Installation instruction

High voltage switchgear
Recommendations for customer-provided earthing

Document owner	First issued	Written by	Updated by	Approved by
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CUSTOMER SUPPORT

In the event of technical or operational problems, please do not hesitate to contact our service department at any time.

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CONTENTS

APPLICABLE DOCUMENTS

- The documents listed in the table are integral parts of this procedure.

Document number	Designation
NT0171	Standard – tightening torques
H47 021 030	Safety practices for work on GIS equipment
H47 020 034	Cleaning procedure
H47 020 XXX	Lubrication instructions
H47 020 156	Lifting various GIS components

GENERAL

About these instructions

- These instructions allow the device to be used safely and efficiently. These instructions are part of the device and must be kept in the immediate vicinity of the device and accessible to personnel at all times. Personnel must carefully read and understand these instructions before beginning any work. Compliance with all safety notices and procedural information in these instructions is an essential requirement for safety on the job.
  Furthermore, local accident prevention codes and general safety provisions in effect at the equipment location must be respected. Illustrations in these instructions are provided for basic comprehension and may differ from the actual execution of the equipment.

Copyright

- These instructions are protected by copyright and are intended exclusively for the operator. Release of these instructions to third parties, reproduction in any manner and form – including that of excerpts – and exploitation and/or communication of the contents are not allowed without the written permission of the manufacturer, except for internal purposes. Violations will entail legal action. Further rights are reserved.

Limitation of liability

- All information and statements in these instructions have been prepared under consideration of applicable standards and procedures, the state of the art and our many years of knowledge and experience.

- The manufacturer accepts no liability for damage incurred due to:
  - Failure to comply with these instructions
  - Improper use
  - Deployment of untrained personnel
  - Unauthorised modifications
  - Use of non-approved spare parts

- The actual scope of delivery may differ from the statements and representations made herein due to additional options ordered or recent technical changes. The obligations agreed in the supply contract, the general terms and conditions of business, the manufacturer's conditions of supply and the legal regulations in effect as of the time of contract finalisation shall apply. We reserve the right to make technical changes to improve service characteristics and in the interest of further development at any time. GE does not actively inform about changes to the devices or adjustments to the document.

- Warranty provisions are contained in the manufacturer's general terms and conditions of business.

SYMBOLS

Explanation of symbols

DANGER!

Indicates an imminent hazard due to electrical current which can result in death or serious injury if not avoided.

DANGER!

Indicates an imminent hazard which can result in death or serious injury if not avoided.

WARNING!

Indicates a potentially hazardous situation which can result in death or serious injury if not avoided.

CAUTION!

Indicates a potentially hazardous situation which can result in minor or slight injury if not avoided.

ATTENTION!

Indicates a potentially hazardous situation which can result in property damage if not avoided.

INFORMATION!

Provides useful tips and recommendations as well as information for efficient, trouble-free operation

SAFETY GUIDELINES

- This section surveys all key aspects of safety for optimal personnel protection and safe, trouble-free operation.
- Failure to comply with procedures and safety notices set forth in these instructions can result in serious hazards to personnel and material.

Product safety

WARNING!

To ensure product safety, the product must be handled as described in the instructions.

Personnel safety

INFORMATION!

Procedure H47021030, "Safety rules for working on GIS equipment", is an integral part of this procedure.
Personnel must carefully read and understand these instructions before beginning any work.
Compliance with all safety notices and procedural information in these instructions is an essential requirement for safety on the job.

Unauthorized access

WARNING!

Hazard to unauthorised persons!
Unauthorised persons not meeting the requirements set forth here will not be aware of hazards in the working area.
Therefore:
- **Keep unauthorised persons away from the working area.**
- **In case of doubt, speak to persons and direct them away from the working area.**
- **Suspend work whenever unauthorised persons are present in the working area.**

Environment

NOTE APPLICABLE TO SUBSTATION!

Contains fluorinated greenhouse gases listed in the Kyoto Protocol.

PERSONNEL

Technical personnel

- The term "technical personnel" denotes persons whose technical training, knowledge and experience, together with their knowledge of relevant regulations, enable them to assess work assigned to them and recognise potential hazards.
- Personnel may be assigned to work on and with the product only if they can be expected to perform their work in a reliable manner. Working methods that impair the safety of persons, the environment or the product shall be avoided.

Training

WARNING!

Danger of injury or damage if work is performed by underqualified personnel

Improper methods can result in serious personal injury and damage.

All activities must be performed only by personnel qualified to carry them out.

Safety rules

INFORMATION!

Before starting assembly work, note and comply with all safety practices found in procedure H47 021 030, "Safety rules for working on GIS equipment".

Hazards

INFORMATION!

- **Always be prepared for accidents and fires.**
- **Keep first aid supplies (first aid kits, blankets, etc.) on hand.**
- **Familiarise personnel with accident reporting, first aid and rescue equipment.**
- **Always keep access routes clear for rescue vehicles.**
- **For accident response instructions, see "First aid practices".**

TECHNICAL DATA

GIS	Type	All types of switchgear

STANDARDS, REGULATIONS

Design	• GIS equipment and components supplied by GE are designed, tested and built in compliance with IEC 62271-1, -203, -100, -102, etc.
Environment	• GE follows procedures set forth in ISO 14001.

IMPORTANT NOTES

- These recommendations are suggestions for execution based on many years' experience in the construction of GIS switchgear. Responsibility for design and implementation of the customer-provided earthing system rests with the customer unless an agreement to the contrary exists.
- The design of the earthing system must take account of fast transients (design of a high frequency (HF) earthing network) occurring upon switching operations of the GIS switchgear; that is, it must also be suitable for high-frequency disturbances.
- The standards DIN/VDE 0101:2000 or IEEE Std 80-2000 shall be considered when determining the design current-carrying capacity of the 50/60 Hz earthing system.

GIS EARTHING SYSTEM - DIMENSIONING

Design of earth conductors

- The design of the earth conductors has to comply with the standard IEEE Std 80-2000 or DIN/VDE 0101:2000. Generally the three-phase initial AC short-circuit current is selected for design criterion as the most severe requirement.

DIN/VDE 0101:2000

- Minimum conductor cross sections $A_{Emin.}$ versus short-circuit current and duration (allowable conductor temperature T_e = 300 °C, ambient temperature T_a = 40 °C):

Material	Min. cross section $A_{Emin.}$ [mm²]									
	25 kA		31.5 kA		40 kA		50 kA		63 kA	
	1s	3s	1s	3s	1s	3s	1s	3s	1s	3s
Copper[1)]	136	235	171	296	217	376	271	469	341	591
Aluminium	205	355	258	448	328	568	410	711	517	895

[1)] uncoated or tin-coated

IEEE Std 80-2000

- Minimum conductor cross sections $A_{Emin.}$ versus short-circuit current and duration (allowable conductor temperature T_e = 300 °C, ambient temperature T_a = 40 °C):

Material	Min. cross section $A_{Emin.}$ [mm²]									
	25 kA		31.5 kA		40 kA		50 kA		63 kA	
	1s	3s	1s	3s	1s	3s	1s	3s	1s	3s
Copper[1)]	136	236	171	297	218	377	272	471	343	594
Aluminium[2)]	205	353	257	445	326	565	407	706	513	889

[1)] annealed soft-drawn [2)] EC grade

Remarks

- Values stated are minimum cross-sections. For the calculations, the material characteristics defined by the relevant standard have been used. The calculated $A_{Emin.}$ values according to DIN/VDE 0101:2000 and IEEE Std 80-2000 are practically the same.

  For earth connections incorporated to the GIS by GE the material characteristics are defined by the manufacturer material standards. The selected conductor cross sections cover both IEEE Std 80-2000 and DIN/VDE 0101:2000.

- In practice, up to the indicated earthing points of the switchgear, GE uses standardized cross-sections based on the greatest possible short-circuit currents and durations with multiple earthing of the installation.
  See “Recommendations for earthing and shielding of primary switchgear” for each type of GIS.

Conductor material

- The use of copper (uncoated or tin-coated) or aluminium as conductor material is recommended. Because of the inferior behaviour at higher frequencies, galvanized steel should not be applied.

EARTHING SYSTEM DESIGN

50/60Hz and HF earthing network

- The 50/60 Hz earthing network is designed to carry the fault current; it is made of copper or aluminium.
- The HF earthing network is made of steel and is so less conductive than the 50/60 Hz earthing network. Therefore, the majority of the fault current circulates inside the less resistive path, i.e. the 50/60 Hz earthing network. Consequently the HF network does not need to be designed to support the fault current.

Standard design

- Steel reinforcing meshes are integrated in the concrete of the switchgear floor and fashioned as a high-frequency earthing network, connected, along with the steel rebars in the concrete, to the 50/60 Hz earthing network. The 50/60 Hz earthing network is mounted at the ceiling of the underground distribution chamber below the GIS.
- In case the structural reinforcement is made of steel, it has to be connected on at least 4 corners of the 50/60 Hz earthing network to avoid floating potential.

Alternative design

- If the structural steel reinforcing cannot be used for earthing purposes and no additional steel meshes can be integrated in the floor (for example in existing buildings), a densified copper or aluminium earthing system has to be constructed under the switchgear floor and used as the 50/60 Hz and HF earthing network.

GIS EARTHING SYSTEM - STANDARD DESIGN

Construction of 50/60 Hz earthing network (see Fig. 1)

- The earthing network is built from copper or aluminium conductors (flat conductors).
- An earthing ring bus a) is generally laid around the high voltage switchgear or switchgear room. The ring bus is connected to building earth at not fewer than four corner points ⑥. Earth conductors b) are laid longitudinally and earth conductors c) transversely under the switchgear and connected to a) and b) respectively. Access should be provided for making additional connections at points identified by the symbol . For example:
  - ① Circuit breakers of each bay
  - ② Cable sheaths at outgoing feeders or cable end box of GIS in case of isolated cable sheath
  - ③ Base point of outdoor bushing in case of overhead outgoing feeder, connected by the shortest possible route to the connection point of the circuit breaker
  - ④ Transformer box if integrally installed
  - ⑤ Control cubicle of each bay
  - ⑥ Building earth
  - ⑦ Metal plate at wall transit for outdoor bushing
- The 50/60 Hz earthing network serves as the connection for all equipment and devices where an earth-fault current fed from the high-voltage side can occur. It is mounted to the concrete ceiling of the underground distribution chamber (see Fig. 2). A connection to the steel reinforcing meshes in the switchgear floor (HF earthing system) is to be made in the region of points identified by the symbol . Adequate holes are to be provided in the floor (see Fig. 1). Spare bays for future expansion must be taken into account in the first expansion phase, including their earth connection points.

Recommended cross sections

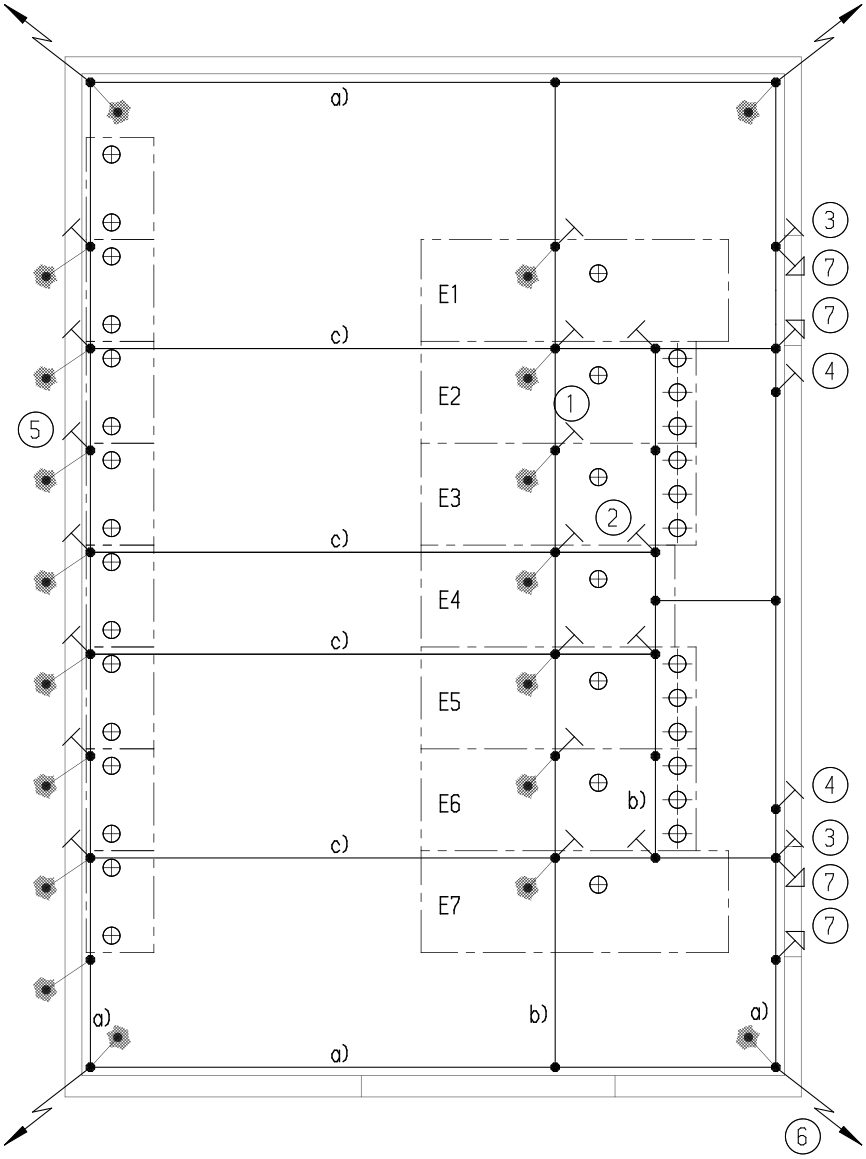
- Conductors a), b) and c): the total fault current is distributed in the grid; thus, each conductor segment in the grid is only subjected to some fraction of the total fault current; 0.5 A_{Emin} may be used as the minimal cross section of the 50/60 Hz earthing network provided that the GIS is earthed at multiple points.

Construction of HF earthing network: (see Fig. 1, 2 and 3)

- Switching operations, flashovers and lightning overvoltages in the high voltage substation cause high-frequency disturbances which may be induced to the earthing system. In order to minimize the impedance of the earthing system and to provide a large-area equipotential surface, a close-meshed earthing system is needed (see Fig. 2 and 3). For this purpose, the structural reinforcement when it includes steel reinforcing meshes (3), conductor diameter approx. 5 mm, max. clear opening 200 mm x 200 mm, is used as the HF earthing network (3). The wires are welded to form an electrically conductive network (3a).
- For full effectiveness, the HF earthing network is conductively connected to the 50/60 Hz earthing network by suitable coupling pins (4) at the points identified by the symbol (Fig.1).
- In case the structural reinforcement is made of steel (Fig. 1) it has to be connected on at least 4 corners to the 50/60 Hz earthing network to avoid floating potential.

GIS EARTHING SYSTEM - STANDARD DESIGN
Earthing plan

Fig. 1



E1	Overhead line bay	E5	Cable bay
E2	Cable bay (transformer)	E6	Cable bay (transformer)
E3	Cable bay	E7	Overhead line bay
E4	Coupler bay		

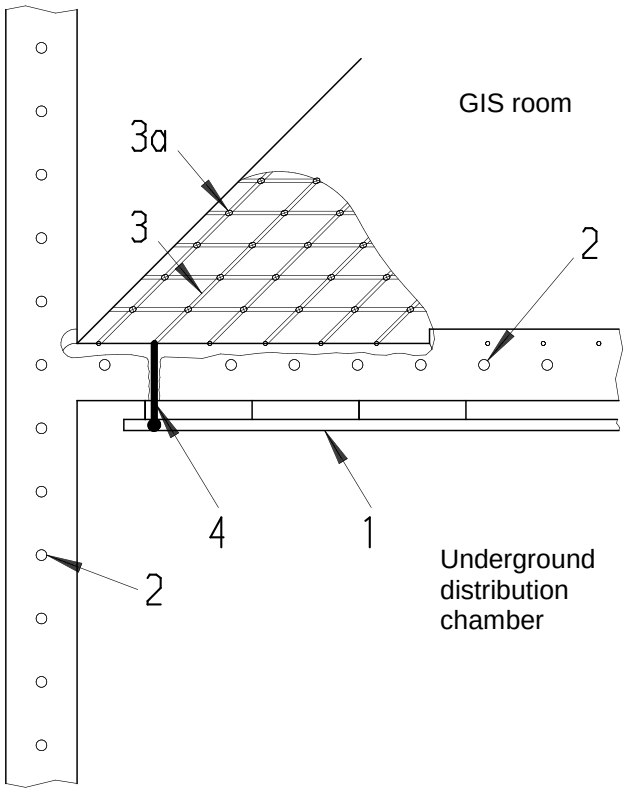
Connections to steel reinforcing meshes (HF earthing system)

Access for connections

⊕ Holes in floor to connect the circuit breakers/control cubicals/cable sheaths to the earthing system

GIS EARTHING SYSTEM – STANDARD DESIGN
Details, system structure with metal structural reinforcement

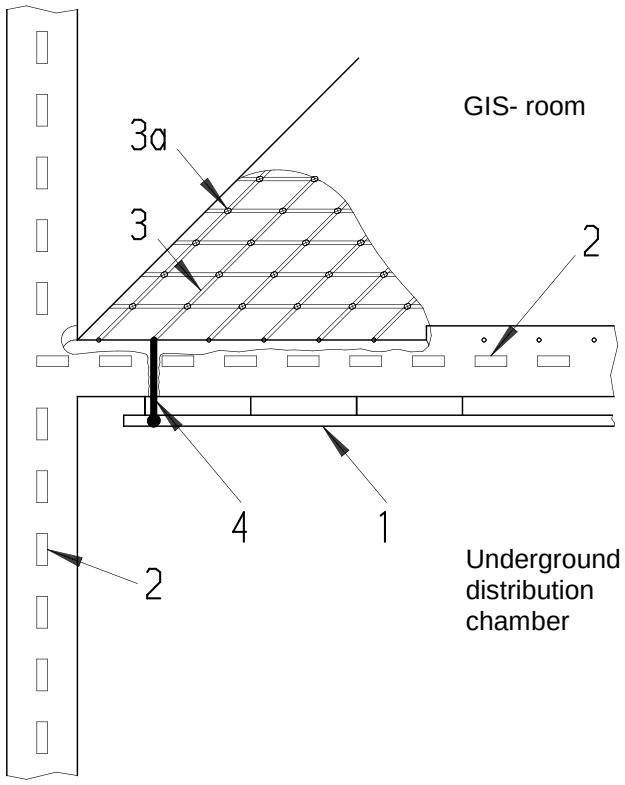
Fig. 2



1	50/60 Hz copper or aluminium earthing network (bolted)
2	Structural steel reinforcement (conducting)
3	HF earthing network (steel reinforcing meshes)
3a	Rods welded at cross points
4	Connection of 50/60 Hz copper network (bolted) to HF earthing network (welded)

GIS EARTHING SYSTEM – STANDARD DESIGN
Details, system structure <u>without</u> metal structural reinforcement

Fig. 3



1	50/60 Hz copper or aluminium earthing network (bolted)
2	Structural non-conductive reinforcement
3	HF earthing network (steel reinforcing meshes)
3a	Rods welded at cross points
4	Connection of 50/60 Hz copper network (bolted) to HF earthing network (welded)

GIS EARTHING SYSTEM – ALTERNATIVE DESIGN

(densified copper or aluminium earthing network mounted under the GIS floor)

Construction of earthing network (see Fig. 4)

- A grid-type earthing network of small mesh size is constructed. Between circuit breaker and control cubicle the mash size must not not be larger than 2m x 2m.
- Copper is the preferred conductor material, flat wires conduct better than round wires. Where the conductors cross, they should be soldered or otherwise connected in an equivalent manner suitable for junctions subject to high-frequency currents.
- The outer earthing ring bus a) is connected to building ground at least four corner points ⑥ (see Fig. 4). Access should be provided for additional connections at points identified by the symbol ⊥ for:

  ① Circuit breakers of each bay
  ② Cable sheaths at outgoing feeders, cable end box of GIS in case of isolated cable sheath
  ③ Base point of outdoor bushing in case of overhead outgoing feeder, connected by the shortest possible route to the connection point of the circuit breaker
  ④ Transformer box if integrally installed
  ⑤ Control panels, each bay
  ⑥ Building earth
  ⑦ Metal plate at wall transit for outdoor bushing
  ⑧ Structural steel reinforcement in floor if metallic (potential equalization)

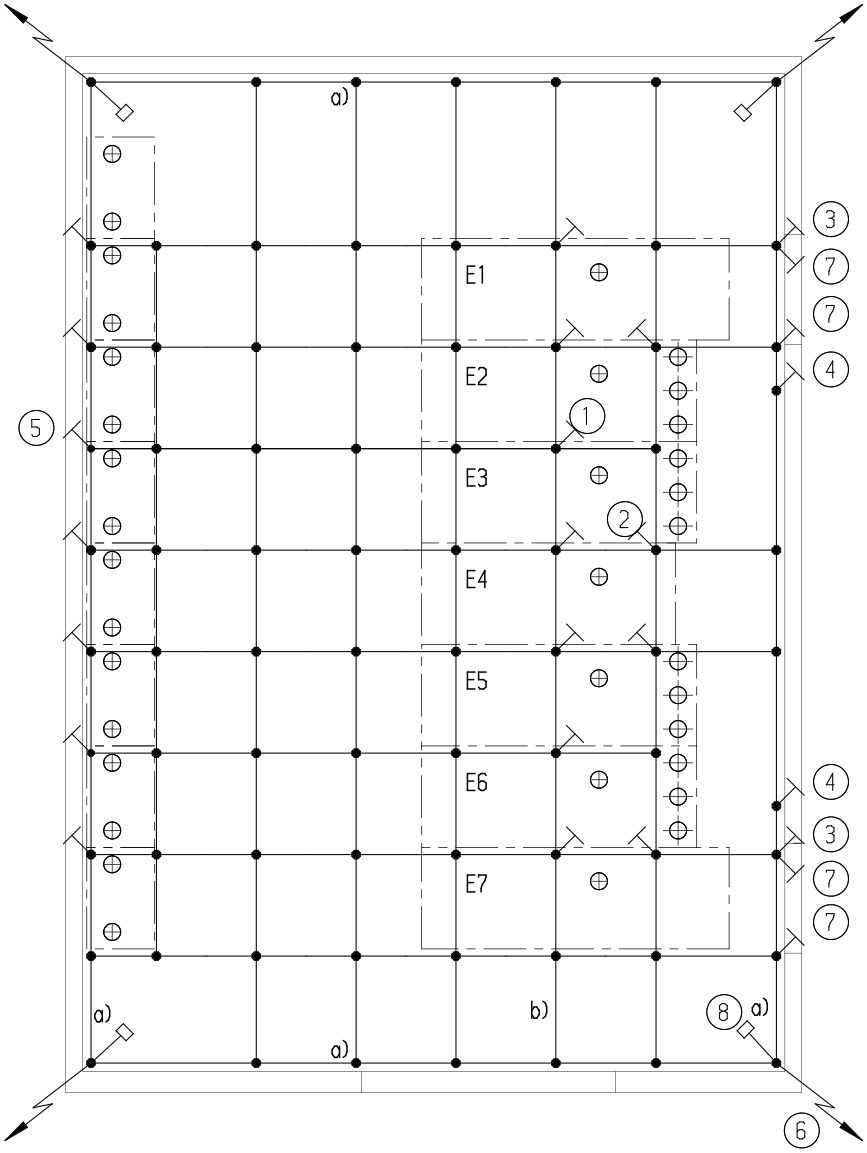
- As a rule, the grid earthing network is emplaced under the GIS floor. Adequate holes should be provided in the floor (see Fig. 4). When a structural steel reinforcement exists in the concrete GIS floor, care should be taken that it is conductively connected to the copper earthing system at multiple points (step and touch voltage problem). If this is not possible, the floors rebar floats, which may contribute to unduly high touch voltages on the GIS. If this is the case, the earthing network should be installed over the floor rebar or the GIS floor should have an insulating covering.
- Cable ducts to local control cubicles installed separately from the GIS should be laid under the earthing network if possible.
- This alternative design should be regarded as a minimum form of an earthing system for switchgear. It should be used only for existing station buildings where if is not possible to incorporate the structural reinforcement or to add additional steel meshes.
- Reducing the mesh size of the grid helps to reduce high frequency disturbances and reduces the also the touch and step voltages.

Recommended cross sections

- Conductors a) and b): the total fault current is distributed by the grid; thus, each conductor segment in the grid is only subjected to some fraction of the total fault current; 0.5 A_{Emin} may be used as the minimal cross section of the 50/60 Hz earthing network provided that the GIS is earthed at multiple points.

GIS EARTHING SYSTEM – ALTERNATIVE DESIGN
Earthing plan

Fig. 4



E1	Overhead line bay	E5	Cable bay
E2	Cable bay (transformer)	E6	Cable bay (transformer)
E3	Cable bay	E7	Overhead line bay
E4	Coupler bay		

Access for connections

⊕ Holes in floor to connect the circuit breakers/control cubicles/cable sheaths to the earthing system

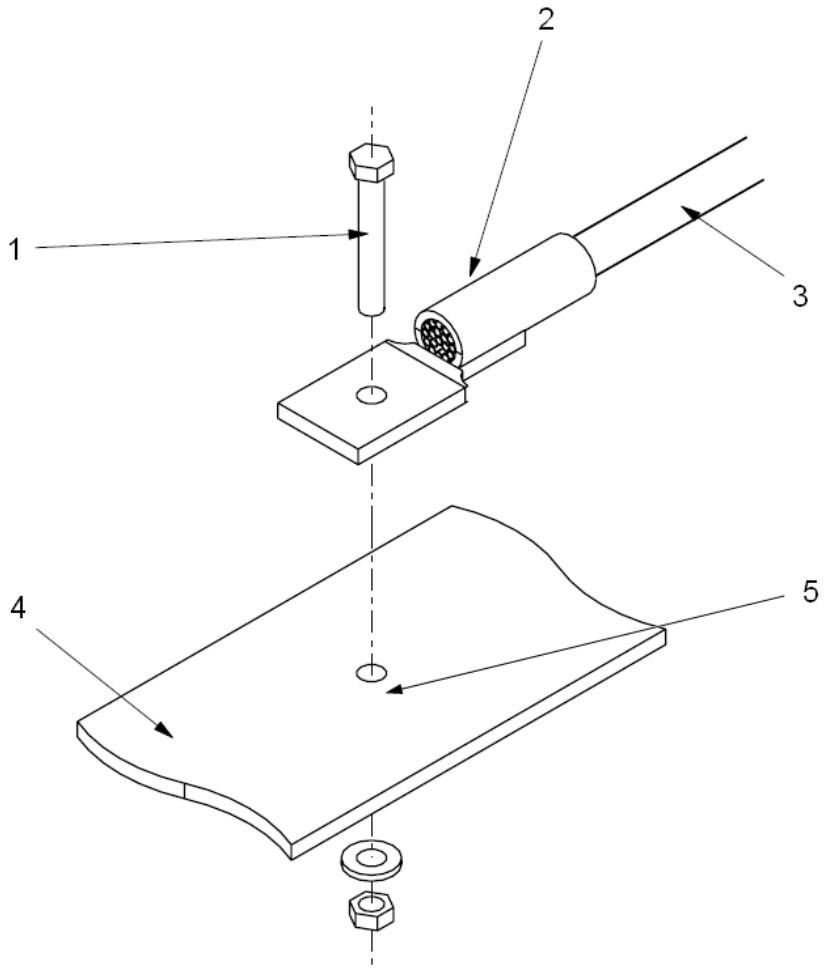
Connection to structural steel reinforcement if metallic

GIS EARTHING CONNECTIONS

Earthing terminals on GIS switchgear	• See Recommendations for “Earthing and shielding of switchgear: primary switchgear” for each type of GIS.
Connections to switchgear (not supplied by GIS manufacturer)	• See Recommendations for “Earthing and shielding of switchgear: primary switchgear” for each type of GIS. • Shape: preferably flat copper, min. width 40 mm. • Connections to switchgear as short as possible. • Points of contact: remove paint, clean surface, and coat surface with L2-62 contact grease (see lubrication instructions). • Use at least M12 bolts for connections. • Customer requirements: take account of customer requirements as to cross section, material, number, and arrangement of bolts. • If customer requirements deviate, get SEH (TAH-SEH) or BHT agreement to earthing design ratings.
Handling of connections to switchgear	• Aluminium-Aluminium connections (see Fig. 5) • Aluminium-Copper and Copper-Copper connections (see Fig. 6) • Copper-Steel connections (see Fig. 7) • Copper-Aluminium and Copper-Steel for structure earthing (see Fig. 8)

HANDLING OF ALUMINIUM-ALUMINIUM CONNECTIONS

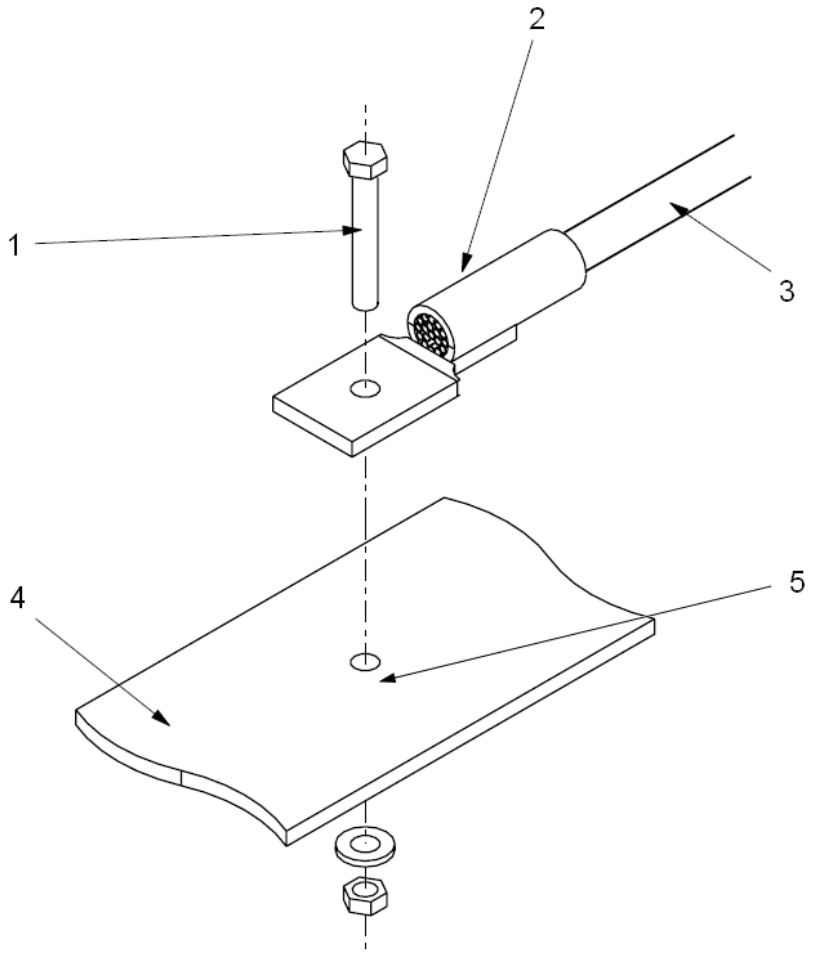
Fig. 5a



1	Stainless steel bolt
2	Straight terminal connector
3	Insulated copper conductor, flat or stranded
4	Aluminium plate
5	Points of contact: remove paint, clean surface, and coat surface with L2-62 contact grease (see lubrication instructions).

HANDLING OF ALUMINIUM-COPPER AND COPPER-COPPER CONNECTIONS

Fig. 6a



1 Stainless steel bolt

2 Straight terminal connector

3 Insulated copper conductor, flat or stranded

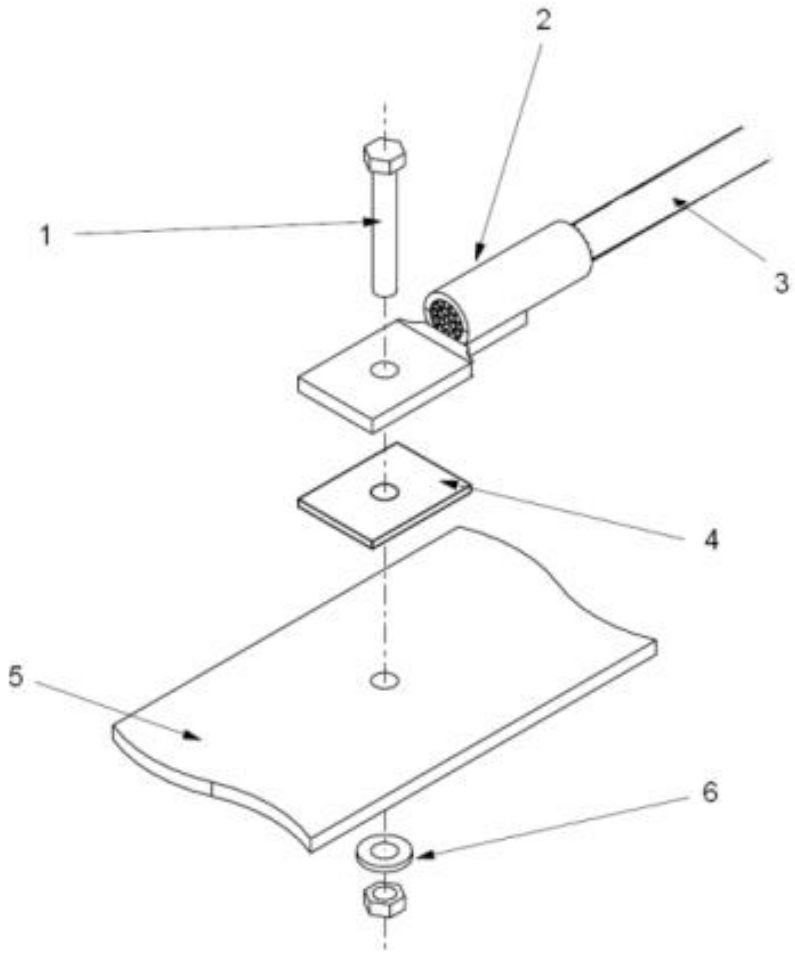
4 Aluminium or copper plate

5 For Copper-Copper connection, surface of contact must be tin-coated.

For Aluminium-Copper points of contact: remove paint, clean surface, and coat surface with L2-62 contact grease (see lubrication instructions).

HANDLING OF COPPER-STEEL CONNECTIONS

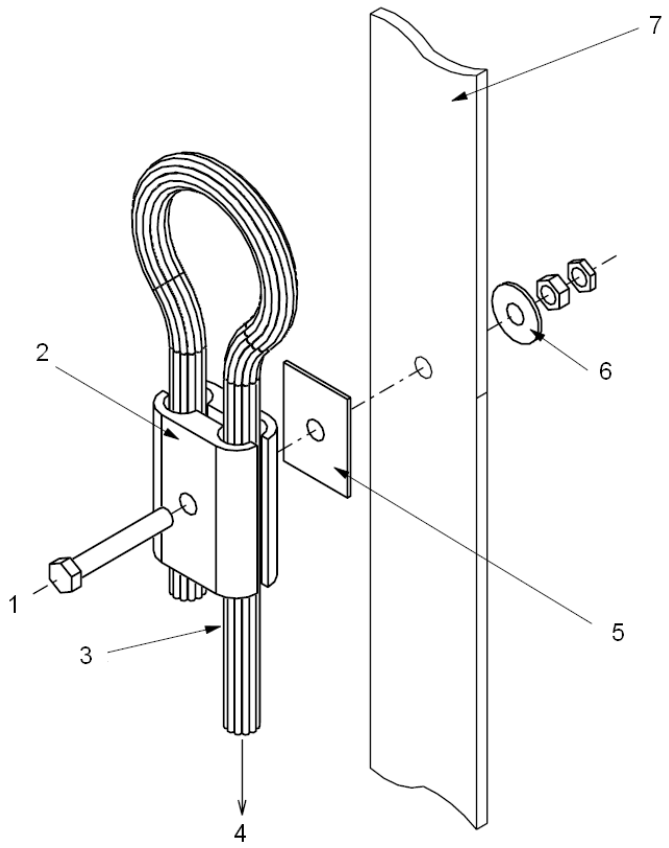
Fig. 7a



1	Stainless steel bolt
2	Straight terminal connector
3	Insulated copper conductor, flat or stranded
4	Bimetallic plate
5	Steel plate
6	Bimetallic washer

HANDLING OF COPPER-ALUMINIUM AND COPPER-STEEL FOR STRUCTURE EARTHING

Fig. 8a



1	Stainless steel bolt
2	Single earth clamp
3	Stranded copper conductor
4	Towards earthing network
5	Bimetallic plate
6	Bimetallic washer
7	Steel / Aluminium structure

SPARE PARTS

- Use only the manufacturer’s original spare parts.

Use of spare parts

WARNING!

Use of incorrect spare parts creates a safety hazard!
Incorrect or defective spare parts can impair safety and lead to damage, malfunctions or total loss of product.
Therefore:
- Use only the manufacturer's original spare parts.

- Use of other than original replacement parts will void all warranty, service, damage and liability claims against the manufacturer and/or its authorised dealers and representatives.

DISASSEMBLY

Electrical hazards

DANGER!

Electrical hazard!
Electrical energy may cause extremely severe injuries.
Verify that electrical equipment has been de-energised before starting work on it.

- Comply with applicable occupational safety and environmental regulations when dismantling decommissioned equipment.
-
- Disassembly must be performed by trained technical personnel only.

Hazard by prestressed elements

WARNING!

Improper disassembly can lead to severe injury and/or damage to equipment.
Before disassembling apparatus containing prestressed elements (e.g. springs), relieve stress as set forth in the procedures.

DISPOSAL

- The equipment must be dismantled and disposed of in an environmentally responsible manner at the end of the service life of the components/ switchgear.

Information

INFORMATION!

For further information on disposal procedures, refer to the station-related disposal instructions.

- Recycle dismantled components if no take-back or disposal agreement is in effect.

Hazardous waste

ATTENTION!

Improper disposal represents an environmental hazard!

SF6 gas, electrical scrap, electronic components, lubricants and other auxiliary materials are subject to hazardous waste regulations and may be disposed only by approved companies.

USER ASSESSMENT

- We have prepared this document to the best of our knowledge. If you as a user find that information is missing or if you have remarks or suggestions concerning its structure or contents, please notify us.

  Your feedback is appreciated. It allows us to maintain the technical and practical quality of our documents.

  Please send comments to the address listed under "Customer Support".