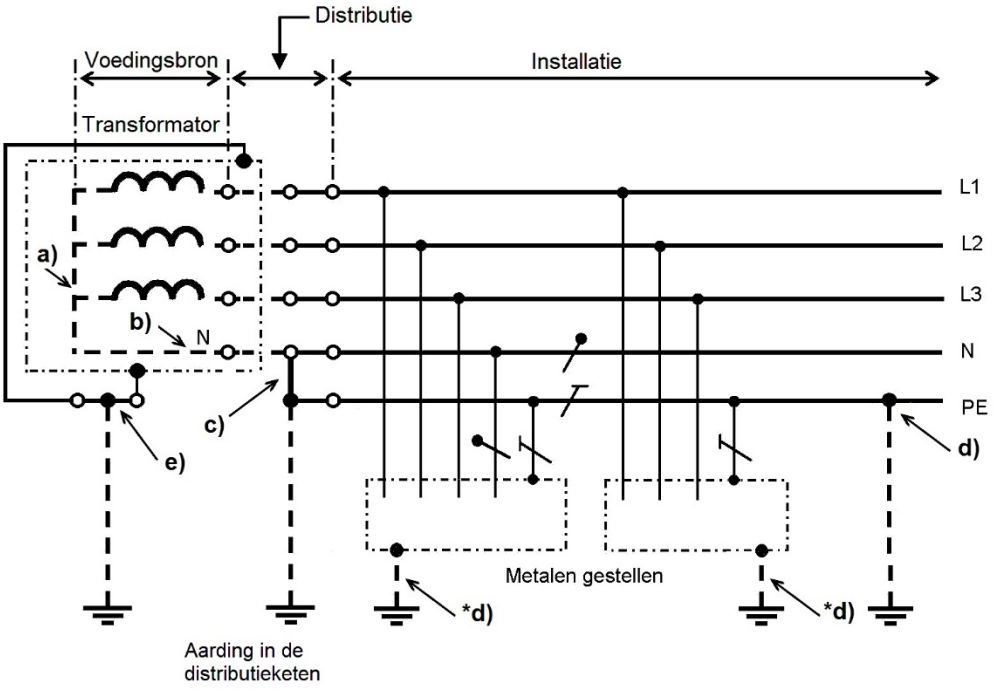


Figure derived from NEN1010 figure 31.8

2.2.2 TN-S system with multiple power sources

(NEN1010 paragraph 312.2.1.2)

a) A direct connection to earth with a neutral point from a transformer or star point of a generator is not allowed.

b) The conductor, connected to the star point of the transformers and/or generators, to the N-rail of the main distribution, is insulated and must be of at least the same cross-section as the phase conductor.

c) Only one (detachable) connection must be made between the interconnected neutral points of the power sources and the PE. This connection must be situated in the main distribution panel.
The PE rail in the main distribution is connected in two places (preferably both ends) to the main earth rail of the building (see paragraph 4.1.2.a).

d) Additional earthing of the PE can be provided in the installation.
* Local earthing of metal frames for potential equalization.

e) Earthing of transformer housing according to paragraph 6.1.5, Figure 5: Principle scheme protection measures main distribution.

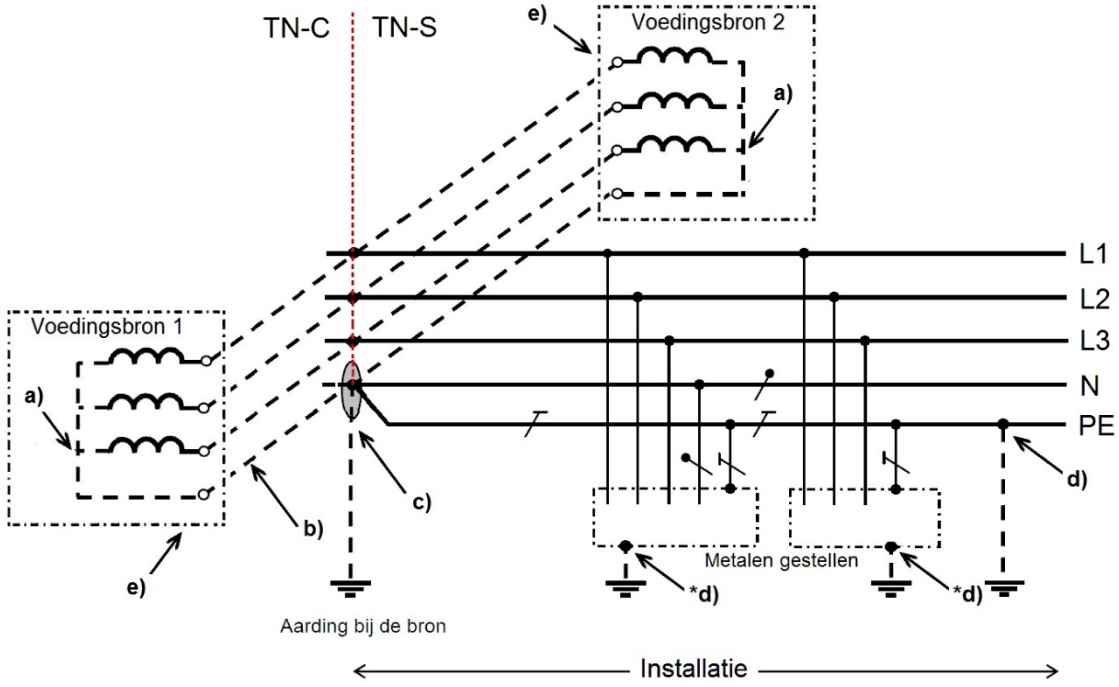


Figure derived from NEN1010 figure 31.11

2.2.3 IT system

(NEN1010 paragraph 312.2.3)

a) The possible star point of the power source is not connected to earth.

a) A possible available neutral line is insulated and/or is not implemented in the installation

b) Additional earthing of the PE can be provided in the installation.
* Local earthing of metal frames for potential equalization.

c) Earthing of transformer housing according to paragraph 6.1.5, Figure 5: Principle scheme protection measures main distribution.

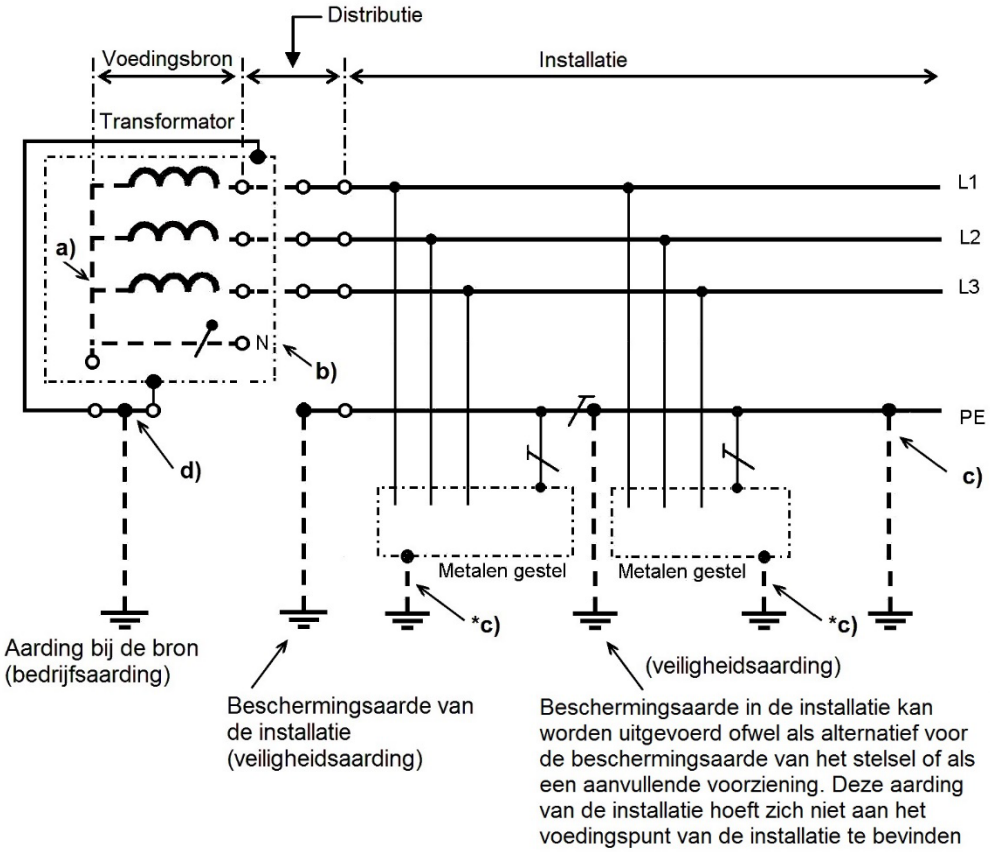


Figure derived from NEN1010 figure 31.14

2.2.4 TN-C-S system

(Only applicable to expansions on existing TN-C or TN-C-S systems)

a) A direct connection to earth with a neutral point from a transformer or star point of a generator is not allowed.

b) The conductor, which must be connected from the star point of the transformer or generator to the N-rail of the main distribution, is insulated and must be of at least the same cross-section as the phase conductor.

c) The star point of each powering transformer or generator is connected to Earth via the PEN rail of the corresponding main distribution. The PEN rail in the main distribution is connected to the main earth rail of the building at both ends (see section 4.1.2.a)

d) Additional earthing of the PE or PEN can be provided in the installation.
* Local earthing of metal frames for potential equalization.

e) Earthing of transformer housing according to paragraph 6.1.5, Figure 5: Principle scheme protection measures main distribution.

Note:
Multiple power sources operate as described in TN-S systems with multiple power sources.

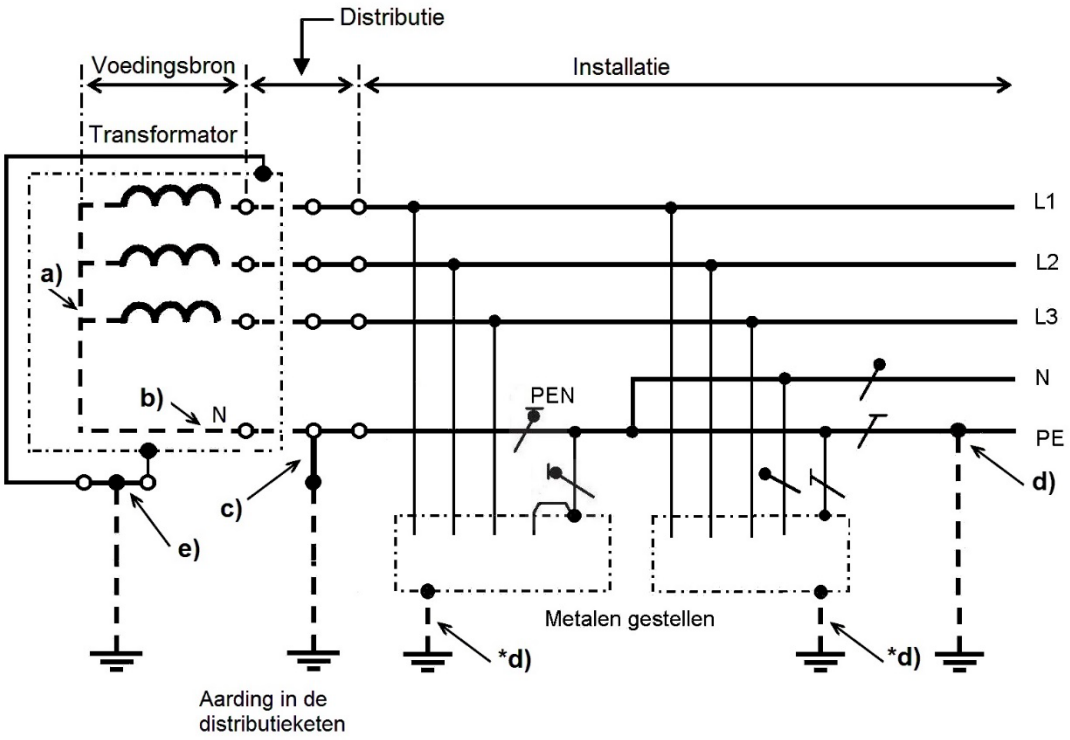


Figure derived from NEN1010 figure 31.9:
TN-C-S system, neutral and PE initially combined in a PEN conductor, is split into a PE and an N conductor elsewhere in the installation.

2.2.5 De-energize and switching in TN-C and TN-C-S systems

a) In TN-C and TN-C-S systems, the PE or PEN conductor may not be switched or separated.

b) Switching the N is only allowed in TN-S systems.

c) After separation, in separate PE and N conductors, the PE conductor must no longer be connected to the N conductor.

2.2.6 De-energize and switching in TN-S systems

In TN-S systems, the N must always be switched, both incoming and outgoing feeders.

3 EARTHING EQUIPMENT

3.1 Certification and additional requirements

3.1.1 Certification

Companies designing, supplying or installing earth facilities must be in possession of the BRL 1201 certification (Assessment Directive of the Stichting InstallQ)

3.1.2 Requirements earth electrodes

Earth electrodes must be in effective contact with the Earth, thus establishing an electrical connection.
For earth electrodes may be used:

- Earth bars (steel core with a copper sheath)
- *For earthing facilities poured into concrete foundations/structures, a separate document will be set up*

3.1.3 Requirements earth conductors

Earth conductors shall be constructed as a connection of copper with a diameter of 50 mm^2

3.2 Earthing equipment in concrete structures

For earthing facilities poured into concrete foundations/structures, a separate document will be set up.

4 PROTECTION MEASURES

4.1 Additional requirements for protective conductors

At Tata Steel IJmuiden, additional requirements have been imposed on the cross-section of protection conductors. These are prescribed in this chapter and are written in *italics.*

4.1.1 Main earth rail

In all electrical rooms a main earth rail made of copper of 25x5 mm must be installed.

The main earth rail must be installed as a ring, if several panels are placed along the different walls. Where possible preferably in the cable compartment or cellar of the electrical room. When installing panels along one wall of the room only, assemble the main earth rail along that wall.

a) *This main earth rail shall be coupled with an earth electrode in at least two places by means of a copper earth line with a diameter of 50 mm$^{2.}$ Earth dispersion resistance of earth electrode/earth plate < 0.5 ohms.*

b) *if the electrical premises are built on a concrete foundation, the main earth rail shall be connected to the concrete reinforcement by means of a copper earth line with a diameter of 50 mm^2* in at least two places by means of *an earth connection point. Earth dispersion resistance of earth electrode/earth plate < 0.5 ohms.*

c) *In the case of a building with a steel structure, the main earth rail shall be connected to this steel structure in at least two places by means of a copper equipotential conductor with a diameter of 25 mm^2.This also applies in other rooms. (see also 4.1.3.a)*

d) *In the case of transformer installation on concrete floors or in steel structures in factory halls, a main earth rail must be mounted at the transformer, which is connected to the concrete reinforcement or steel construction according to descriptions from 4.1.1.b or 4.1.1.c.*

4.1.2 Connection of PE-rails

All distribution switch boards, motor control centres, control panels and operator desks must be equipped with a PE rail.

The PE rail in a main distribution must, by use of a N conductor with same cross section as the supply phase conductor, be connected to the star point of the power source (see 2.2.1.b)

a) The PE rails of distribution switch boards and motor control centres shall be connected to the main earth rail (50kA/1s) of the room (preferably the ends)by use of two separate flat copper 25x5 mm protection conductors or insulated copper wire with a diameter of 95 mm2.

b) The PE rails of distribution panels and motor control centres shall be connected to the PE rail in the feeding distribution by means of a copper protection conductor with a cross-section in accordance with NEN 1010 Table 54.2.

c) The PE rails of control panels and operator desks must be connected to the main earth rail of the respective room by a separate protective conductor with a diameter of half of the protective conductor of the power supply, with a minimal cross section of at least 10 mm2 and maximum 25 mm2.

d) Metal enclosures or frames of prefabricated switch- and distribution panels may be used as protection conductor if:
- Interconnections are protected against damage and degradation, and
- the conductivity is sufficient according to NEN 1010 543.1, and
- an external protection conductor can be connected to each intersection point.

e) The metal enclosures of distribution panels and motor control centres must be inter-connected with a copper protective conductor with a cross section of 25 mm^2. At both ends this protective conductor must be connected to the available PE-rail in the E-room.

f) In the case of installations for powering cranes via towing lines (400V; 500V; 690 V), the PE conductor is connected to the installation at half the diameter of the phase.

4.1.3 Equipotential bonding conductors

Any foreign conductive parts shall be connected to the main earth rail in the room by means of equipotential bonding conductors. This includes metal pipes; metal parts of the building structure; concrete reinforcement if possible.

a) In each room, conductive parts shall be connected to the main earth rail of that area by means of a standard copper protective conductor with a cross section of half of the power supply protective conductor; minimal 6 mm^2 and maximum 25 mm^2.

4.1.4 Additional protective equipotential bonding conductors

Additional protective equipotential bonding shall be applied to simultaneously touchable metal frames of fixed material and any other conductive parts.

a) The metal frames of the appliances must be interconnected by means of an additional copper equipotential bonding conductor with a diameter of the smallest protective conductor of at least 6 mm^2 (see Figure 3).

b) The metal frames of appliances shall be connected to any other conductive parts by means of an additional copper equipotential bonding conductor with a cross section of half of the protective conductor, minimal 6 mm^2 and maximum 25 mm^2 (see Figure 4).

4.2 Requirements for transformers and motors

4.2.1 Transformers

a) *Metal frames of transformers, installed inside a building, must be connected to the main earth rail of the building as basic protective measure by use of two separate insulated copper conductors with a cross section of 95 mm^2*

4.2.2 Motors

a) In addition to the protective conductor of the supply cable, the motors must also be connected to the steel structure of the building by use of a separate copper equipotential bonding conductor with half the cross section of the protective conductor sized at least 6 mm^2 and maximum 25 mm^2

b) Where several motors can be touched simultaneously, the motors must be connected with an additional equipotential bonding conductor. This conductor is at least the smallest nominal cross-section of the protective conductor of the cable that is connected to the motors. (See also 4.1.4.a)

4.3 E- equipment in steel containers

4.3.1 Metal containers with switchboards- or distribution panels at construction sites

(Temporary) spaces on construction sites, such as metal containers with a switching or distribution panel, must additionally be earthed. A lower touch voltage applies to these rooms, (25 instead of 50 Volts) so that fuses/breakers must respond, i.e. 0.2 sec. instead of 0.4 sec.

a) Each distribution device must have a PE rail. This rail must be connected to the PE of the power supply by a copper protective conductor line in the power cable, with a cross-section according to Table 54.2.

b) The container (consider this to be a extraneous conductive parts) must be connected to the PE rail of distribution power supply by means of a basic potential bonding conductor made of copper with a cross-section of half the protective conductor of the power supply, minimum 6 mm^2 and maximum 25 mm^2.

c) The container must be connected by means of a basic bonding conductor made of copper with a cross-section of at least 25 mm^2, to a steel construction in the vicinity of the container.

d) If there is no steel structure in the vicinity of the container, the earthing must be carried out by means of earth conductor connected to an earth electrode.

e) A main earth busbar must be installed in every room with switching and distribution equipment (and/or other fixed electrical equipment). This main earth rail must be a separately laid protective conductor with a cross-section of half the protective conductor of the power supply, minimum 6 mm^2 and maximum 25 mm^2, to be connected to the PE rail of the distribution system.

4.3.2 Metal containers as prefab E-room in industrial installations

Consider metal containers with a main distribution and / or a sub-distribution, control panel, cabinet or operator desk as an E-room.

a) The container (consider this as a extraneous conductive part) must be connected to the main earth busbar in the container by means of a basic equipotential bonding conductor made of copper with a cross-section of half of the protective conductor of the power supply, minimum 6mm^2 and maximum 25mm^2.

b) The container must be connected on both sides by means of two additional copper bonding conductors with a cross-section of 95 mm^2 to a steel structure in the vicinity of the container

4.4 Requirements for storage tanks and piping systems

In general, the requirements for earthing and/or equipotential bonding of storage tanks and piping systems are comparable to the measures already mentioned for extraneous conductive parts.

However, depending on the medium in question to be stored or transported, or the environment in which they are installed, additional requirements apply.

a) For volatile or flammable liquids or for non-conductive liquids or gases, additional requirements are defined in so-called PGS sheets (Publicatiereeks Gevaarlijke Stoffen)
b) In situations or installations where the ATEX Directive applies, additional equipotential bonding or earthing measures may be necessary.

5 MEASUREMENTS AND REPORTING

Commissioning inspection to be carried out in accordance with NEN1010 Part 6

5.1 Implementation

All protection and earth conductors, as well as basic and additional potential bonding conductors, shall be tested for continuousness and the results shall be recorded

6 ATTACHMENTS

6.1.1 Figure 1: Maximum Switch off times

Maximum switch off times

Stelsel	50 V < U_0 ≤ 120 V s		120 V < U_0 ≤ 230 V s		230 V < U_0 ≤ 400 V s		U_0 > 400V s	
	Wissel-spanning	Gelijk-spanning	Wissel-spanning	Gelijk-spanning	Wissel-spanning	Gelijk-spanning	Wissel-spanning	Gelijk-spanning
TN	0,8	[a]	0,4	5	0,2	0,4	0,1	0,1
TT	0,3	[a]	0,2	0,4	0,07	0,2	0,04	0,1

Indien de uitschakeling in TT-stelsels door een beveiligingstoestel tegen overstroom plaatsvindt en de beschermende vereffening is verbonden met alle vreemde geleidende delen binnen de installatie, mogen de maximale uitschakeltijden worden toegepast die gelden voor TN-stelsels.

U_0 is de nominale spanning ten opzichte van aarde.

[a] Uitschakeling kan ook om andere redenen zijn vereist dan vanwege bescherming tegen elektrische schok.

OPMERKING Indien uitschakeling door een toestel voor aardlekbeveiliging plaatsvindt, wordt verwezen naar de toelichting bij 411.4.4, bij 411.5.3 en bij 411.6.4 b).

(NEN1010 Table 41.1)

6.1.2 Figure 2: Minimum core cross-section of protection conductors

Minimum core cross-section of protection lines (if not calculated according to 543.1.2)

Kerndoorsnede van faseleiding ***S*** mm² koper	**Minimale kerndoorsnede van de beschermingsleiding** mm² koper	
	Indien de beschermingsleiding van hetzelfde materiaal is als de faseleiding	**Indien de beschermingsleiding niet van hetzelfde materiaal is als de faseleiding**
$S \leq 16$	S	$\frac{k_1}{k_2} \times S$
$16 < S \leq 35$	16 [a]	$\frac{k_1}{k_2} \times 16$
$S > 35$	$\frac{S}{2}$ [a]	$\frac{k_1}{k_2} \times \frac{S}{2}$

waarin:

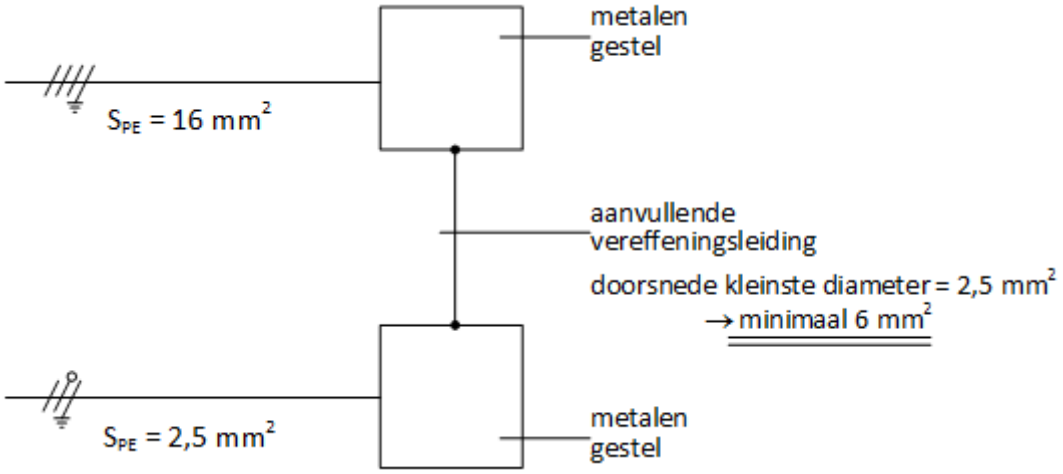
k_1 is de waarde van k voor de faseleiding, bepaald aan de hand van de formule in bijlage 54.A of geselecteerd uit de tabellen in hoofdstuk 43, overeenkomstig het materiaal van geleider en isolatie;

k_2 is de waarde van k voor de beschermingsleiding, gekozen aan de hand van de tabellen 54.A.2 t.m. 54.A.6, zoals van toepassing.

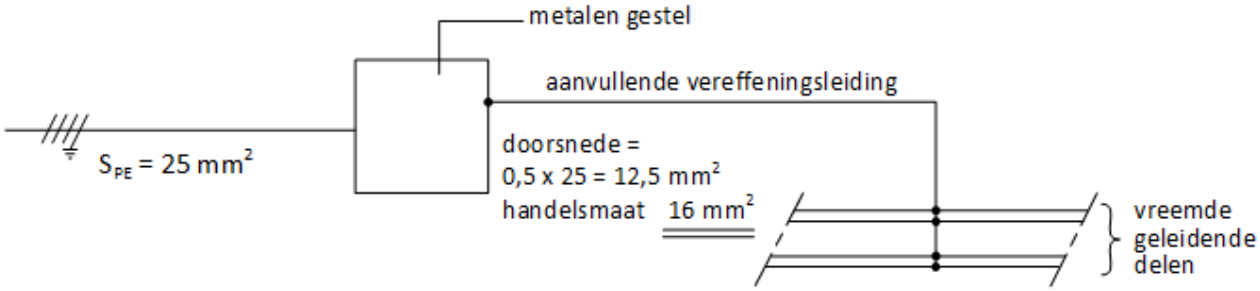
[a] Voor een PEN-leiding mag de kerndoorsnede alleen worden verminderd overeenkomstig de voorschriften inzake de kerndoorsnede van de nul (zie hoofdstuk 52).

(NEN1010 Table 54.2)

6.1.3 Figure 3: Equipotential bonding

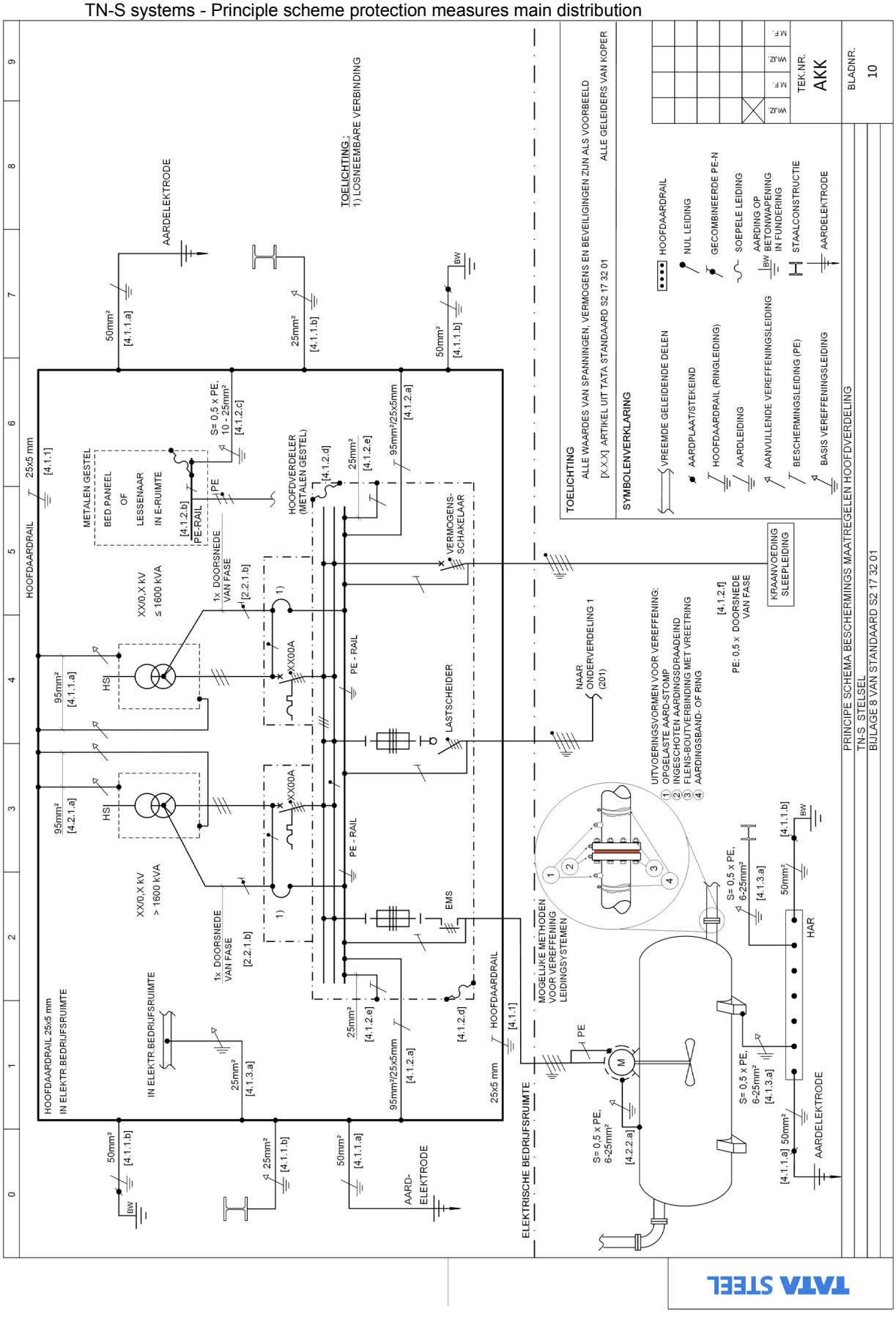


6.1.4 Figure 4: Additional potential bonding



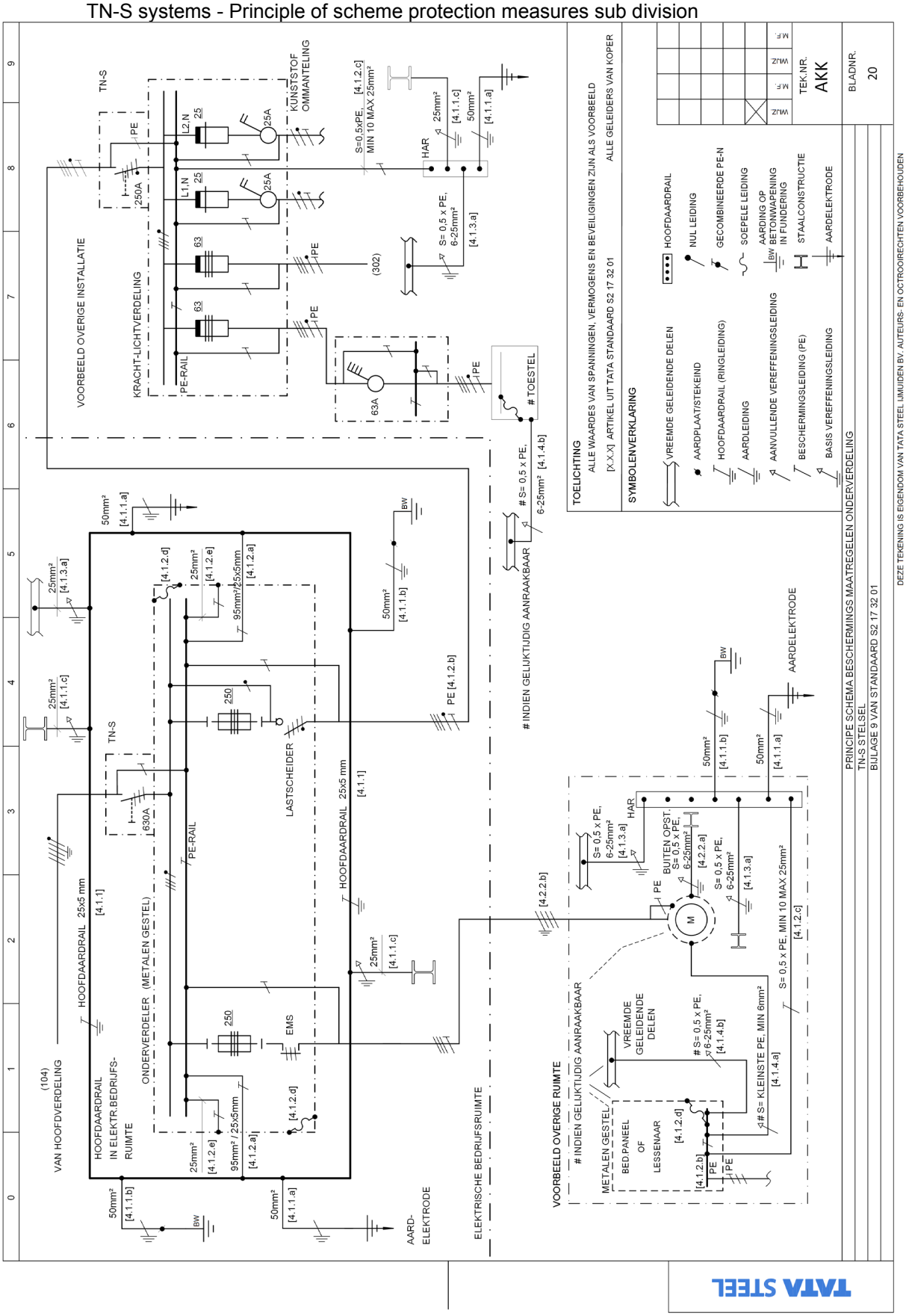
6.1.5 Figure 5: Principle scheme of protection measures main distribution (TN)

TN-S systems - Principle scheme protection measures main distribution



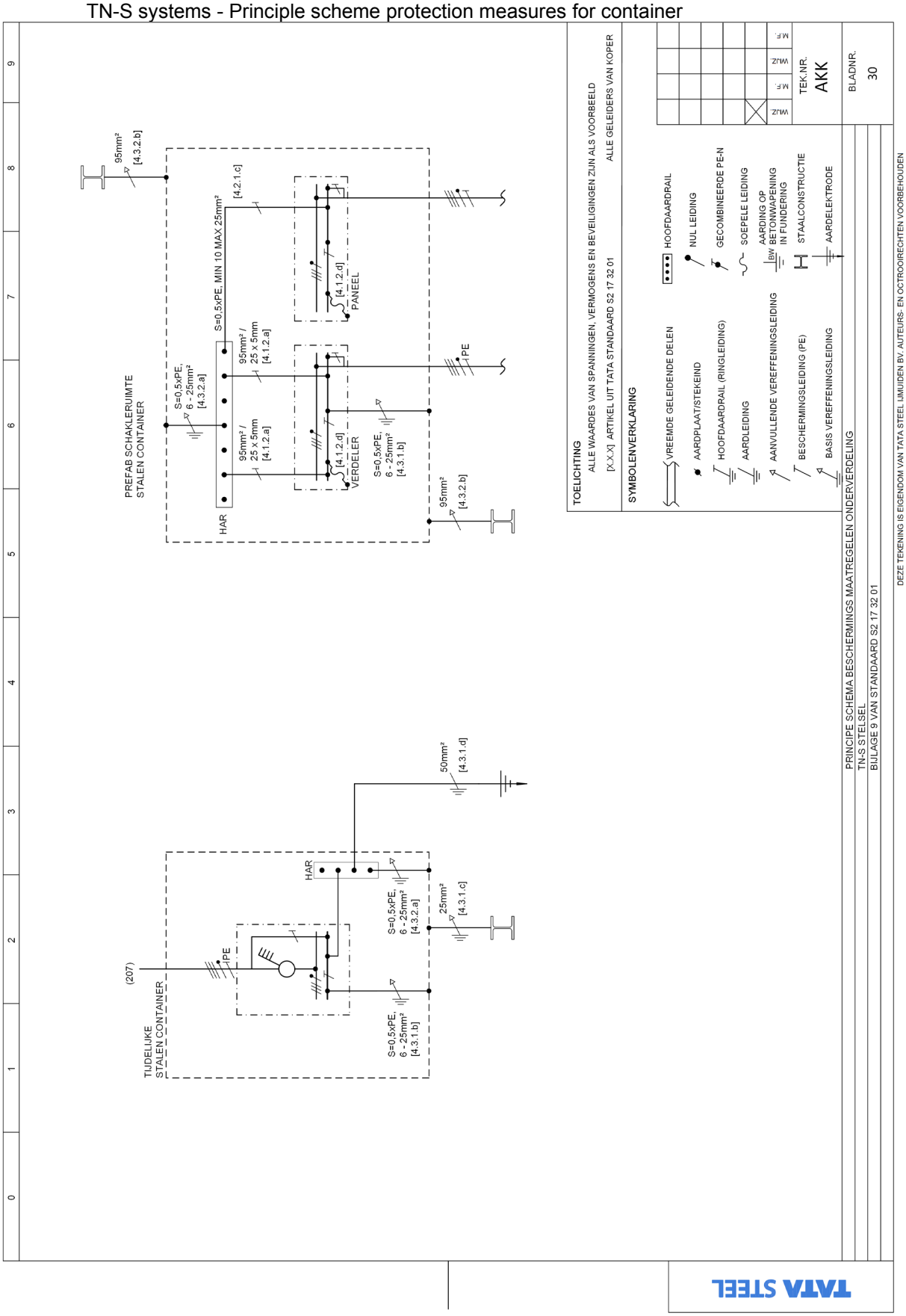
6.1.6 Figure 6: Principle scheme of protection measures sub division (TN)

TN-S systems - Principle of scheme protection measures sub division



6.1.7 Figure 7: Principle scheme of protection measures for container (TN)

TN-S systems - Principle scheme protection measures for container



6.1.8 Figure 8: Principle scheme of protection measures main distribution (IT)

IT systems - Principle scheme of protection measures main distribution