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BHILAI STEEL PLANT

220 kV GIS

(CHHATTISGARH, INDIA)

INSTRUCTION MANUAL

GANZ TRANSELEKTRO

ELECTRIC CO. LTD.

GIS BUSINESS UNIT

2008

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Ganz Transelektro Electric Co. Ltd. is a wholly-owned subsidiary of Crompton Greaves Ltd.

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1. Introduction

The first SF6 gas insulated substations (GIS-s) were established at the end of the 1960s. Application of this new technology spread very fast all over the world. Many years of working experiences have proved and the continuous technical research and development have improved the following important general features of the new GIS type substations: small space requirement, easy and fast installation, high reliability, resistance against environmental and climatic effects, maximal safety for the personnel, minimal maintenance and long service life.

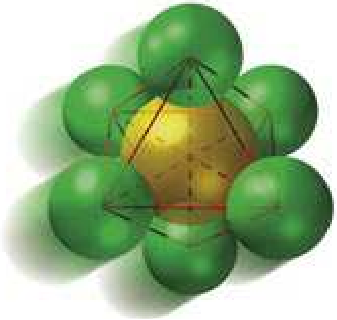
GANZ TRANSELEKTRO (earlier GANZ Electric Works and GANZ ANSALDO) has got more than 30 years of experience in designing, manufacturing, erection and commissioning of GIS projects. Our gas-insulated switchgear shows the following properties in addition to the above mentioned ones:

- Single phase enclosure for each component
- Continuous, earthed enclosures made of aluminium alloy
- Modular system with ∅ 430 mm connection flanges
- Ethylene-propylene rubber sealing rings between the flanges
- Conical form epoxy resin support insulator discs
- Several gas compartments, separated by barrier insulators
- Gas filters to absorb moisture and arcing by-products
- Metal rupturing discs with deflector plates
- Two pressure level contact manometers as gas density monitors
- DILO type gas connection valves for gas manipulations
- Aluminium current carrying tubes
- Tulip type contacts with copper fingers
- Silver plating at the contact surfaces

Our design departments, productive factories, assembly workshops and test stations are working on the basis of a complex, very strict Quality Assurance System in compliance with the standard ISO 9001. The systematic inspections and test measurements ensure the conformity of the end product to the client's requirements and to the international standard specifications.

2. Sulphur Hexafluoride (SF6)

Sulphur hexafluoride is a synthetic gas formed by 6 atoms of fluorine gathered around a centrally situated atom of sulphur.



Structure of SF6 molecule

The pure sulphur hexafluoride (SF6) is a colourless, odourless, non-toxic, non-flammable insulating gas of high dielectric strength and thermal stability. With a molecular weight of 146.05 SF6 is about 5 times denser than air and one of the heaviest gases.

ATTENTION!

Although the gas is non-toxic, it does not support life, as it is not oxygen. Equipment containing SF6 must not be entered without adequate ventilation and personal protection equipment.

As the gas is heavier than air, areas below ground level, poorly ventilated or unventilated areas (i.e.: cable ducts, trenches, inspection pits, drainage system, etc.), may remain full of SF6. Personnel must be aware of the danger of asphyxiation in such places.

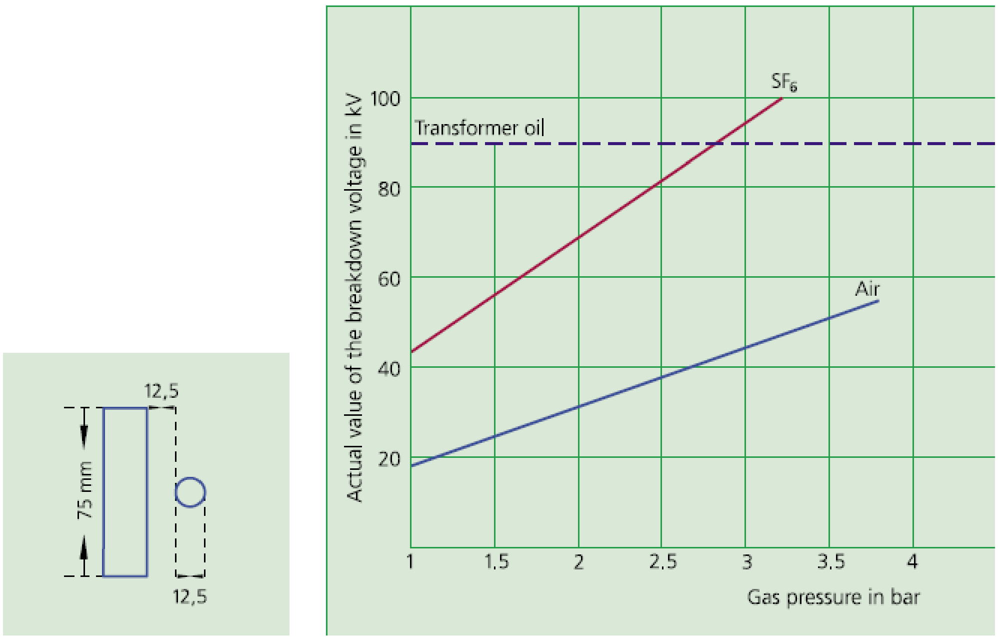
Under normal conditions, SF6 is chemically inert and stable; its reactivity is among the lowest of all substances. The chemical bond between fluorine and sulphur is known as one of the most stable existing atomic bonds. Six of these grant the molecule very high chemical and thermal stability. In addition, the compatibility of SF6 with material used in electric constructions is similar to that of nitrogen, up to temperatures of about 180 ℃.

The excellent insulating properties of SF6 are attributable to the strong electron affinity (electro-negativity) of the molecule. This is based on two mechanisms, resonance capture and dissociative attachment of electrons, in accordance with the equations:

$$SF6 + e^{-} \Rightarrow SF6^{-}$$

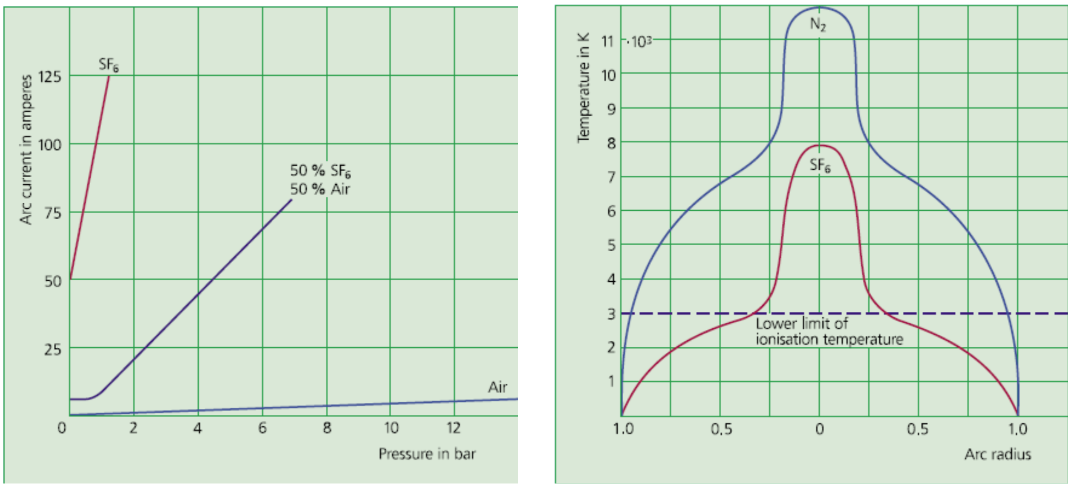
$$SF6 + e^{-} \Rightarrow SF5^{-} + F$$

The strong interaction of high-energy electrons with the polyatomic SF6 molecule causes their rapid deceleration to lower energy and produce very slow moving heavy ions at the same time. So the further process of ionisation is prevented. SF6-breakdown is therefore only possible at relatively high field strengths. The breakdown voltages at 50 Hz and 1 bar in a homogenous field are thus 2.5 to 3 times higher than the corresponding values for air or nitrogen. The breakdown strength of air is dramatically increased by the addition of small quantities of SF6. In contrast the air has only a limited influence on the breakdown strength of SF6. The addition of 10 % of air by volume reduces the breakdown voltage of SF6 by about 3 %, the addition of 30 % air by about 10 %. The breakdown voltage of SF6 reaches that of transformer oil at a pressure of only 3 bars.



Breakdown voltage of different insulating materials as a function of pressure
(Source: Solvay Fluor / Sulphur Hexafluoride Brochure)

On account of its thermal properties (low heat transmission factor at arc-temperature) and low ionisation temperature SF6 exhibits outstanding characteristics for the extinguishing of electric arcs. All other conditions being equal, the arc-quenching time using SF6 is about 100 times less than that using air. The residual arc column is of extremely small diameter and of small accumulated energy. Under the influence of the electric arc, part of the SF6 is dissociated into its atomic constituents. This reaction is reversible. After the electric discharge the dissociation products recombine, provided that no secondary reactions with vaporised electrode metal, the enclosure wall or other components occur. The decomposition products are good dielectrics, but if they are exposed to moisture, they hydrolyse and form secondary products: corrosive electrolytes, which may cause damage and operational failure.



Quenching capacity and radial temperature profile of different insulating materials
(Source: Solvay Fluor / Sulphur Hexafluoride Brochure)

Purity requirements for SF6 (including moisture level in the equipment) are specified by the relevant IEC standards.

SF6 does not harm the ecosystem: biological accumulation in the food chain does not occur. It is an inert gas with very low solubility in water so that it presents no danger to surface and/or ground water and/or the soil.

SF6 has no impact on the stratospheric ozone layer, but it is a potent and persistent greenhouse gas. The related characteristics:

- Ozone Depletion Potential = ODP = 0
- Global Warming Potential = GWP = 22500 - 22200 times CO2
- Atmospheric Life Time = ALT = 650 - 3200 years

SF6 is one of the fluorinated greenhouse gases controlled under the Kyoto Protocol.

ATTENTION!

SF6 has to be used in a closed cycle. When gas removal from containment is needed, a proper handling procedure shall be implemented to avoid any deliberate release into the atmosphere.

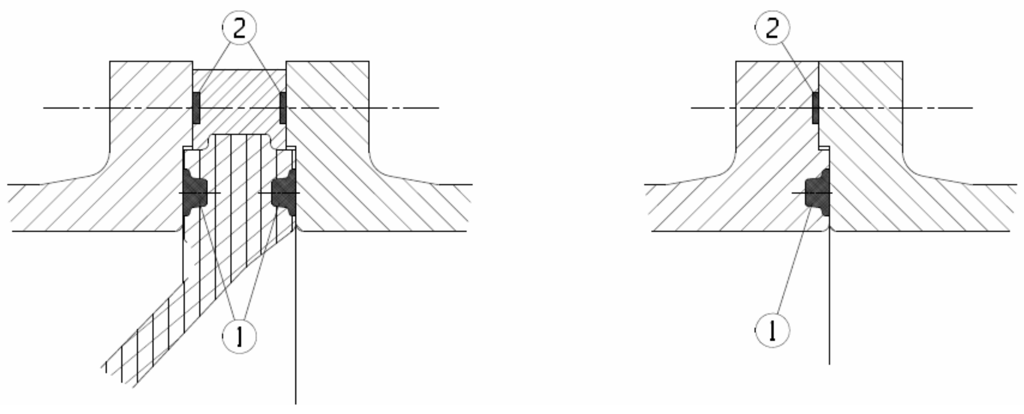
2.1. Gas conditions of 220 kV GAI-3 type GIS

The GAI-3 type gas-insulated switchgear represents **closed pressure** system. (See IEC 62271-1 item 5.15.2) The gas leakage losses are below 0.5 % per annum. This feature theoretically enables the switchgear to remain in service at least 20 years before gas has to be replenished.

ATTENTION!

Filling pressure of each gas compartment has to be checked regularly. In case of gas leakage the reason of the failure has to be found and eliminated as soon as possible.

The single-phase enclosures are built up from modular units. These modules join to each other with flanges. The epoxy resin insulator discs, which support the live parts, can be found always between flanges of the neighbour units. Between the flange surfaces single ethylene-propylene rubber rings ensure the static gastight sealing. In case of outdoor applications the sealing surfaces around the sealing ring are protected by special grease against corrosion. Structure and details of the dynamic sealing solutions are described in the detailed switchgear manuals.



Arrangement of flanges with and without insulating disc
1 – Sealing O ring; 2 – Grease ring (applied only at outdoor applications)

ATTENTION!

In case of outdoor applications the state of the protecting grease ring has to be checked regularly. If necessary, it has to be replenished or exchanged.

In the GAI-3 type GIS the SF6 is used as insulating and arc-quenching material. The gas pressure in the puffer type circuit breakers is higher, because of the better arc-extinguishing effect. The pressure data of the 220 kV GIS are summarized in the Table below:

GAI-3 type GIS	**Circuit breakers:**	**Other elements:**	**Units:**
Design pressure:	8.5	7.0	bar (gauge)
Rated / Filling pressure:	6.3	5.2	bar (gauge)
Rated / Filling density:	48.7	40.6	kg/m³
Alarm pressure:	5.5	4.6	bar (gauge)
Alarm density:	42.8	36.3	kg/m³
Isolating & Lockout pressure:	5.3	4.4	bar (gauge)
Isolating & Lockout density:	41.3	34.9	kg/m³
Operation pressure of rupturing discs:	10.5	10.5	bar (gauge)
Routine test pressure:	17.0	14.0	bar (gauge)
Bursting test pressure of epoxy parts:	25.5	21.0	bar (gauge)
Bursting test pressure of metal parts:	42.5	35.0	bar (gauge)

The **design pressure** is an abstract value used at determining the wall thickness of all enclosure elements. It is given at the design temperature, which is the average of the permissible temperatures of the active parts and the enclosures. According to IEC 62271-1 the maximum temperature for silver coated contacts in SF6 is 105 °C, and for accessible parts expected to be touched in normal operation is 70 °C. From this the design temperature shall be: (105 + 70)/2 = 87.5 °C.

The **rated pressure** means the working value on which the equipment is filled up under normal conditions. It is given at 20 °C gas temperature. Some type tests of the GIS are performed at rated gas pressure (gas tightness test, mechanical endurance tests, internal arc test, and inductive current breaking capacity test).

The **alarm pressure** is approximately 90 % of the rated value. This is the setting level for the first step of the gas protection. At this value the contact manometer gives alarm signal for the personnel for refilling.

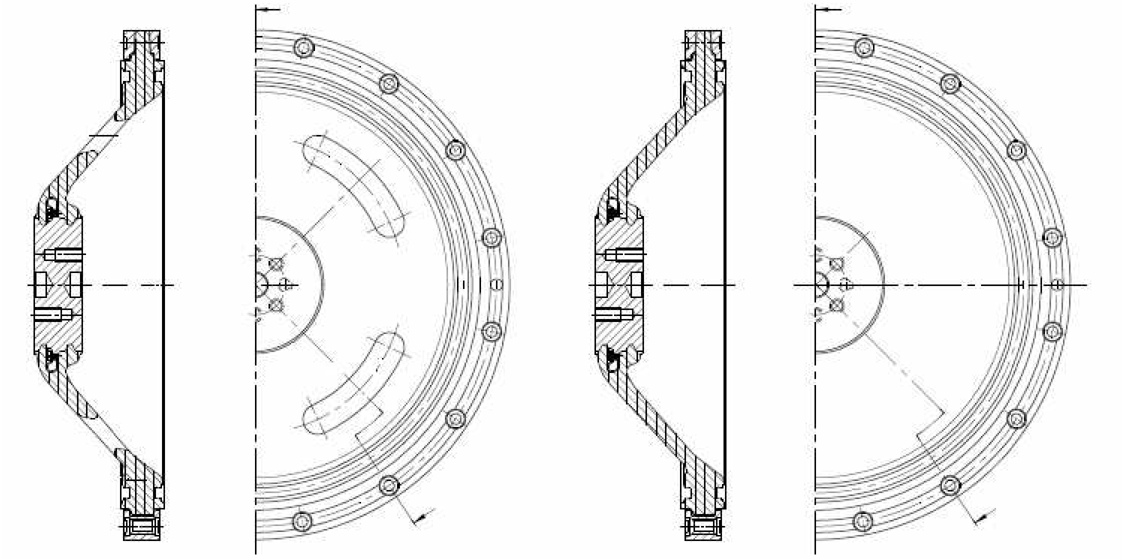
The **isolating or lockout pressure** is equal with the minimum functional pressure. From electrical point of view it is the minimal permissible pressure value of the equipment. It is given at 20 °C gas temperature as well. The most important type tests (dielectric tests, most switching tests, temperature rise tests) are performed at this pressure level. Therefore at lower pressure value there is no guarantee for the normal operation. If the pressure falls under this level, the second step of the gas protection has to provide the electrical isolation of the defected gas compartment. Moreover in case of circuit breaker the switching operation has to be locked. These functions are performed by second step of the gas protection. It is realized by the second contact and (only at CB) the third contact of the contact manometer.

As **pressure relief device** GANZ TRANSELEKTRO uses rupturing discs made of metal. The task of the rupture disc is to relieve the overpressure due to the internal fault in the gas compartments before the overstress of the enclosure elements. When the pressure exceeds the maximal permitted service pressure, the rupture disc bursts and the gas is streaming outside through a gas nozzle in the designed direction and so the enclosure remains unhurt. The undamaged membrane does not let the SF6 gas through, neither in traces. Because of the manufacturing tolerances the **operation pressure of the rupturing discs** can be given only with a tolerance of ±10 %. The minimum value of the membrane operation pressure is ordered with a margin to the design pressure.

The **routine test pressure** of the enclosure elements is given by IEC 62271-203 (item 7.101), and shall be "k"-times higher than the design pressure. This "k" factor is 1.3 for welded and 2.0 for cast enclosures. We use the higher value because our GIS consist of welded and cast parts as well.

The **bursting test pressure** of the enclosure elements is determined according to IEC 62271-203 (item 6.103) and the related CENELEC standards. In case of aluminium enclosure elements it is 5-times higher than the design pressure (see EN 50069). In case of the cast resin parts (partitions) it is 3-times higher than the design pressure (see EN 50089).

The GIS bays contain a number of independent **gas compartments**. Arrangement of these gas compartments is determined by the gas schematic diagram. The three phases are identical; therefore the drawing presents only one of them. The internal barriers between the compartments are realized by solid type insulator discs.



Outlines of opened (support type) and solid (barrier type) insulator discs

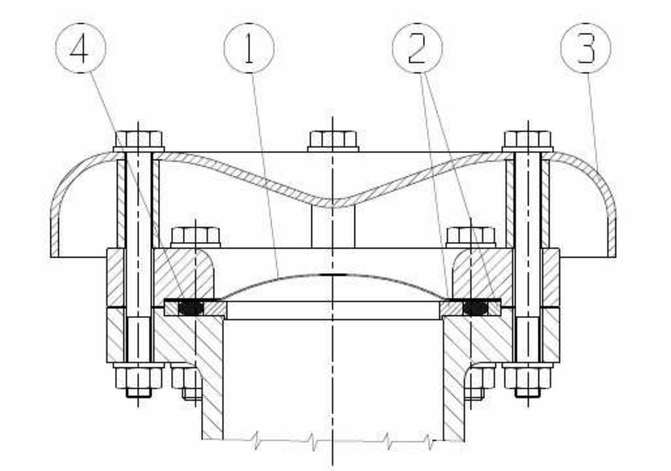
ATTENTION!

The outer metal support ring of each solid (border type) insulator disc is painted by red colour to signalize the border lines of the different gas compartments. The opened (support type) insulator discs are grey.

The gas sectioning gives possibilities for decreasing gas-losses, for restriction of damages caused by fault arc and for reducing the time of gas-manipulations. The gas volumes of the different gas compartments are usually not equivalent. At normal service of the switchgear is advantageous if the gas volumes are as large as possible, because in the larger gas volumes the changes of the internal pressure are always slower. On the other hand the gas handling at the erection and maintenance needs too much time if the gas compartments are very large. These opposite points of view cause that some small gas compartments often are connected with bypass tubes to the neighbour (larger) gas compartments. Hereby at working conditions the small gas volumes are added to a large one, which can be divided into independent parts at the connection tubes if it is necessary.

All of the gas compartments include the following **basic accessories**:

1.) Metal **rupturing disc** assembly with deflector cover, which has to ensure the relief of the enclosure if the internal overpressure rises to dangerous level (for instance in case of internal short circuit).



Indoor type rupturing disc installed on earthing flange of the enclosure
1 – rupturing disc; 2 – support rings; 3 – deflector plate; 4 – sealing ring

ATTENTION!

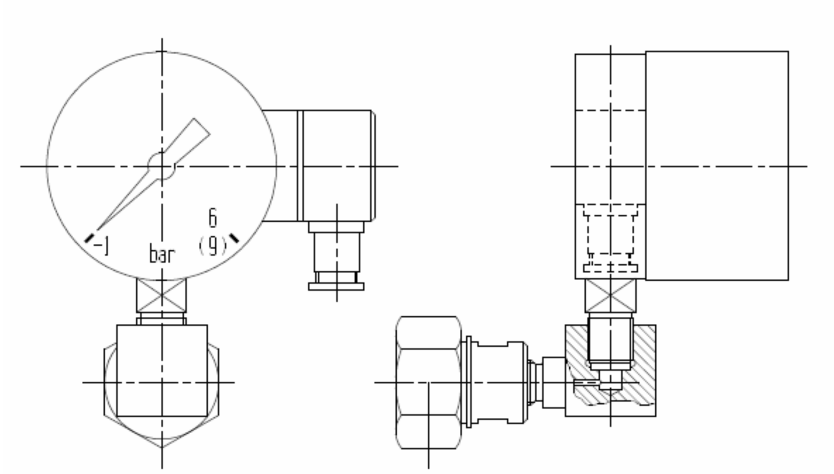
In case of operation hot and high-pressure gas can flow out through the opening between the enclosure and the deflector cover. The big noise can frighten the personnel. For these reasons it can cause direct or indirect accidents. Don't stay very close to the rupturing discs if it is not necessary. Don't store any sensitive or flammable material here.

In case bursting disc operated the directly touched and the neighbouring gas compartments have to be disconnected and directly earthed by the earthing switches. Internal pressure of the neighbouring compartments shall be reduced (to the half of the rated value) to avoid further damages.

The place of the failure (the GIS room) has to be ventilated and cleaned up.

The failure has to be investigated by experts of the user and the manufacturer. After opening of the enclosure the exact place of the failure has to be found. The defected parts have to be examined and exchanged. The possible reasons have to be analyzed and eliminated. After repairing and cleaning the renewed part can be tested and switched on again.

2.) Temperature compensated **contact manometer** for continuous monitoring of the internal SF6 gas pressure, which gives alarm signals with for the Local Control Cubicle in two or three steps:



Contact manometer with manometer connection (applied at GAI SC3 circuit breakers)

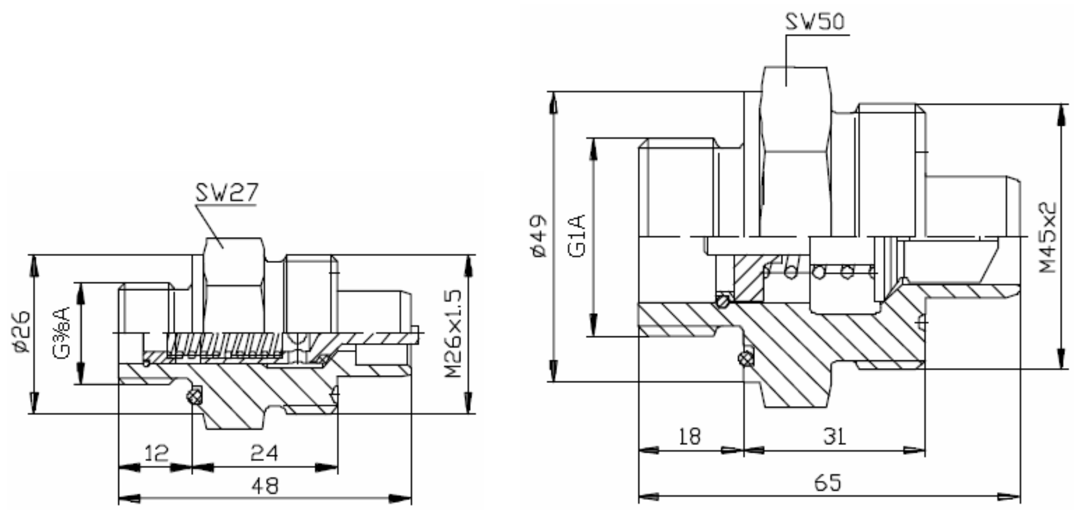
- if the gas compartment needs SF6 refilling because the internal gas pressure dropped below the alarm level due to gas leakage,
- if the live part must be disconnected because the internal gas pressure continued to drop and decreased below the isolating pressure level, and it is too low to provide the normal, specified insulation of the live parts,
- if the operation of the circuit breaker must be blocked because the gas pressure fell below the lock-out pressure and it is too low to provide the regular operation of the circuit breaker, more exactly to the regular arc quenching. (The second and third functions operate at the same gas pressure level.)

The contact manometer is always installed on gas connection valve. This arrangement provides the possibility of removing or exchange without the reduction of the internal gas pressure.

ATTENTION!

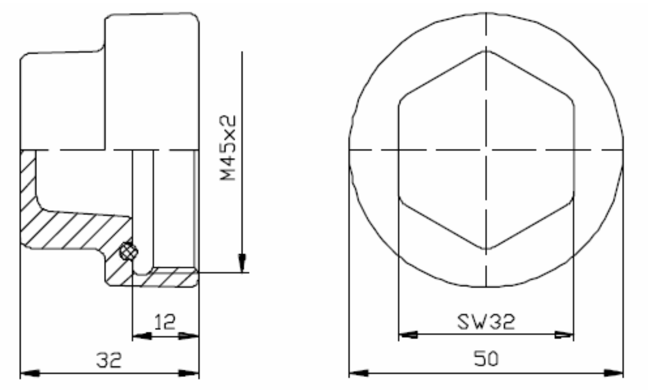
The calibration of each contact manometer is fulfilled in the workshop of the manufacturer. Any change of the settings is on site impossible. Check of the settings shall be realized in off-load and voltage-free conditions only.

3.) **Gas connection valves** (DN8 or DN20), which give possibility to connection of the gas handling or testing equipment. Material of the valves is aluminium (Al), similar to the enclosure elements.



DN8 and DN20 gas connection valves
(Type: VK/BG-03/8 and VK/BG-03/20 made by DILO GmbH)

After installation the G⅜ or G1 type connections (left side in the figures) are threaded into the enclosures. The outer parts (right side in the figures) are suitable to join gas handling equipment or measuring devices. These parts are protected against damage and contamination by aluminium covering caps.

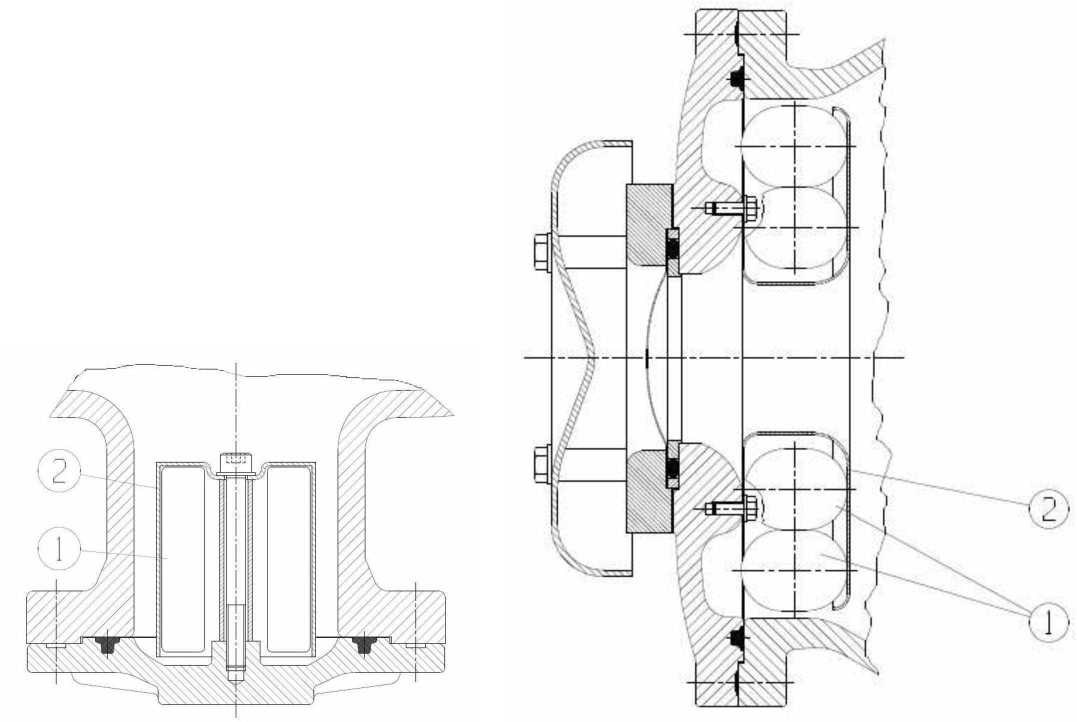


Covering cap for DN20 gas connection valve. (Type: VK/KN-04/20 made by DILO GmbH)

ATTENTION!

Don't remove the protecting cover of any gas valve if it is not absolutely necessary. Very important to avoid any contamination or damage of these gas valves.

4.) Gas filter, which has to adsorb the moisture and the decomposed substances of the SF6 gas, which can be produced by the electric arc.



Gas filters installed under cover of earthing flange and under cover of switchgear flange
1 – filter bag; 2 – support & holder structure

ATTENTION!

The gas filter is placed inside the gas compartment, under a flange cover which is signalised by label.

The filters are built up directly before the final filling up of the gas compartment with SF6 gas, because the atmospheric moisture can damage them. Up to the installation the filters shall be stored in hermetic closed plastic package.

In case of change the old filters have to be collected and handle very carefully as a dangerous waste.

3. General description of BHILAI 220 kV GIS

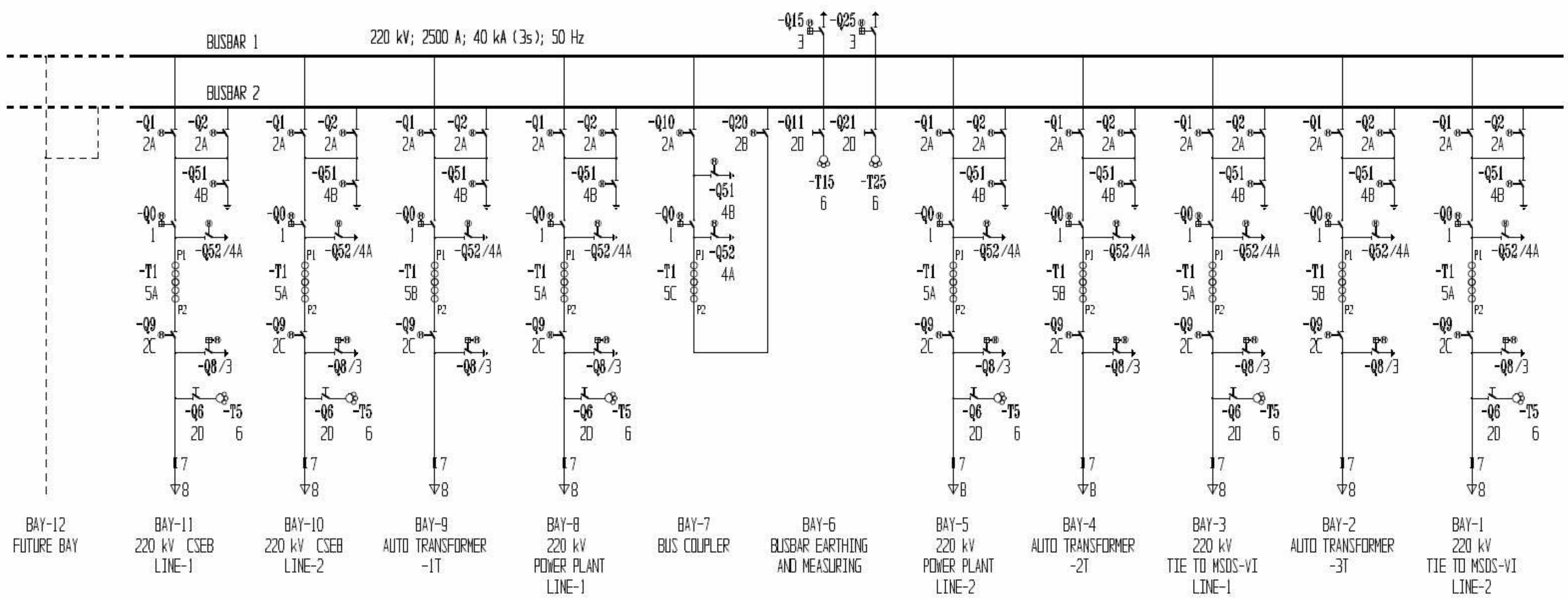
BHILAI 220 kV GIS is a double busbar system which consist of eleven bays:

- 6 pcs Incoming cable bays
- 3 pcs Transformer bays (with cable connections)
- 1 pc Bus Coupler bay
- 1 pc Busbar Earthing and Measuring bays

The sequence and connection of the bays can be seen in the enclosed single line diagram (see Figure 1), gas schematic diagram (see Figure 2) and layout (see Figures 3). The power transformers are connected through high-voltage cables to the 220 kV GIS. The code numbers and names of the feeders:

- BAY-1: 220 kV Tie to MSDS-VI / Line-2
- BAY-2: Auto-Transformer -3T
- BAY-3: 220 kV Tie to MSDS-VI / Line-1
- BAY-4: Auto-Transformer -2T
- BAY-5: 220 kV Power Plant-3 / Line-2
- BAY-6: Busbar Earthing and Measuring bay
- BAY-7: Bus Coupler
- BAY-8: 220 kV Power Plant-3 / Line-1
- BAY-9: Auto-Transformer -1T
- BAY-10: 220 kV CSEB / Line-2
- BAY-11: 220 kV CSEB / Line-1

The complete 220 kV gas-insulated switchgear is installed inside a room. The room width is 12.7 m and the length is 36 m approximately. All circuit breakers of the GIS bays are arranged in a line. Local control cubicles are placed in front of the connecting bays, at the longer wall of the room. The width of each bay is 2000 mm. The total width of the complete GIS is approximately 22 m. Maximum length of the bays is 6.8 m. There are free maintenance ways around the switchgear. The width of this way is 3 m between the GIS and the LCC cubicles, 2 m at the rear side and 6 m between the last bays and the shorter walls. The line and transformer bays are connected by plug-in type high-voltage cables to the GIS. The cables are going down vertically towards the cable cellar below the GIS room.



Legend:

Common technical data:
- Rated voltage (highest system voltage):............. 245 kV
- Service voltage (working value):.................... 220 kV
- Rated frequency:.. 50 Hz
- Rated insulation levels:
  - Lightning impulse withstand voltage :........... 1050 kV
  - Power frequency withstand voltage :............. 460 kV
- Rated short-time withstand current:.................. 40 kA
- Rated duration of short circuit:...................... 3 s
- Rated peak withstand current:....................... 104 kA
- Related standards:.................................IEC

Item 1: Circuit breakers
- Type:.................................... GAI SC3
- Rated short circuit breaking current:......... 40 kA
- Rated making current. .... 104 kA
- First pole to clear factor:.................. 1.5
- Rated current:............................ 2500 A
- Drives:.............. single-pole, motor operated hydraulic mechanism, type: ETNA
- Rated operating sequence:.... O-0.3sec-CO-3min-CO

Item 2: Disconnectors
- Rated currents:............................. 2500 A
- 2A: Branching type:.......................... GAI IB3
- 2B: Corner type:............................. GAI IC3
- 2C: Linear type:............................. GAI IL3
- Drives:.............. three-pole, motor operated
- 2D: Branching type:.......................... GAI IB3 with hand operation possibility

Item 3: High speed earthing switches
- Type:.................................... GAI EQ3
- Rated making current:........................ 104 kA
- Drives:.............. three-pole, motor operated with spring energy storage system

Item 4: Maintenance earthing switches
- 4A: Type:.................................. GAI EM3
  - Position of earthing flanges:.. on the same level
- 4B: Type:.................................. GAI EG3
  - Position of earthing flanges:. on parallel levels
  - Drive:............... three-pole, motor operated

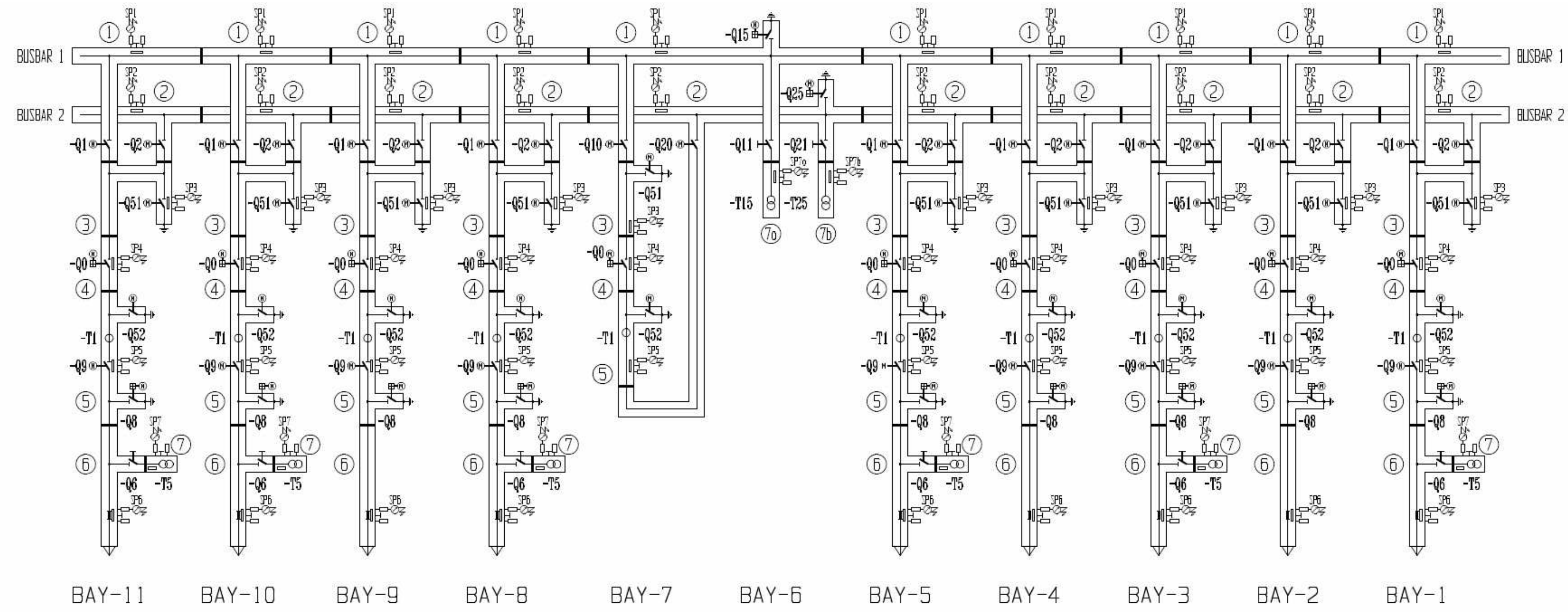
Item 5: Current transformers
- Type:..................................... GAI TI3
- 5A: 1&2. 1600-800/1 A; PS; vk>=2400-1200 V; Im<30 mA at vk/2; R<8-4 ohm
  - 3. 1600-800/1 A; class 0,5 - Fs5; 40 VA
  - 4&5. 2000/1 A; PS; vk>=1000 V; Im<30 mA at vk/2; R<8 ohm
- 5B: 1. 600-300/1 A; PS; vk>=900-450 V; Im<30-45 mA at vk/2; R<6-3 ohm
  - 2. 600-300/1 A; 5P20; 30 VA
  - 3. 600-300/1 A; class 0,5 - Fs5; 40 VA
  - 4&5. 2000/1 A; same as 5A:4&5
- 5C: 1&2. 1600-800/1 A; 5P20; 30 VA
  - 3. 1600-800/1 A; same as 5A:3
  - 4&5. 2000/1 A; same as 5A:4&5

Item 6: Inductive voltage transformers
- Manufacturer:.......................... Nissin
- Type:................................ SVR-20A
- Rated primary voltage:............... 220000/√3 V
- Rated secondary voltages:.............. 110/√3 V
- Secondary windings: .1:......... class 3P; 100 VA
  - .2:......... class 3P; 100 VA
  - .3:........ class 0.5; 100 VA

Item 7: Removable element for site testing

Item 8: Cable sealing end enclosures
- Manufacturer (sealing ends):......... Pfisterer
- Type (sealing ends):................. CONNEX 6S

Figure 1: Single Line Diagram of BHILAI 220 kV GIS

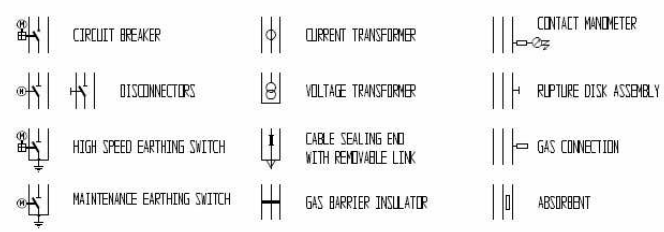


Bays of the 220 kV GIS

BAY-1: 220 kV Tie to MSDS-VI / Line-2
BAY-2: Auto-Transformer -3T
BAY-3: 220 kV Tie to MSDS-VI / Line-1
BAY-4: Auto-Transformer -2T
BAY-5: 220 kV Power Plant-3 / Line-2
BAY-6: Busbar Earthing and Measuring bay
BAY-7: Bus Coupler
BAY-8: 220 kV Power Plant-3 / Line-1
BAY-9: Auto-Transformer -1T
BAY-10: 220 kV CSEB / Line-2
BAY-11: 220 kV CSEB / Line-1
BAY-12: Future Bay

PRESSURE CHARACTERISTICS	(Units)	Circuit Breakers	Other Compartments
Design pressure	(bar g)	8,5	7,0
Filling pressure	(bar g)	6,3	5,2
Filling density	(kg/m3)	48,7	40,6
Alarm pressure	(bar g)	5,5	4,6
Alarm density	(kg/m3)	42,8	36,3
Isolating pressure	(bar g)	5,3	4,4
Isolating density	(kg/m3)	41,3	34,9
Lock-out pressure	(bar g)	5,3	---
Lock-out density	(kg/m3)	41,3	---
Membran operation	(bar g)	10,5	10,5

Legend:



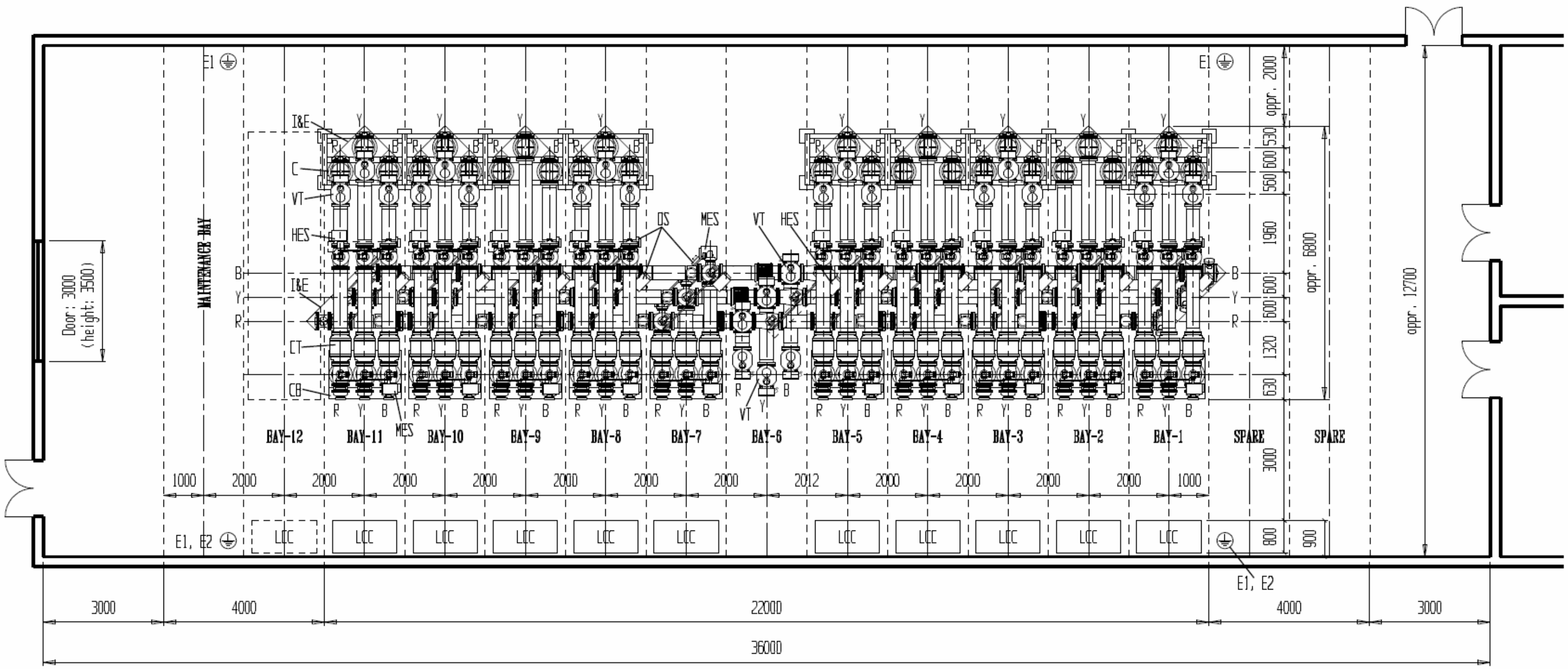
Note: The (N) numbers indicate the different gas compartments of each bay.

Figure 2A: Gas Schematic Diagram of BHILAI 220 kV GIS

BAY NO & DENOMINATION	SF6 gas volume of the gas compartments (dm3)																					
	1			2			3			4			5			6			7			All
	Busbar No.1 (lower ones)			Busbar No.2 (upper ones)			Busbar Connection			Circuit Breaker Poles			Upper Connections			Cable Terminations			Voltage Transformers			Altogether (bays)
	R	Y	B	R	Y	B	R	Y	B	R	Y	B	R	Y	B	R	Y	B	R	Y	B	All
BAY-1 : 220 kV Tie to MSDS-VI / Line-2	95	95	95	106	106	106	110	158	206	540	540	540	397	397	397	342	391	342	130	130	130	5353
BAY-2 : Auto-Transformer -3T	185	185	185	197	197	197	110	158	206	540	540	540	397	397	397	306	354	306	N.A.	N.A.	N.A.	5397
BAY-3 : 220 kV Tie to MSDS-VI / Line-1	185	185	185	197	197	197	110	158	206	540	540	540	397	397	397	342	391	342	130	130	130	5896
BAY-4 : Auto-Transformer -2T	185	185	185	197	197	197	110	158	206	540	540	540	397	397	397	306	354	306	N.A.	N.A.	N.A.	5397
BAY-5 : Power Plant-3 / Line-2	185	185	185	197	197	197	110	158	206	540	540	540	397	397	397	342	391	342	130	130	130	5896
BAY-6 : Busbar earthing and measuring	335	416	432	209	209	209	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	260	260	260	2590
BAY-7 : Bus Coupler	185	185	185	293	293	293	110	158	206	540	540	540	179	227	276	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	4210
BAY-8 : Power Plant-3 / Line-1	185	185	185	197	197	197	110	158	206	540	540	540	397	397	397	342	391	342	130	130	130	5896
BAY-9 : Auto-Transformer -1T	185	185	185	197	197	197	110	158	206	540	540	540	397	397	397	306	354	306	N.A.	N.A.	N.A.	5397
BAY-10: 220 kV CSEB / Line-2	185	185	185	197	197	197	110	158	206	540	540	540	397	397	397	342	391	342	130	130	130	5896
BAY-11: 220 kV CSEB / Line-1	213	213	213	224	224	224	110	158	206	540	540	540	397	397	397	342	391	342	130	130	130	6061
ALTOGETHER (THREE PHASES)	6547			6633			4740			16200			11401			9348			3120			57989

BAY NO & DENOMINATION	SF6 gas content of the gas compartments (kg)																					
	1			2			3			4			5			6			7			All
	Busbar No.1 (lower ones)			Busbar No.2 (upper ones)			Busbar Connection			Circuit Breaker Poles			Upper Connections			Cable Terminations			Voltage Transformers			Altogether (bays)
	R	Y	B	R	Y	B	R	Y	B	R	Y	B	R	Y	B	R	Y	B	R	Y	B	All
BAY-1 : 220 kV Tie to MSDS-VI / Line-2	3,8	3,8	3,8	4,3	4,3	4,3	4,5	6,4	8,4	26,3	26,3	26,3	16,1	16,1	16,1	13,9	15,9	13,9	5,3	5,3	5,3	230,4
BAY-2 : Auto-Transformer -3T	7,5	7,5	7,5	8,0	8,0	8,0	4,5	6,4	8,4	26,3	26,3	26,3	16,1	16,1	16,1	12,4	14,4	12,4	N.A.	N.A.	N.A.	232,2
BAY-3 : 220 kV Tie to MSDS-VI / Line-1	7,5	7,5	7,5	8,0	8,0	8,0	4,5	6,4	8,4	26,3	26,3	26,3	16,1	16,1	16,1	13,9	15,9	13,9	5,3	5,3	5,3	252,6
BAY-4 : Auto-Transformer -2T	7,5	7,5	7,5	8,0	8,0	8,0	4,5	6,4	8,4	26,3	26,3	26,3	16,1	16,1	16,1	12,4	14,4	12,4	N.A.	N.A.	N.A.	232,2
BAY-5 : Power Plant-3 / Line-2	7,5	7,5	7,5	8,0	8,0	8,0	4,5	6,4	8,4	26,3	26,3	26,3	16,1	16,1	16,1	13,9	15,9	13,9	5,3	5,3	5,3	252,6
BAY-6 : Busbar earthing and measuring	13,6	16,9	17,5	8,5	8,5	8,5	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	10,6	10,6	10,6	105,3
BAY-7 : Bus Coupler bay	7,5	7,5	7,5	11,9	11,9	11,9	4,5	6,4	8,4	26,3	26,3	26,3	7,3	9,3	11,2	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	184,2
BAY-8 : Power Plant-3 / Line-1	7,5	7,5	7,5	8,0	8,0	8,0	4,5	6,4	8,4	26,3	26,3	26,3	16,1	16,1	16,1	13,9	15,9	13,9	5,3	5,3	5,3	252,6
BAY-9 : Auto-Transformer -1T	7,5	7,5	7,5	8,0	8,0	8,0	4,5	6,4	8,4	26,3	26,3	26,3	16,1	16,1	16,1	12,4	14,4	12,4	N.A.	N.A.	N.A.	232,2
BAY-10: 220 kV CSEB / Line-2	7,5	7,5	7,5	8,0	8,0	8,0	4,5	6,4	8,4	26,3	26,3	26,3	16,1	16,1	16,1	13,9	15,9	13,9	5,3	5,3	5,3	252,6
BAY-11: 220 kV CSEB / Line-1	8,6	8,6	8,6	9,1	9,1	9,1	4,5	6,4	8,4	26,3	26,3	26,3	16,1	16,1	16,1	13,9	15,9	13,9	5,3	5,3	5,3	259,2
ALTOGETHER (THREE PHASES)	265,2			269,4			193,0			789,0			462,5			379,8			127,2			2486,1

Figure 2B: Gas Schematic Diagram of BHILAI 220 kV GIS



Legend:

C: Cable Sealing End
CB: Circuit Breaker
CT: Current Transformer
DS: Disconnector
HES: High-speed Earthing Switch
I&E: Interconnection and Earthing
LCC: Local Control Cubicle
MES: Maintenance Earthing Switch
VT: Voltage Transformer

E1: Earthing point in the GIS room
E2: Earthing point in the cable cellar
(each earthing point dimensioned for short circuit current: 40 kA/1 sec)

Bays of the 220 kV GIS

BAY-1: 220 kV Tie to MSDS-VI / Line-2
BAY-2: Auto-Transformer -3T
BAY-3: 220 kV Tie to MSDS-VI / Line-1
BAY-4: Auto-Transformer -2T
BAY-5: 220 kV Power Plant-3 / Line-2
BAY-6: Busbar Earthing and Measuring bay
BAY-7: Bus Coupler
BAY-8: 220 kV Power Plant-3 / Line-1
BAY-9: Auto-Transformer -1T
BAY-10: 220 kV CSEB / Line-2
BAY-11: 220 kV CSEB / Line-1
BAY-12: Future Bay

Data for overhead crane:
- Maximum load: 32 kN (= 3,2 ton)
- Min. height of the hook: 5.5 m

Connecting drawings:

4802725: Single line diagram
4802726: Gas schematic diagram
4802728: Section of Incoming Line bays
4802729: Section of Transformer bays
4802730: Section of Bus Coupler bay
4802731: Busbar Earthing and Measuring
4802732: Busbar arrangement
4802733: Civil data drawing

Figure 3: Layout of BHILAI 220 kV GIS

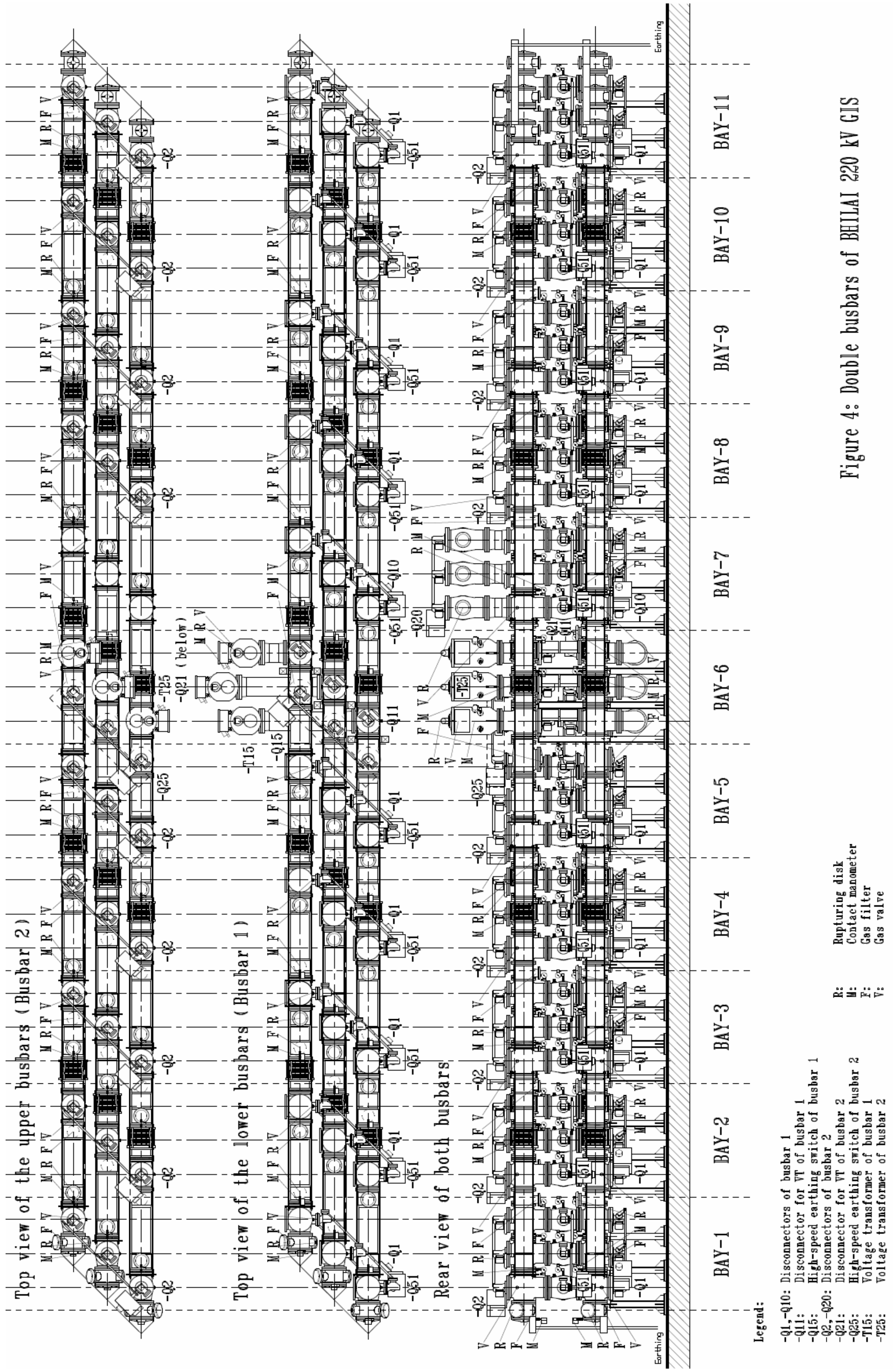
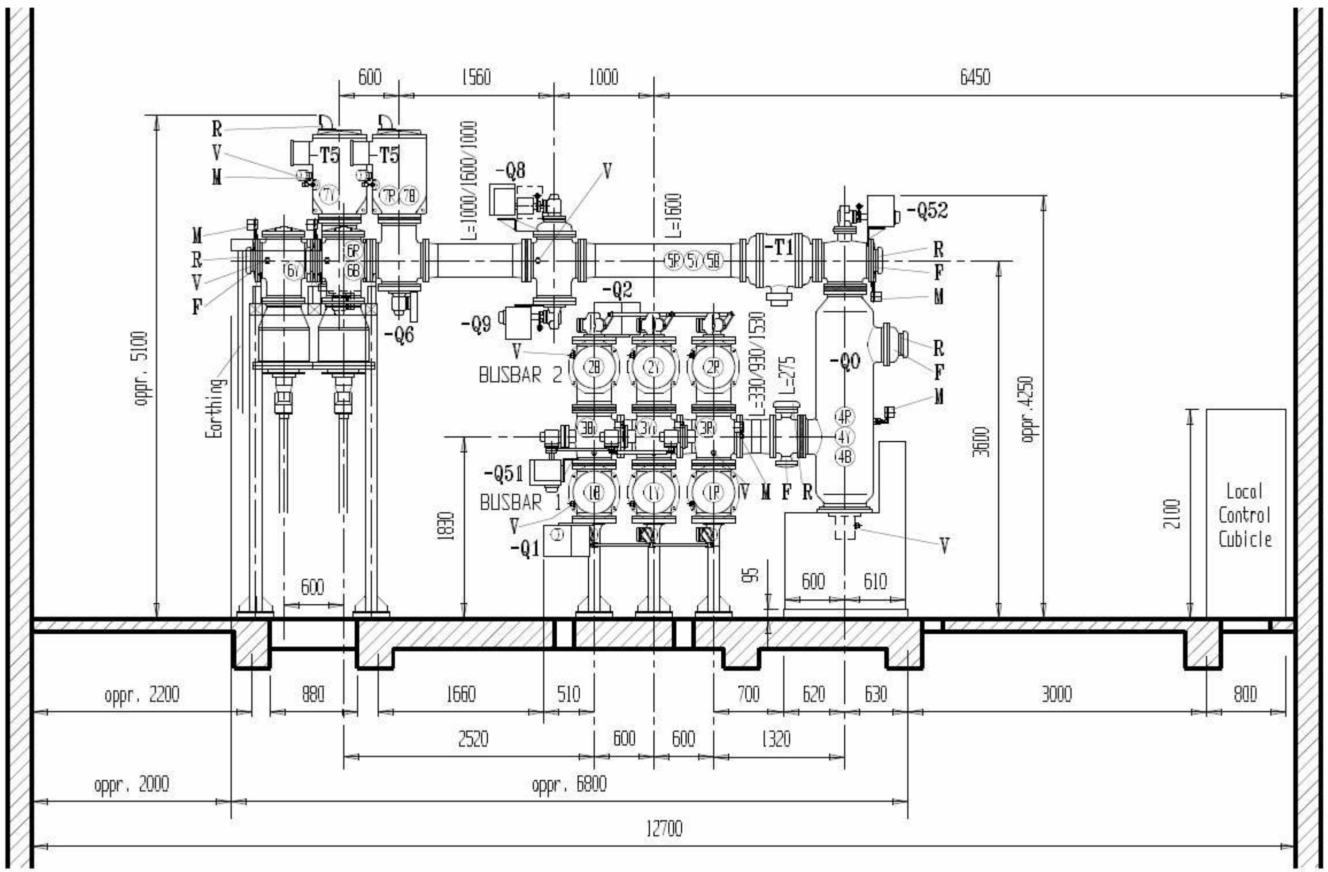


Figure 4: Double busbars of BHILAI 220 kV GIS



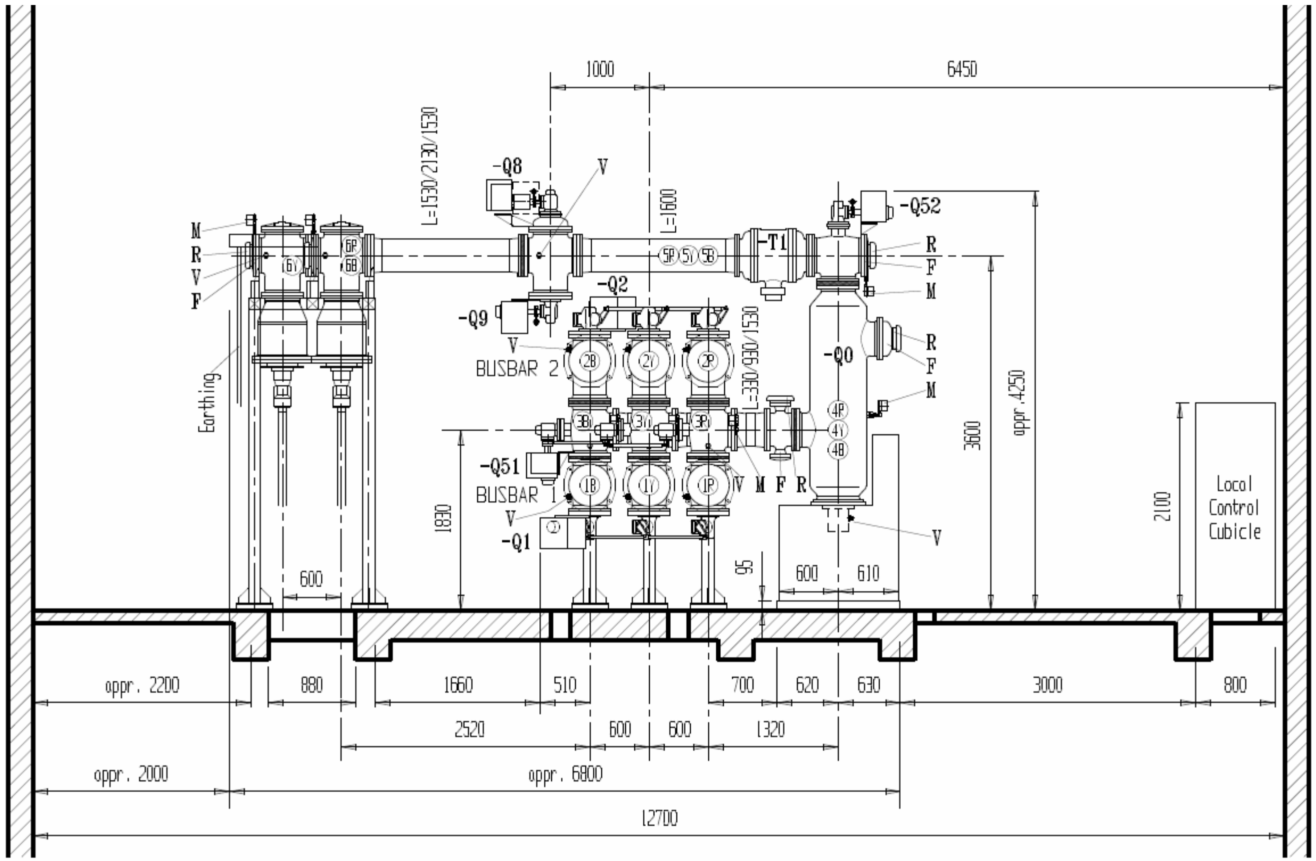
Legend:

-Q0:	Circuit breaker
-Q1:	Busbar disconnector No.1
-Q2:	Busbar disconnector No.2
-Q6:	Disconnector of the VT
-Q8:	High speed earthing switch
-Q9:	Line disconnector
-Q51:	Maintenance earthing switch No.1
-Q52:	Maintenance earthing switch No.2
-T1:	Current transformer
-T5:	Voltage transformer
R:	Rupturing disk
M:	Contact manometer
F:	Gas filter
V:	Gas valve

Remarks:

1) The (N) numbers indicate the gas compartments.
2) Dimensions of the floor opening around the HV cables are appr. 880 x 1480 mm, symmetrically arranged.
3) Surface of the concrete floor in the GIS room must have a tolerance of +0 / -10 mm.
4) Steel structures will be fixed to the floor by HILTI type anchoring bolts.

Figure 5: Section of Incoming Line and Tie bays at BHILAI 220 kV GIS



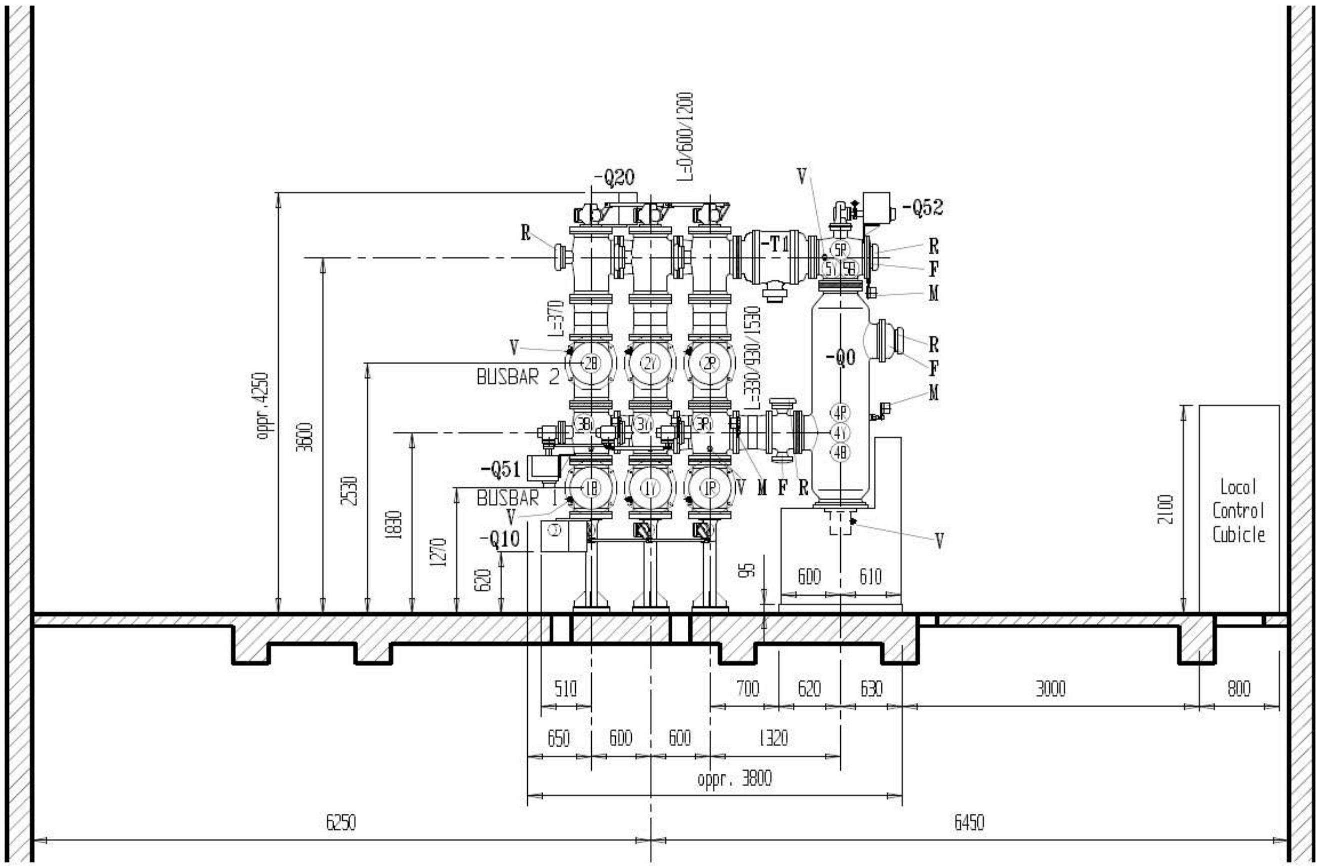
Legend:

-Q0:	Circuit breaker
-Q1:	Busbar disconnector No.1
-Q2:	Busbar disconnector No.2
-Q8:	High speed earthing switch
-Q9:	Line disconnector
-Q51:	Maintenance earthing switch No.1
-Q52:	Maintenance earthing switch No.2
-T1:	Current transformer
R:	Rupturing disk
M:	Contact manometer
F:	Gas filter
V:	Gas valve

Remarks:

1) The (N) numbers indicate the gas compartments
2) Dimensions of the floor opening around the HV cables are appr. 880 x 1480 mm, symmetrically arranged.
3) Surface of the concrete floor in the GIS room must have a tolerance of +0 / -10 mm.
4) Steel structures will be fixed to the floor by HILTI type anchoring bolts.

Figure 6: Section of Transformer bays at BHILAI 220 kV GIS



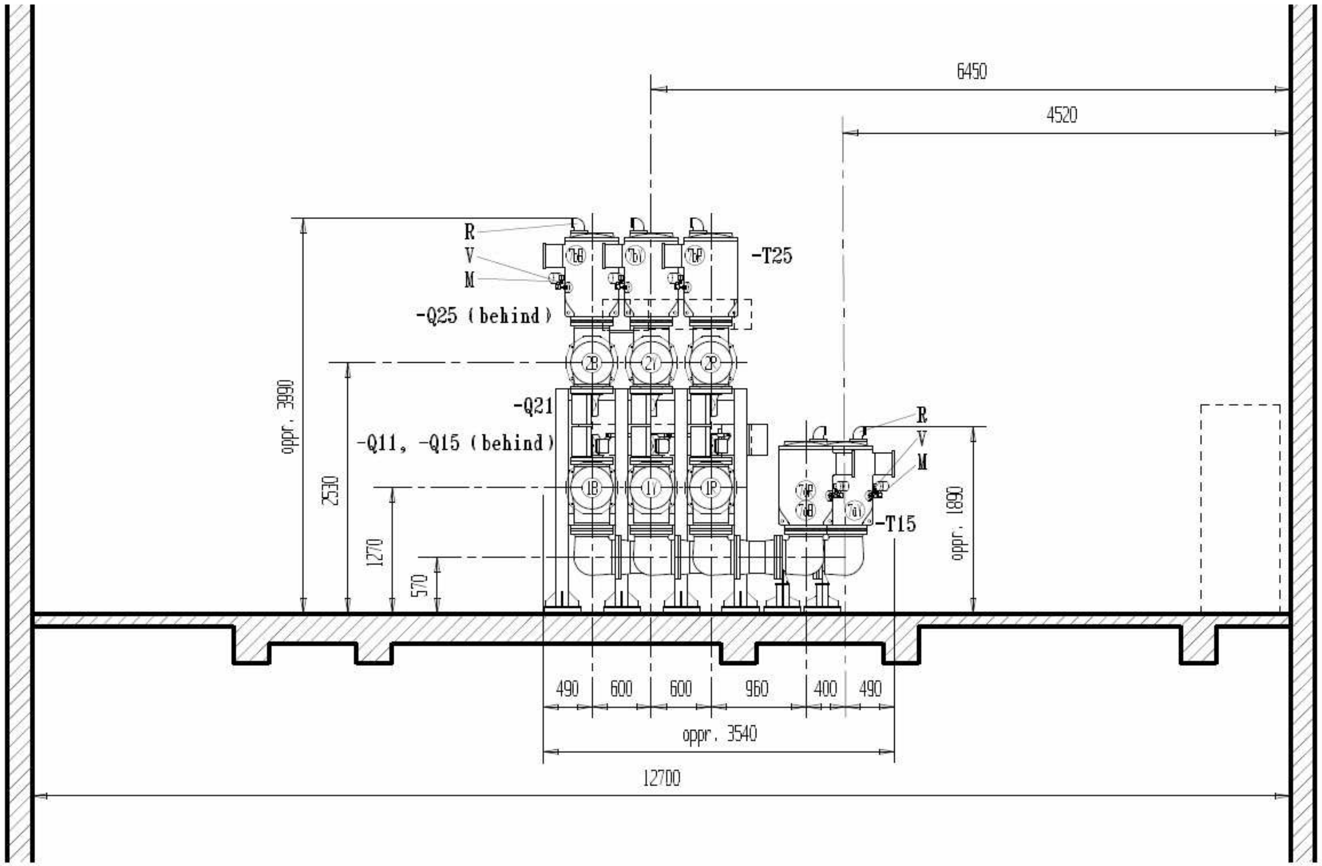
Legend:

-Q0:	Circuit breaker
-Q10:	Busbar disconnector No.1
-Q20:	Busbar disconnector No.2
-Q51:	Maintenance earthing switch No.1
-Q52:	Maintenance earthing switch No.2
-T1:	Current transformer
R:	Rupturing disk
M:	Contact manometer
F:	Gas filter
V:	Gas valve

Remarks:

1) The (N) numbers indicate the gas compartments.
2) The concrete floor of the GIS room shall be a horizontal surface with a tolerance of +0 / -10 mm.
3) Steel structures will be fixed to the floor by HILTI type anchoring bolts.

Figure 7: Section of Bus Coupler bay at BHILAI 220 kV GIS



Legend:

-Q11:	Disconnector of VT for busbar 1
-Q15:	High speed earthing switch for busbar 1
-Q21:	Disconnector of VT for busbar 2
-Q25:	High speed earthing switch for busbar 2
-T15:	Voltage transformer for busbar 1
-T25:	Voltage transformer for busbar 2
R:	Rupturing disk
M:	Contact manometer
F:	Gas filter
V:	Gas valve

Remarks:

1) The (N) numbers indicate the gas compartments.
2) The concrete floor of the GIS room shall be a horizontal surface with a tolerance of +0 / -10 mm.
3) Steel structures will be fixed to the floor by HILTI type anchoring bolts.

Figure 8: Section of Busbar Earthing and Measuring bay at BHILAI 220 kV GIS

3.1. Double busbars / Figure 4

All the bays are connected through double busbars, which are placed in single-phase housings above each other. The lower busbars (No.1) are in the height of 1270 mm; the upper busbars (No.2) are in the height of 2530 mm. The phase distance is 600 mm, the phase sequence: B, Y, R started from Q0 circuit breakers.

The busbars cannot be divided. Two sets of high speed earthing switches give possibilities to earth. Q15 can earth the lower busbar (No.1) and Q25 can earth the upper busbar (No.2). Each phase of both busbars is equipped with inductive type voltage transformers, which can be disconnected by manual operated disconnecting switches. T15 is connected through Q11 disconnector to busbar No.1 and T25 is connected through Q21 disconnector to of busbar No.2. These devices are arranged in the busbar earthing and measuring bay (=BAY-6).

The busbars are kept in their positions by steel structures. These support structures are connected through relative long anchoring bolts to the concrete floor. The threaded part of the anchoring bolts gives possibility to adjust the exact height above the floor level. All second supports are rigidly fixed (at BAY-1, 3, 5, 7, 9, 11); the others between them are sliding fixations (at BAY-2, 4, 6, 8, 10). At fixed supports the fixing screws between the switchgear legs and the head plate are tightened. At sliding supports the same screws are not tightened but adjusted and fixed by double nuts. The busbar sections between the fixed, unmoving flanges include flexible parts, so called compensators. These elements can balance the effects of the thermal dilatation and the little dimension differences caused by the manufacturing tolerances and by the inaccuracies of the civil works. The length of each two-bay long section of the busbars is adjusted and fixed by four steel tension rods, which are placed symmetrically. The removable parts of the compensators give possibility to dismounting of the busbars and removing sections without interfering with the neighbouring parts.

The gas volume of each busbar is divided into several gas compartments belonging to different bays. Each bay has got two gas compartments in each phase of the busbars. These are parts of the lower or upper busbars (see Figure No.2). The set of gas compartments No.1 belong to the lower busbar and contain Q1 busbar disconnectors and interconnecting elements between the neighbouring bays. The rupturing discs and the gas filters are placed in the earthing flanges of the tubes next to the X-houses of the Q1 busbar disconnectors. The contact manometers are arranged on the same tubes, on DN8 type gas valves of the flanges. The X-houses of the busbar disconnectors are equipped with DN20 type DILO valves. In like manner the set of gas compartments No.2 belong to the upper busbar and contain Q2 busbar disconnectors and interconnecting elements. Devices of the gas handling and protection are installed similarly to the other busbar.

3.2. Uniform parts of the different bays

The branch connections between busbars to each bay are carried out by busbar disconnectors (Q1 and Q2), which are integrated into the busbar sections. Between X-houses of these busbar disconnectors T-houses make connections on the earthing flanges of them are arranged Q51 maintenance earthing switches. These T-houses are connected through horizontal tubes to the lower connections of Q0 circuit breakers. The circuit breaker poles are arranged in vertical position. Each pole has its own independent hydraulic operating cylinder. The parts of the drives are enclosed in drive boxes below the CB-s. Each pole has two connections: the lower connection coming horizontally from the busbars and the higher, top connection, which starts vertically then changes direction into horizontal through a T-house and goes towards the "load" side of the feeder. Details about these parts can be found at the description of the different bays.

All circuit breakers are arranged along a line, and are fastened to steel beams. These support beams are connected through relative long anchoring bolts to the concrete floor of the 220 kV GIS room. The threaded parts of the anchoring bolts give possibility to adjust the exact height above the floor level.

The T-shape connection part represents independent gas compartment in each phase. This is the gas compartment No.3 of the bays (see Figure No.2). The rupturing disc and the gas filter are placed on the earthing flanges of the short tubes next to the CB. The contact manometer can be found on the flange of the next tube. One set DN20 valves are mounted on to the T-houses of Q51 maintenance earthing switch. All CB poles are independent gas compartments (gas compartment No.4), equipped with rupturing discs, contact manometers, DILO-valves and gas filters. The pressure of these gas compartments is higher than others. The contact manometers have got three secondary contacts, because there are independent additional contacts for the lockout function of the operation. The contact manometers are placed on DN20 type DILO valves, above the front side of the drive-box.

3.3. Incoming Cable bays (BAY-1, 3, 5, 8, 10, 11) / Figure 5

The Incoming Cable bays connect high voltage (single) cables to the GIS.

The busbar side with the busbar connections is described in the general chapters (see items 3.1 and 3.2). The top connections above the busbars run in the same height (3600 mm). The upper horizontal sections consist of Q52 maintenance earthing switches, T1 current transformers, linear tubes, X-houses with Q9 line disconnectors, and Q8 high speed earthing switches, short tubes, X-houses with Q6 disconnectors, which connect T5 voltage transformers and at the end one set of X-houses for connection of the cable sealing end enclosures. The cable sealing end enclosures are arranged in a triangle under the X-houses.

The upper part of the incoming cable bay is supported by the circuit breakers and by steel support structure next to the cable sealing ends. This is a sliding support, which gives possibility to a little horizontal movement because of the thermal dilatation of the horizontal tubes. The support structure is connected through relative long anchoring bolts to the concrete floor of the GIS room. The threaded part of the anchoring bolts give possibility to adjust the exact height above the floor level. The fixing screws between the switchgear legs and the upper beams are not tightened but adjusted and fixed by double nuts.

The gas compartments of the busbars and uniform parts are similar to the other bays. The next gas compartment No.5 include the enclosure elements of Q52 maintenance earthing switch, T1 current transformer Q9 line disconnector and Q8 high-speed earthing switch. The rupturing disc, the gas filter and the contact manometer are arranged on the T-house of Q51 maintenance earthing switch, above the circuit breaker. One set of DN20 type gas valves is placed on the X-houses of the line switches. The gas compartment No.6 includes the cable sealing end enclosure, the X-house above them, the X-house of Q6 disconnector and the tube up to the line switches. The rupturing disk, the gas filter, the contact manometer and the gas valve are arranged on the X-house above the cable termination. The gas compartment No.7 is the voltage transformer.

3.4. Transformer bays (BAY-2, 4, 9) / Figure 6

The Transformer bays make connection through high-voltage cables between the gas insulated switchgear and the main transformers.

The busbar side with the busbar connections is described in the general chapters (see items 3.1 and 3.2). The top connections above the busbars run in the same height (3600 mm). The upper horizontal sections consist of Q52 maintenance earthing switches, T1 current transformers, linear tubes, X-houses with Q9 line disconnectors, and Q8 high speed earthing switches, short tubes and at the end one set of X-houses for connection of the cable sealing end enclosures. The cable sealing end enclosures are arranged in a triangle under the X-houses.

The upper part of the transformer bay is supported the same way as the incoming cable bay (see item 3.3).

The gas compartments of the busbars and uniform parts are similar to the other bays. The next gas compartment No.5 include the enclosure elements of Q52 maintenance earthing switch, T1 current transformer Q9 line disconnector and Q8 high-speed earthing switch. The rupturing disc, the gas filter and the contact manometer are arranged on the T-house of Q51 maintenance earthing switch, above the circuit breaker. One set of DN20 type gas valves is placed on the X-houses of the line switches. The gas compartment No.6 includes the cable sealing end enclosure, the X-house above them and the tube up to the line switches. The rupturing disk, the gas filter, the contact manometer and the gas valve are arranged on the X-house above the cable termination.

3.5. Bus coupler bays (BAY-7) / Figure 7

The Bus Coupler bay can connect the two busbars. The busbars and Q0 circuit breaker seem to be similar as described in the general chapter (See items 3.1 and 3.2). But there are important differences: inside the T-houses of Q51 maintenance earthing switches between the busbars there aren't any electrical connections to the upper busbars. There are aluminium splitting discs instead of the support insulator discs between the T-shape interconnecting parts and the reserve busbars. So the lower side connections of the CB can run through Q10 busbar disconnector only towards the main busbars. The higher connections turn into horizontal at the T-houses above the CB, which include Q52 maintenance earthing switches and runs through T1 current transformers up to the lines of the busbars, where are located in other T-houses Q20 disconnector switches of the upper busbars. Vertical tubes and X-houses of the busbar connections can be found under these disconnectors.

There is no any special steel structure in this bay, only the usual busbar supports and the base frame of the circuit breaker.

The gas compartments of the main busbars, the circuit breakers and the connection parts between the lower busbars and the circuit breakers are similar to the other bays. The gas compartments of the upper busbar (No.2) are bigger than at the other bays, because the higher position of Q20 busbar disconnector switches. The T-houses above Q0 circuit breaker poles T1 current transformers and the short tubes up to the busbar disconnectors represent the gas compartments No.5. Rupturing disc, gas density monitor, gas filter and DN20 type DILO valve are placed at the T-house above the CB.

3.6. Busbar Earthing and Measuring bay (BAY-6) / Figure 8

The busbars include two sets of high-speed earthing switches: Q15 on the lower busbar (No.1) and Q25 on the upper busbar (No.2). Additionally both busbars include inductive type voltage transformers, which are connected through manual operated disconnectors. T15 is connected through Q11 to busbar No.1 and T25 is connected trough Q21 to busbar No.2.

The Busbar Earthing and Measuring bay includes unique support structures under the voltage transformers.

The Busbar Earthing and measuring bay have got only two sets of independent gas compartments: the two sets of voltage transformers. The busbar sections of this bay are connected to the busbar sections of the neighbouring bay (BAY-7: Bus Coupler bay). The voltage transformers are independent compartments: T15 is the gas compartment No.7a and T16 is the gas compartment No.7b. The voltage transformers are equipped with rupturing disk, contact manometer; DN20 and DN8 type DILO valves as well.

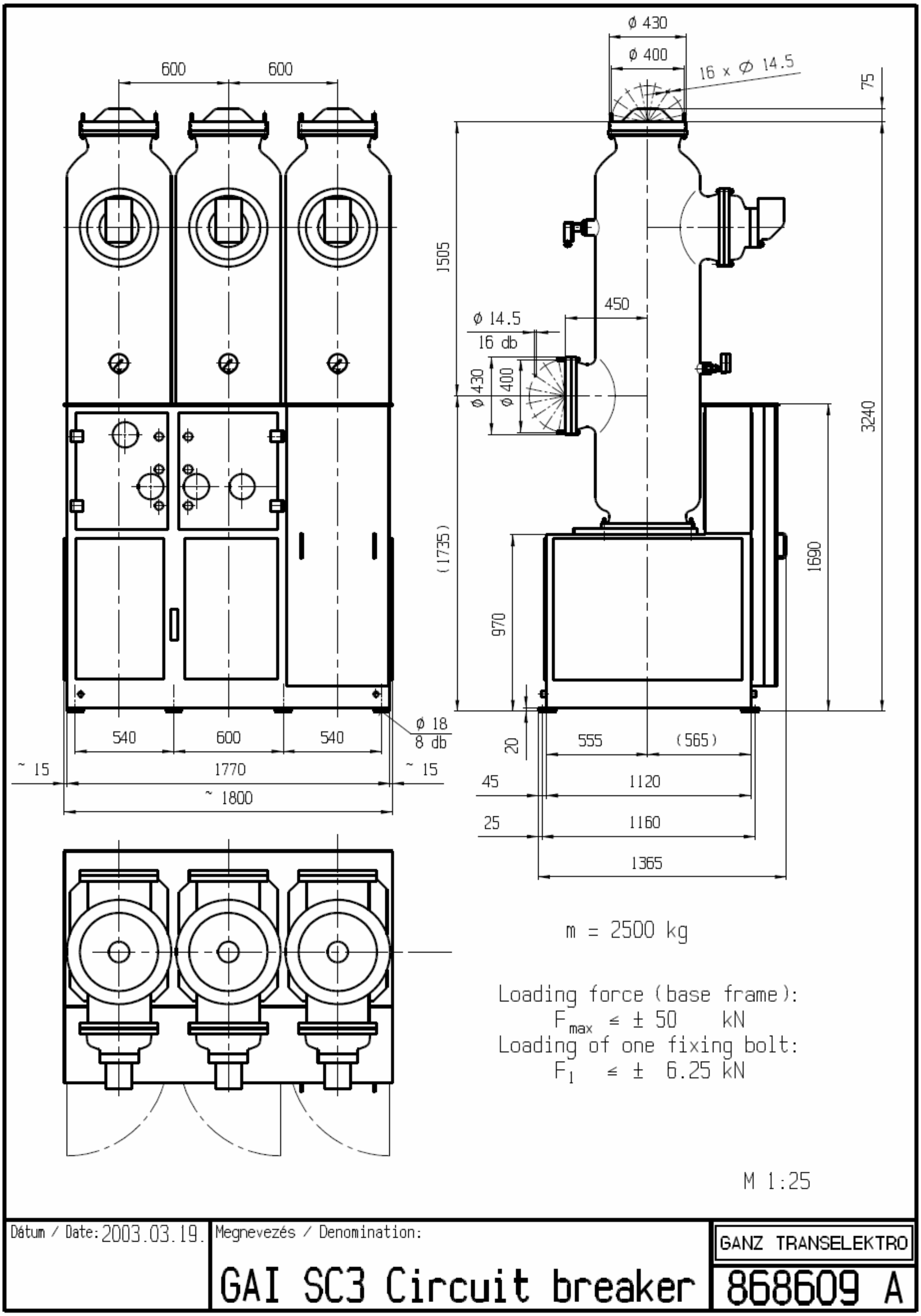
4. Construction of main components

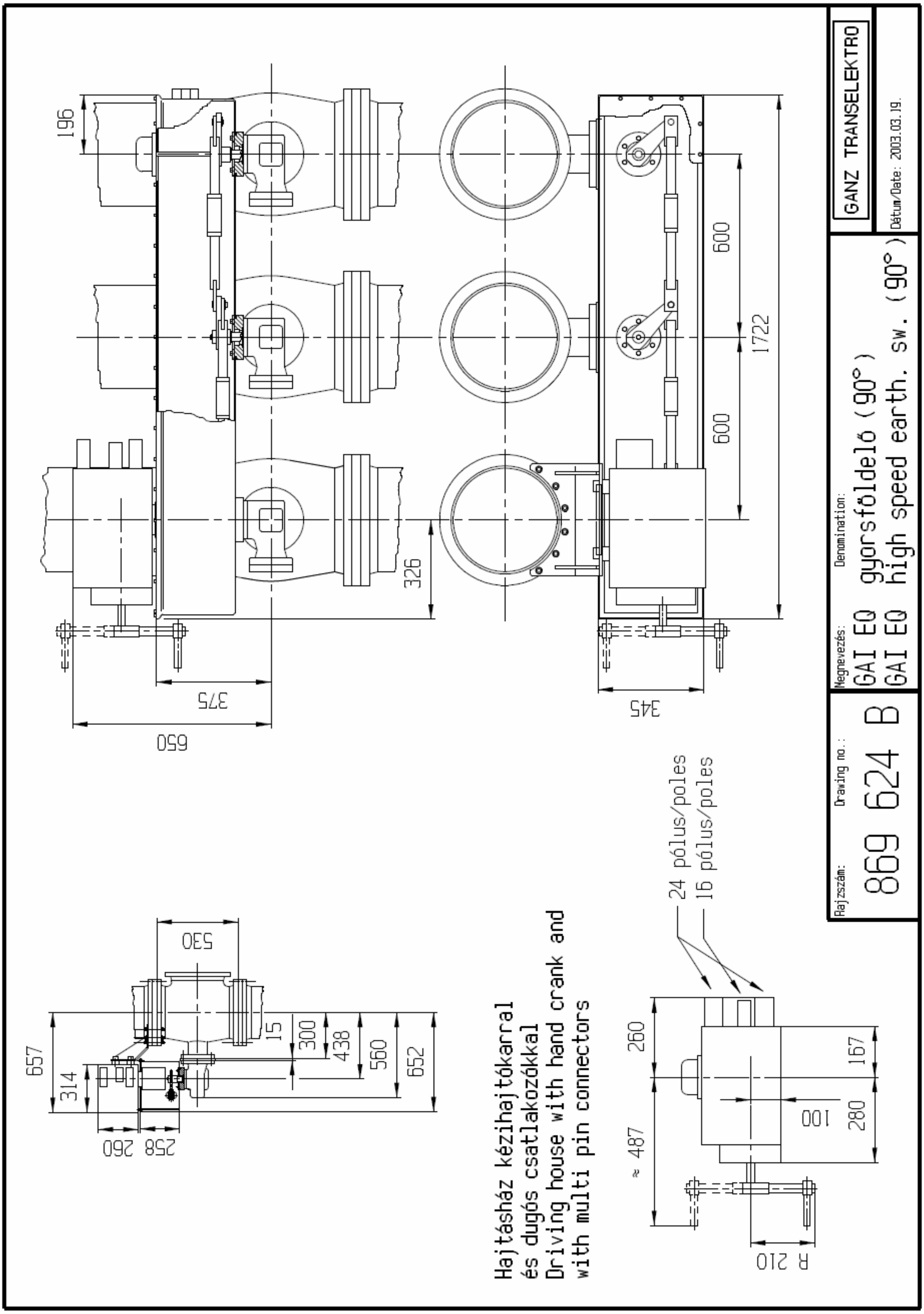
The general description and the instructions for operation and maintenance of the main components can be found in separate "operational, commissioning and maintenance manuals". In case of replacement or extension the nameplates data of all equipment have to be carefully studied.

4.1. Drawings of components

The drawings of the main components are listed below:

- Circuit breakers (GAI SC3)
  - Outline drawing 868609A
- High speed earthing switches (GAI EQ3)
  - Outline drawing of normal (90°) arrangement 869624B
  - Outline drawing of diagonal (45°) arrangement..... .... 869625B
- Disconnectors (GAI IB3, IC3, IL3)
  - Outline drawing of normal (90°) arrangement 869617C
  - Outline drawing of diagonal (45°) arrangement..... .... 869618C
- Maintenance earthing switches (GAI EG3)
  - Outline drawing 869620B
- Maintenance earthing switches (GAI EM3)
  - Outline drawing of normal (90°) arrangement 869621C
- Current transformers (GAI TI3)
  - Outline drawing 868210C
- Voltage transformers (SVR-20A made by NISSIN)
  - Outline drawing DN-35950
- Rupturing disc assembly
  - Outline drawing 870948A
- Contact manometer assemblies
  - Outline drawing of linear (180°) arrangement 870944A
  - Outline drawing of normal (90°) arrangement 870945
- Contact manometers
  - Outline drawing and data sheet at circuit breakers 870003E/11


m = 2500 kg
Loading force (base frame):
F_{max} ≤ ± 50 kN
Loading of one fixing bolt:
F_1 ≤ ± 6.25 kN
M 1:25
Dátum / Date: 2003.03.19.
Megnevezés / Denomination:
GAI SC3 Circuit breaker
GANZ TRANSELEKTRO
868609 A


GANZ TRANSELEKTRO
Dátum/Date: 2003.03.19.
Rajzszám: Drawing no.:
869 624 B
Megnevezés: Denomination:
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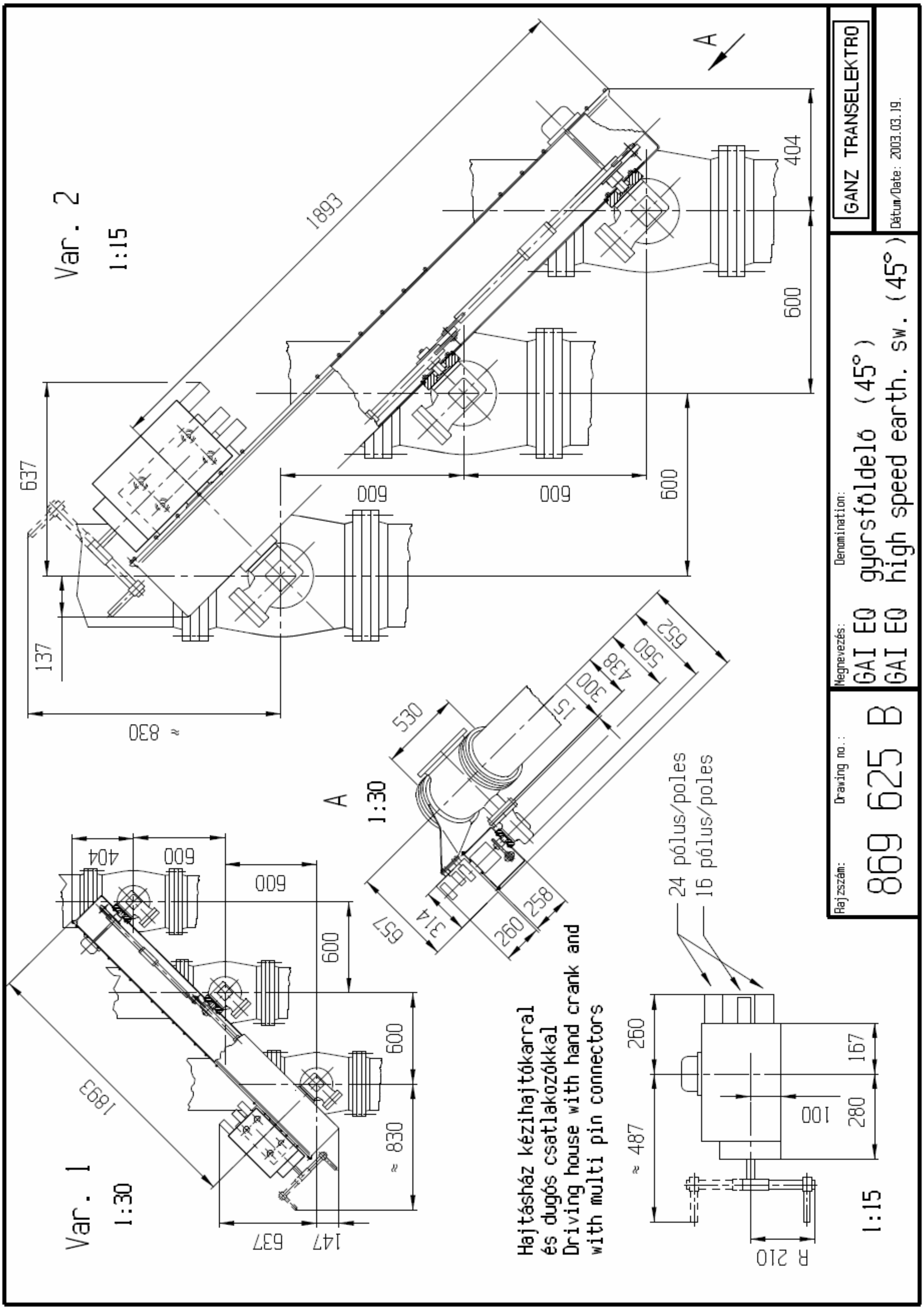
GAI EQ high speed earth. sw. (90°)
Hajtásház kézihajtókarral
és dugós csatlakozókkal
Driving house with hand crank and
with multi pin connectors
24 pólus/poles
16 pólus/poles
196
600
600
1722
326
375
650
345
530
657
314
15
300
438
560
652
258
260
260
167
≈ 487
100
280
R 210


Var. 2
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Var. 1
1:30
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1:30
1:15
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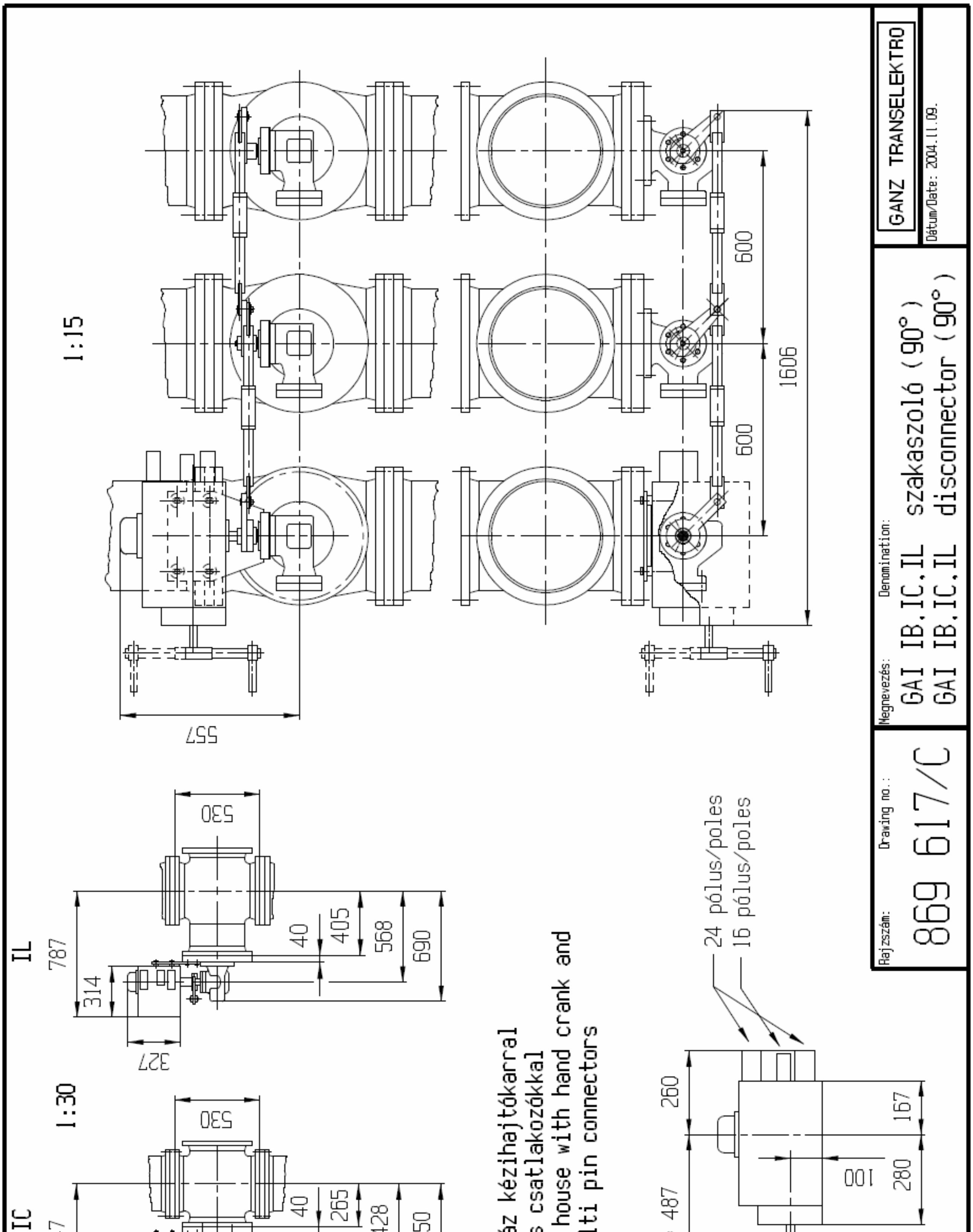
137
≈ 830
600
404
530
652
560
438
300
15
657
314
260
258
260
≈ 487
167
280
100
R 210
147
24 pólus/poles
16 pólus/poles
Hajtásház kézihajtókarral
és dugós csatlakozókkal
Driving house with hand crank and
with multi pin connectors
Rajzszám:
Drawing no.:
869 625 B
Megnevezés:
Denomination:
GAI EQ gyorsföldelő (45°)
GAI EQ high speed earth. sw. (45°)
GANZ TRANSELEKTRO
Dátum/Date: 2003.03.19.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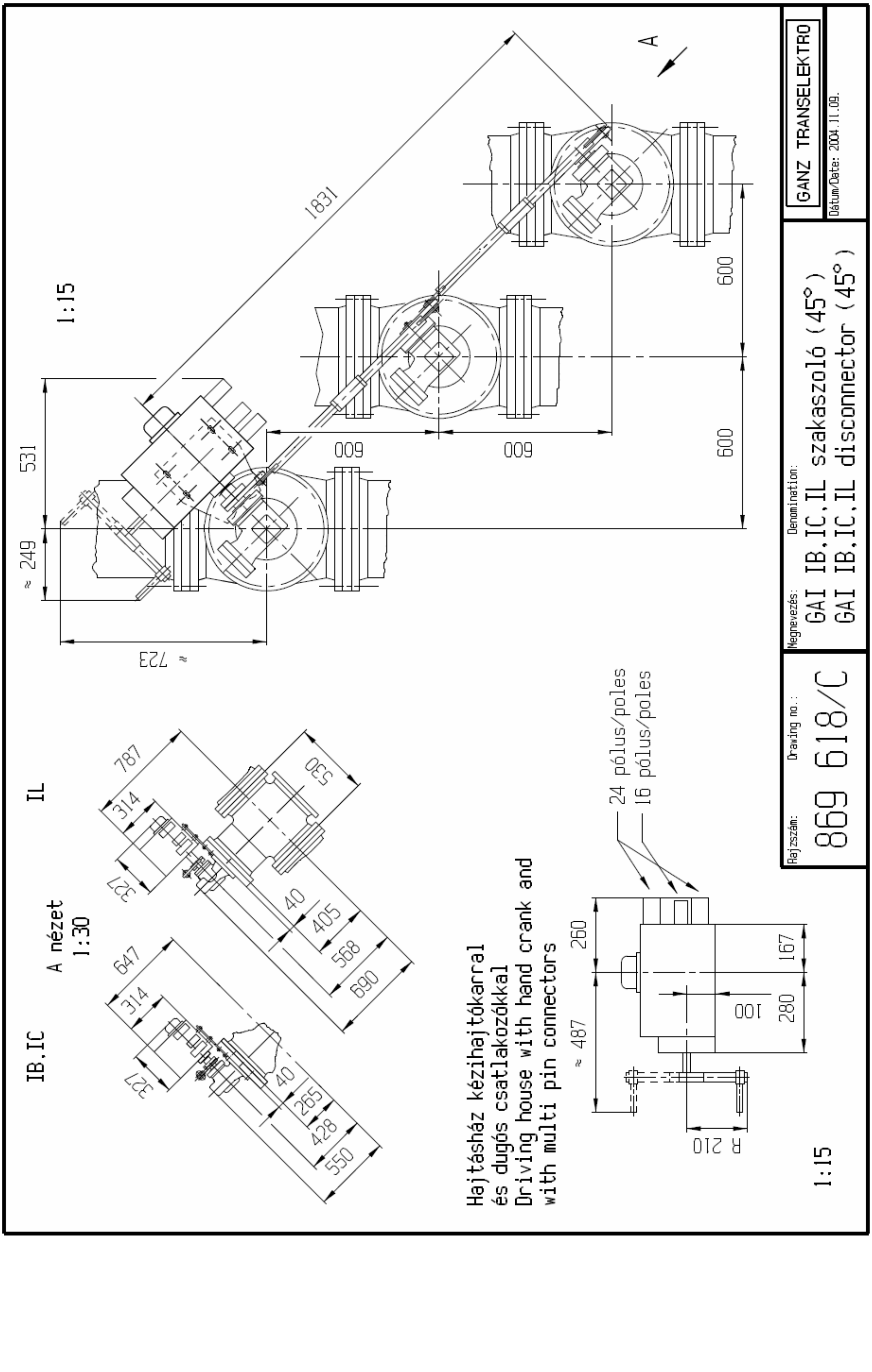
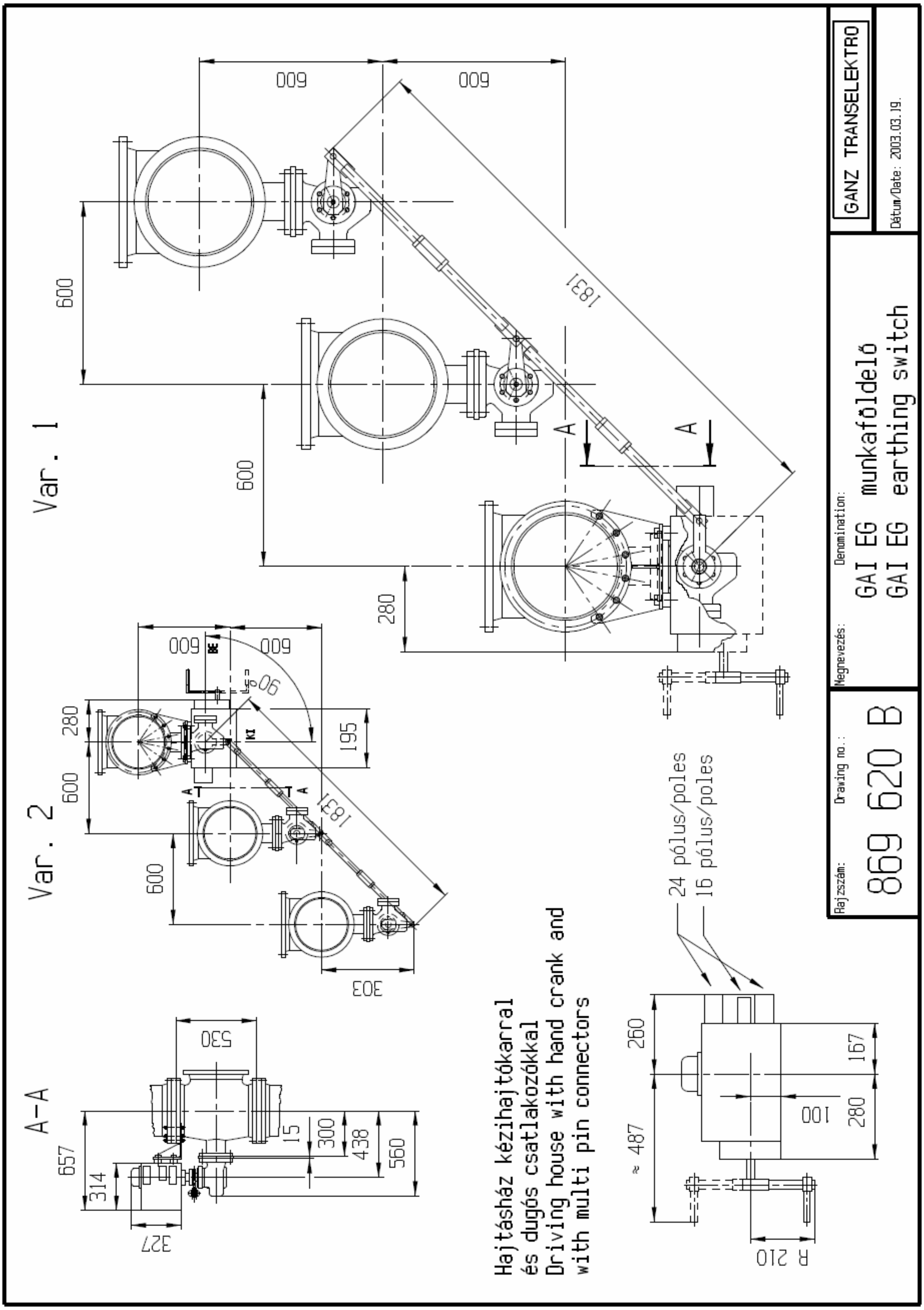
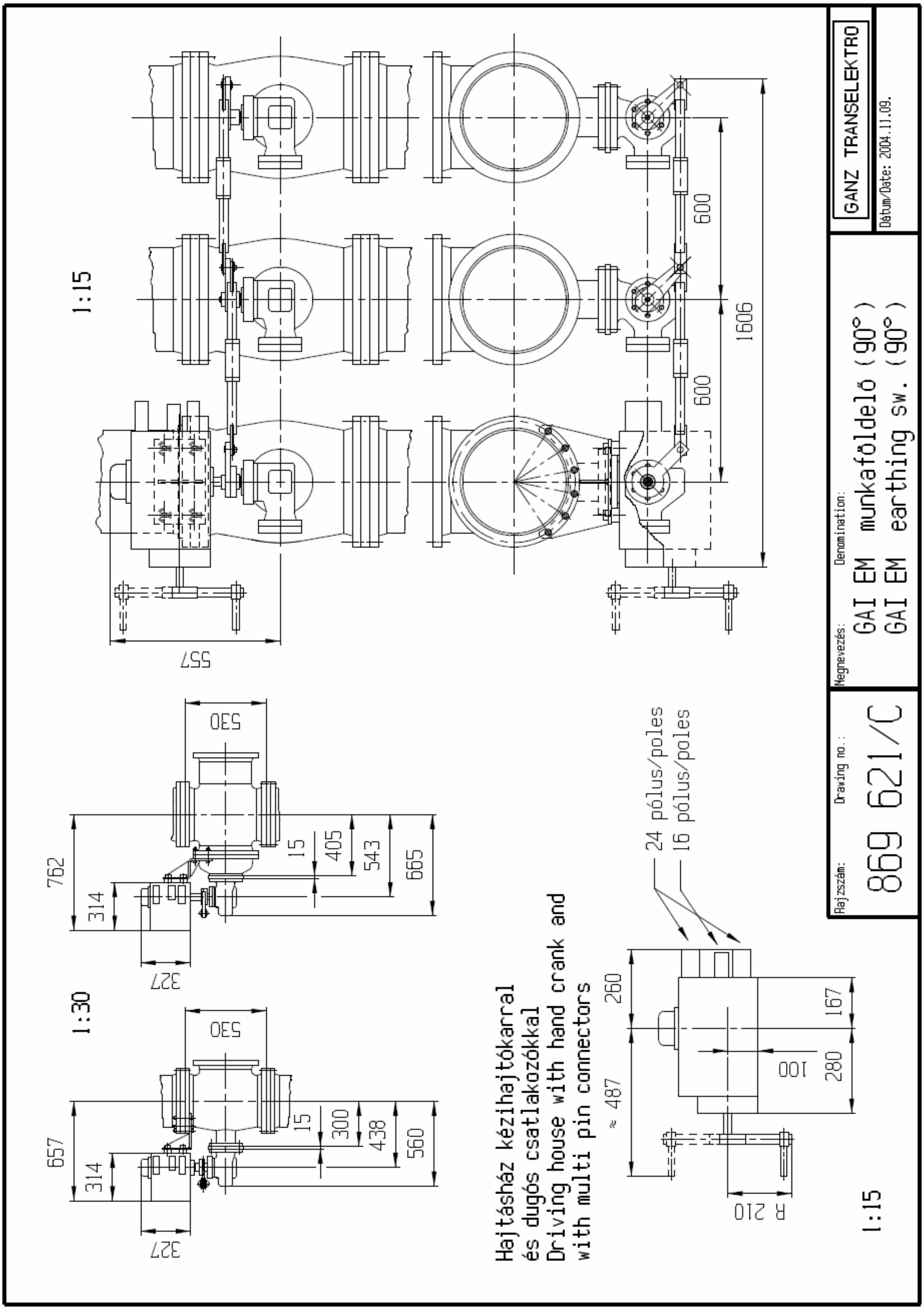
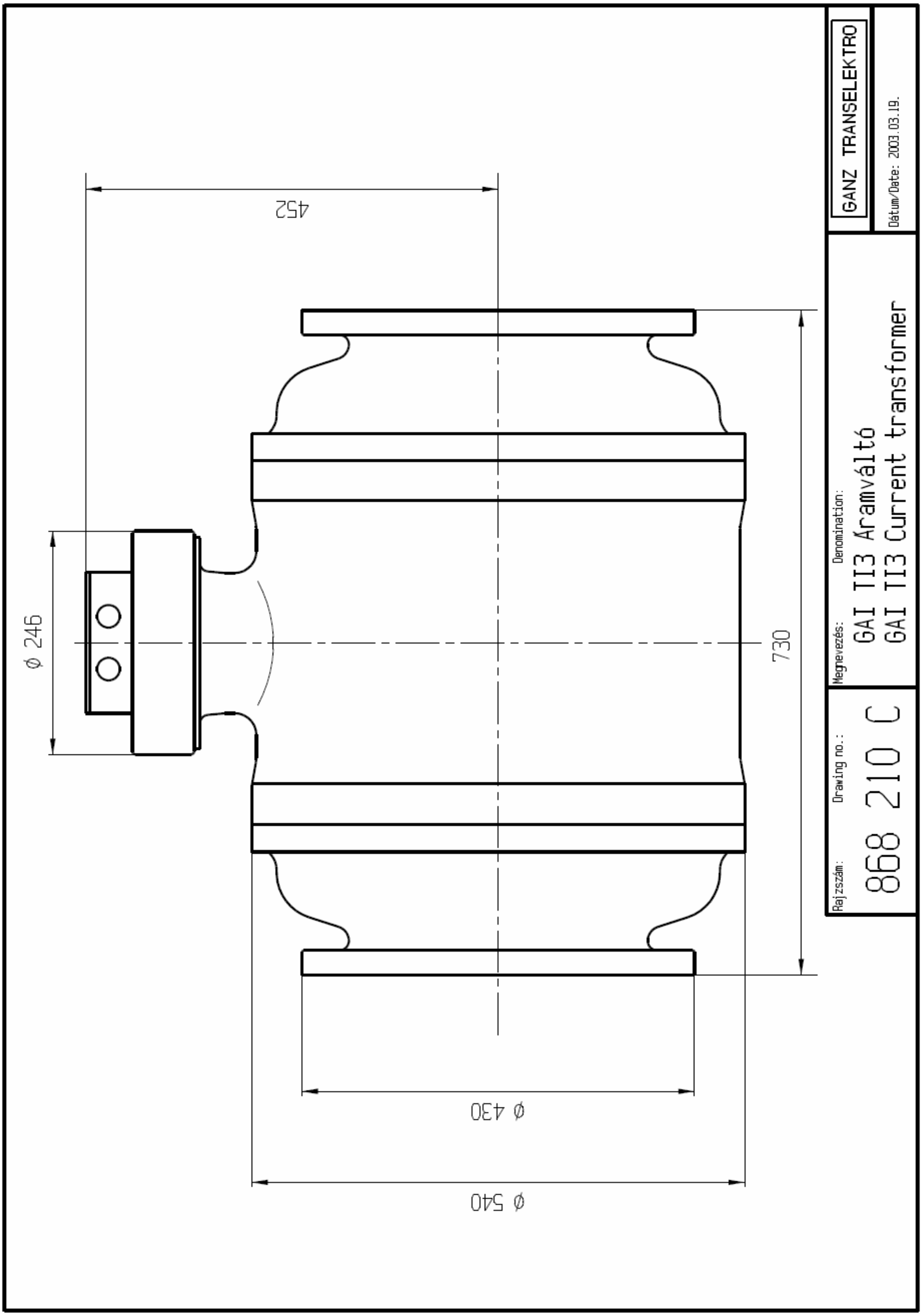
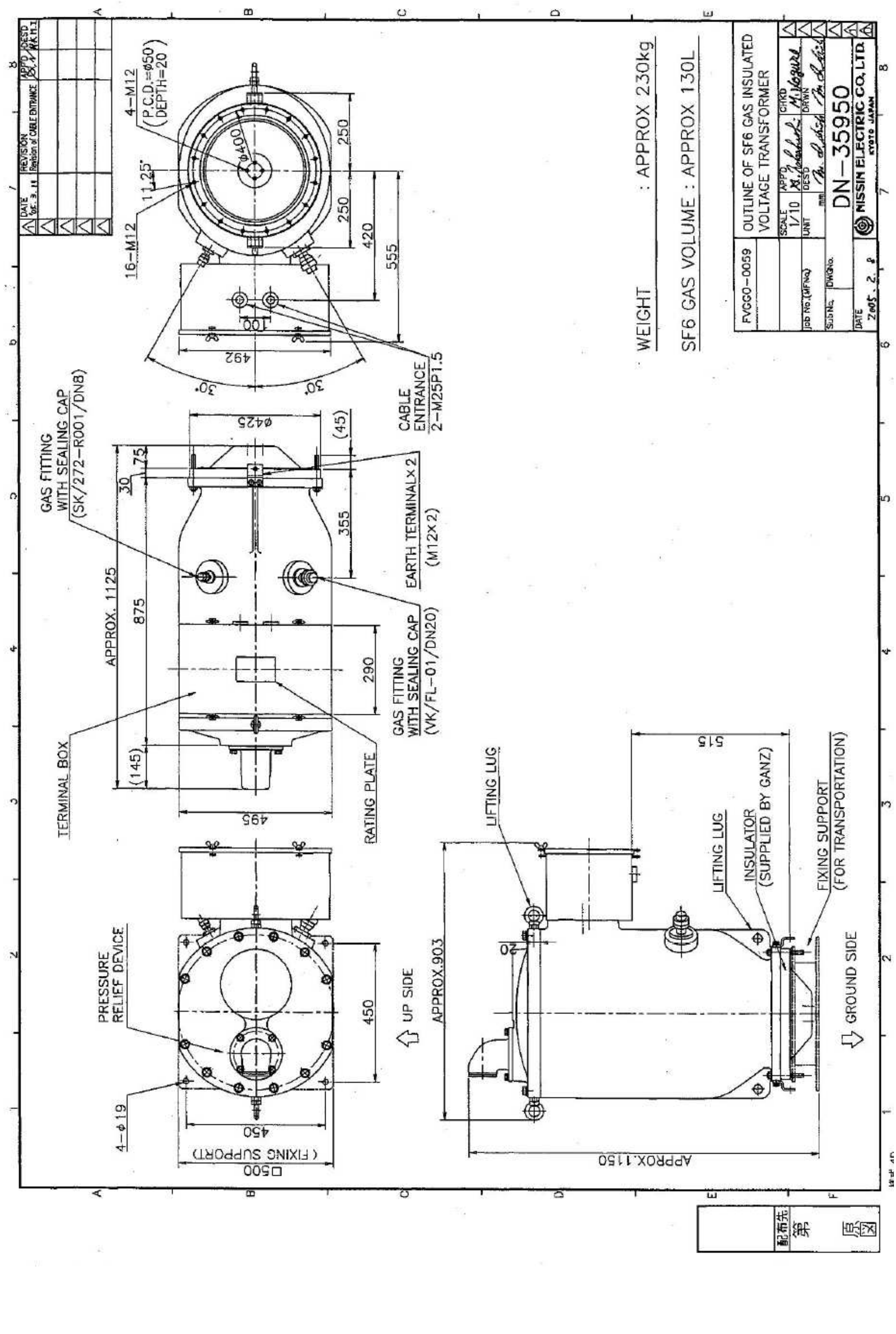
557
600
600
1606
IL
787
314
327
530
40
405
568
690
IB:IC
1:30
647
314
327
530
40
265
428
550
Hajtásház kézihajtókarral
és dugós csatlakozókkal
Driving house with hand crank and
with multi pin connectors
24 pólus/poles
16 pólus/poles
260
≈ 487
167
280
100
R 210
1:15
Rajzszám:
Drawing no.:
869 617/C
Megnevezés:
Denomination:
GAI IB,IC,IL szakaszoló (90°)
GAI IB,IC,IL disconnector (90°)
GANZ TRANSELEKTRO
Dátum/Date: 2004.11.09.

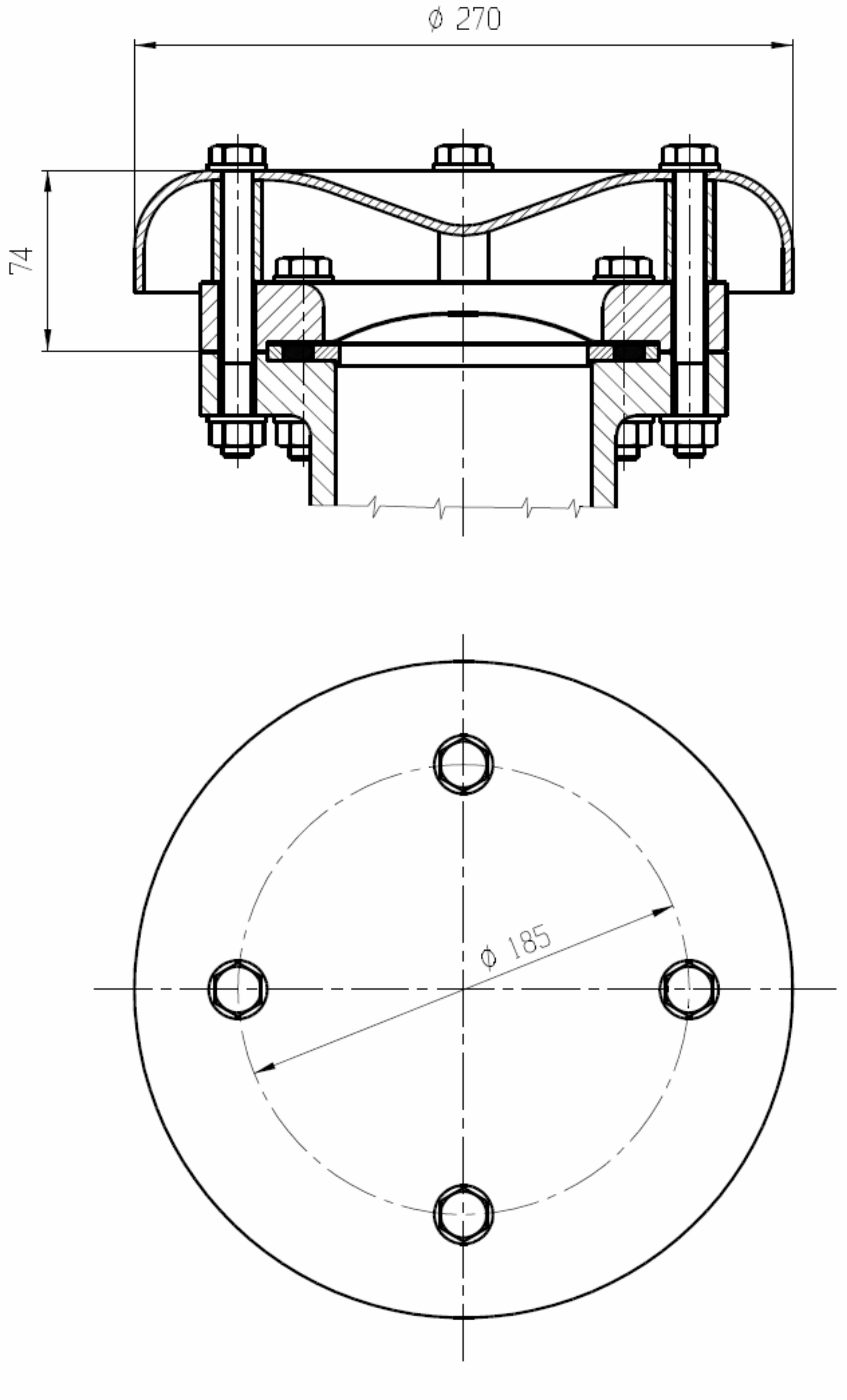

1:15
1831
A
531
≈ 249
≈ 723
600
600
600
600
IB.IC
A nézet
1:30
IL
787
314
327
40
405
568
690
530
647
314
327
40
265
428
550
Hajtásház kézihajtókarral
és dugós csatlakozókkal
Driving house with hand crank and
with multi pin connectors
24 pólus/poles
16 pólus/poles
260
≈ 487
167
100
280
R 210
1:15
GANZ TRANSELEKTRO
Dátum/Date: 2004.11.09.
Megnevezés:
Denomination:
GAI IB,IC,IL szakaszoló (45°)
GAI IB,IC,IL disconnector (45°)
Rajzszám:
Drawing no.:
869 618/C


Var. 1
Var. 2
A-A
Hajtásház kézihajtókarral
és dugós csatlakozókkal
Driving house with hand crank and
with multi pin connectors
24 pólus/poles
16 pólus/poles
GANZ TRANSELEKTRO
Dátum/Date: 2003.03.19.
Megnevezés:
Denomination:
GAI EG munkaföldelő
GAI EG earthing switch
Rajzszám:
Drawing no.:
869 620 B

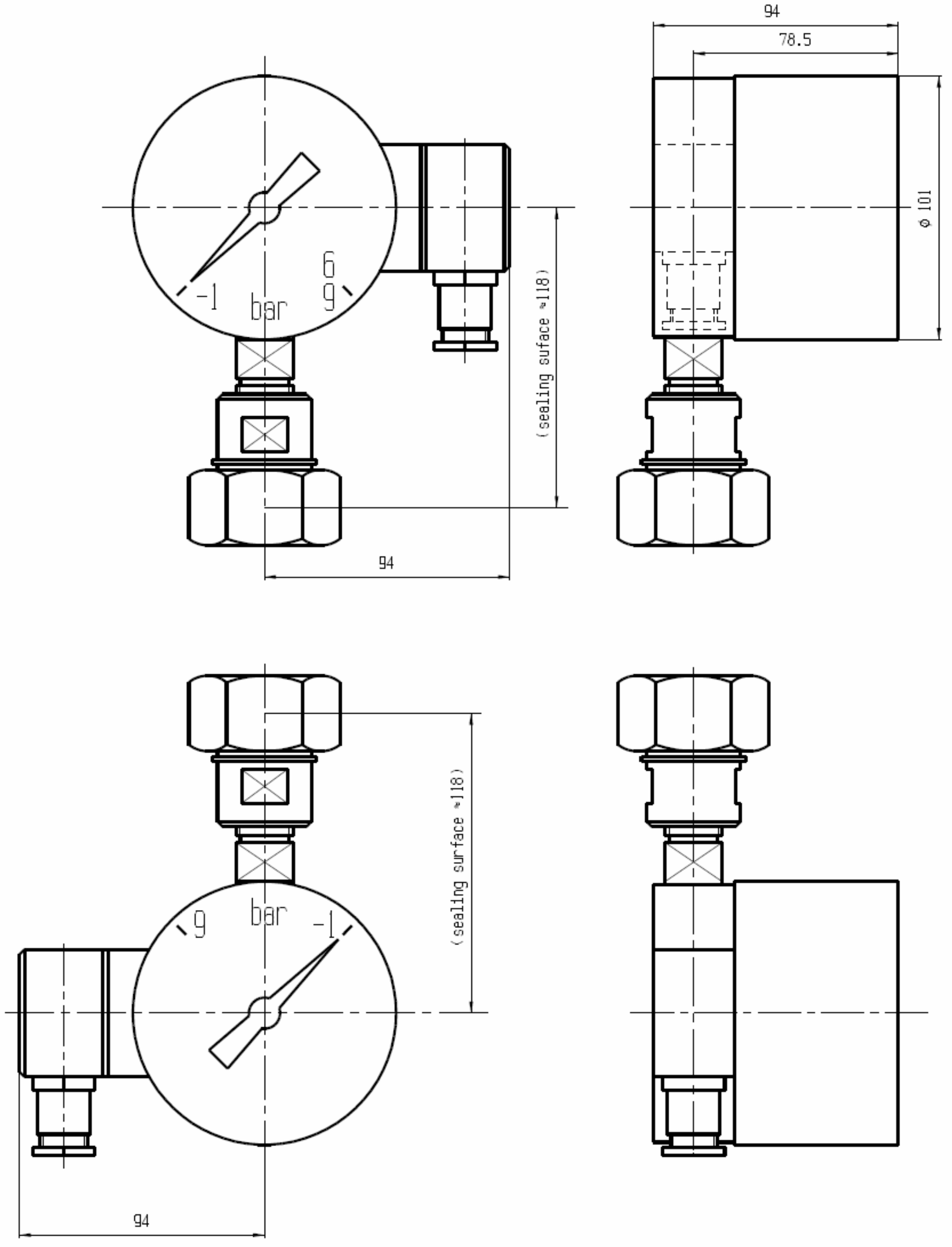

1:15
1:30
Hajtásház kézihajtókarral
és dugós csatlakozókkal
Driving house with hand crank and
with multi pin connectors
24 pólus/poles
16 pólus/poles
1:15
GANZ TRANSELEKTRO
Dátum/Date: 2004.11.09.
Rajzszám: Drawing no.:
869 621/C
Megnevezés: Denomination:
GAI EM munkaföldelő (90°)
GAI EM earthing sw. (90°)


GANZ TRANSELEKTRO
Dátum/Date: 2003.03.19.
Megnevezés: Denomination:
GAI TI3 Áramváltó
GAI TI3 Current transformer
Rajzszám: Drawing no.:
868 210 C
452
ø 246
730
ø 430
ø 540

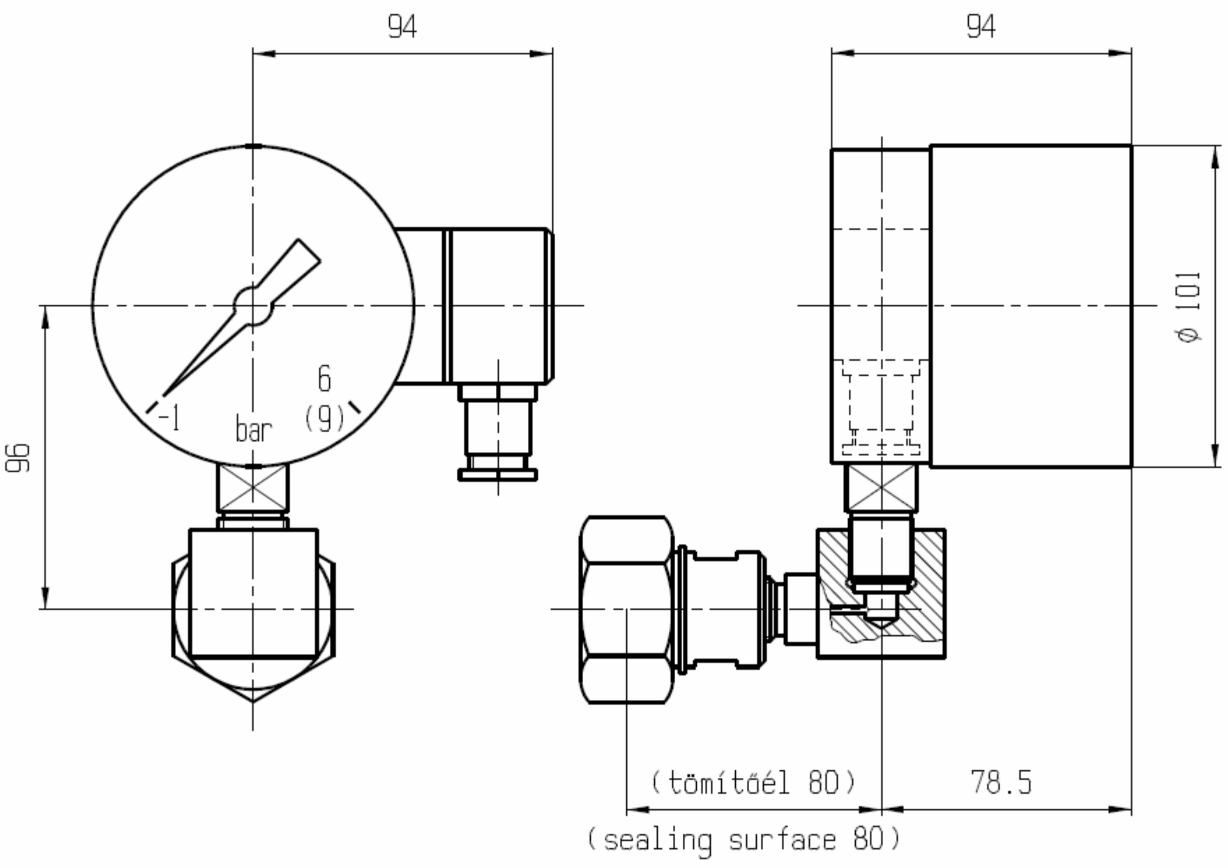

WEIGHT : APPROX 230kg
SF6 GAS VOLUME : APPROX 130L
OUTLINE OF SF6 GAS INSULATED VOLTAGE TRANSFORMER
SCALE 1/10
FVGG0-0059
DN-35950
NISSIN ELECTRIC CO., LTD.
KYOTO JAPAN
REVISION
Revision of CABLE ENTRANCE
4-M12
(P.C.D.=φ50 DEPTH=20)
16-M12
11.25°
φ400
250
250
420
555
100
492
30°
30°
CABLE ENTRANCE
2-M25P1.5
GAS FITTING
WITH SEALING CAP
(SK/272-R001/DN8)
φ425
(45)
75
30
355
EARTH TERMINAL×2
(M12×2)
APPROX. 1125
875
GAS FITTING
WITH SEALING CAP
(VK/FL-01/DN20)
290
TERMINAL BOX
(145)
RATING PLATE
495
LIFTING LUG
515
LIFTING LUG
INSULATOR
(SUPPLIED BY GANZ)
FIXING SUPPORT
(FOR TRANSPORTATION)
PRESSURE
RELIEF DEVICE
450
UP SIDE
APPROX.903
20
GROUND SIDE
4-φ19
450
(FIXING SUPPORT)
□500
APPROX.1150



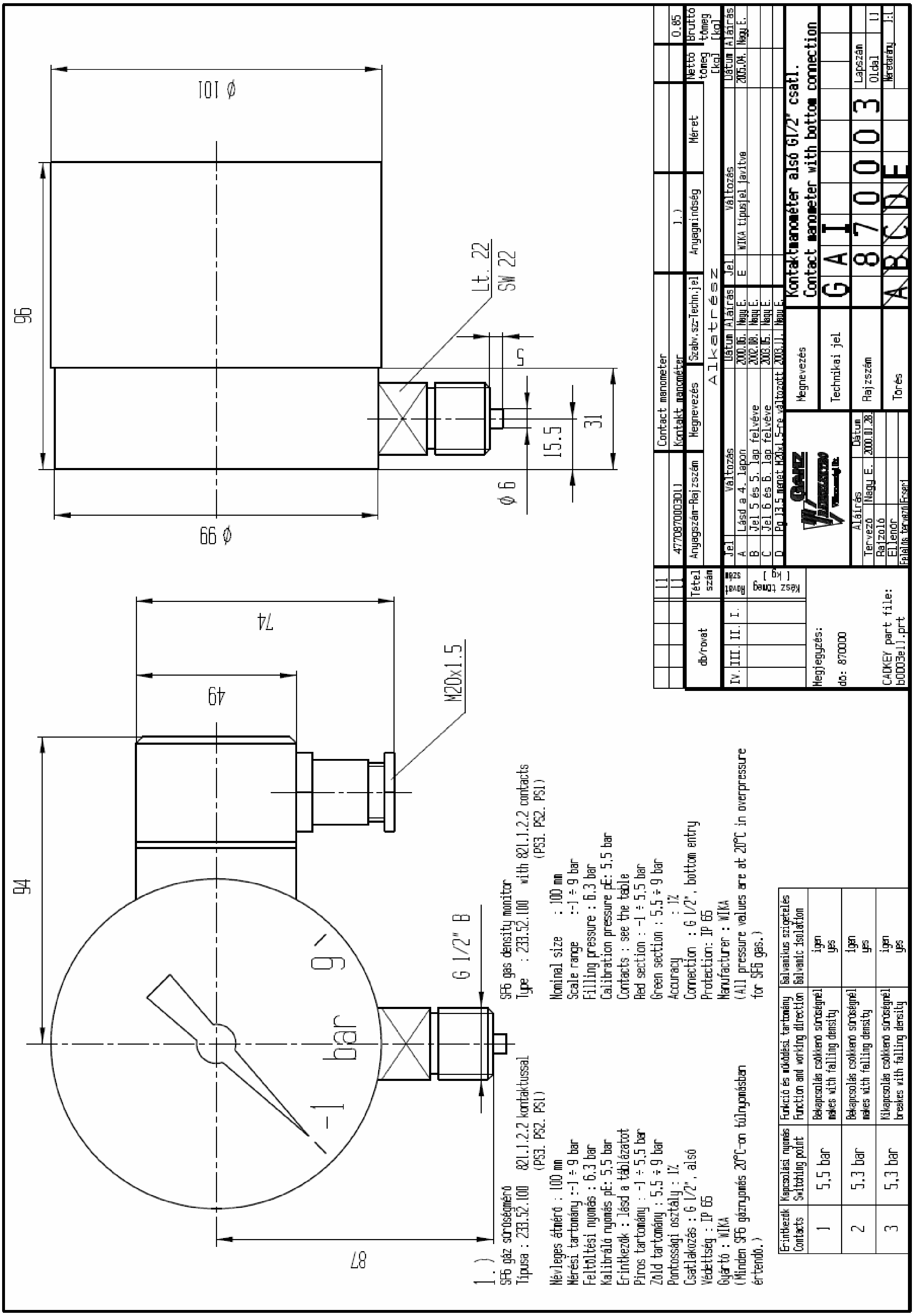
Dátum / Date: 2008.06.27.	Megnevezés / Denomination:	GANZ TRANSELEKTRO
CADKEY part file: b0948a.prt	GAI XB Hasadó tárcsa GAI XB Bursting disc	870948A

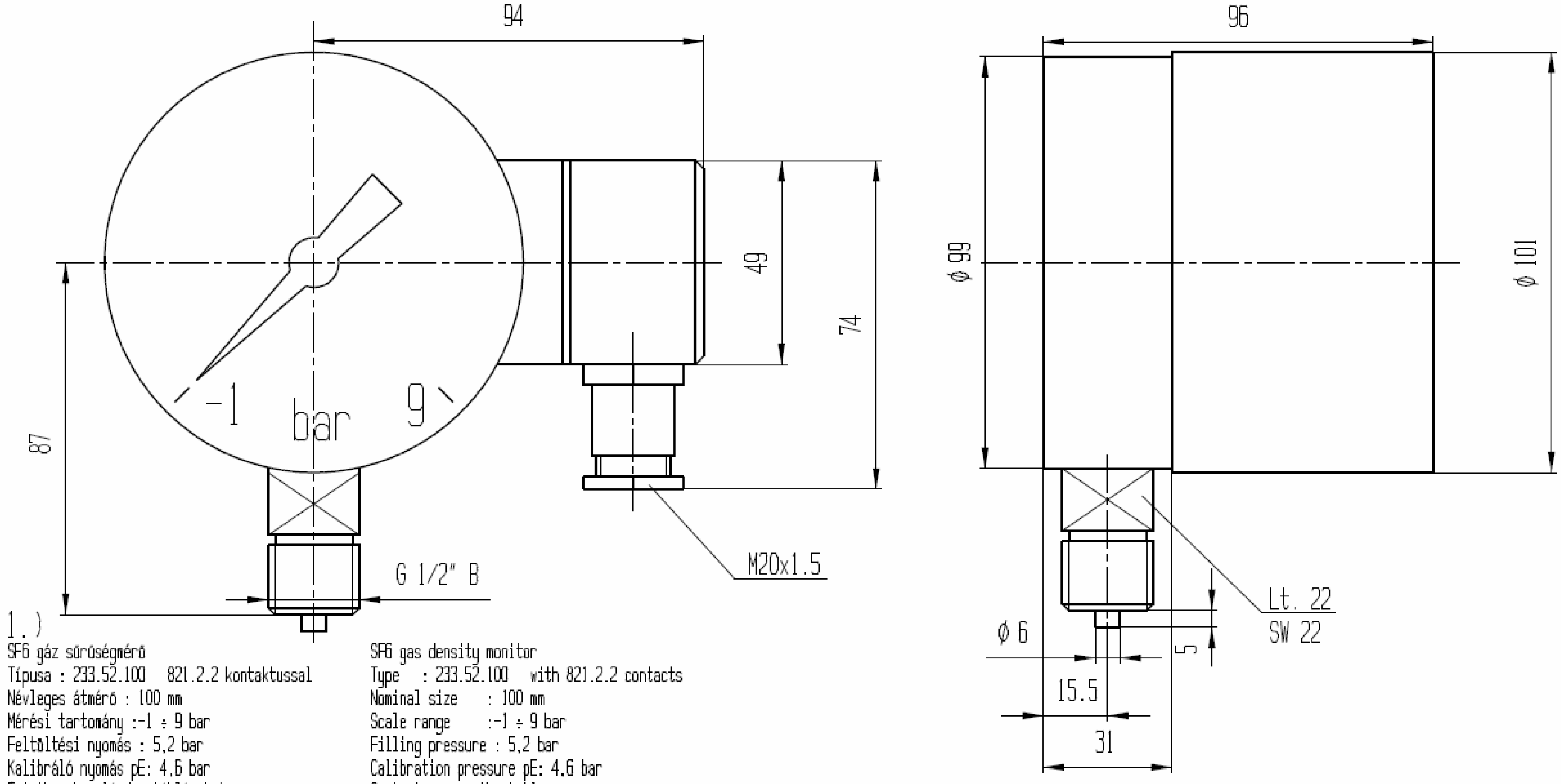


Dátum / Date: 2008.06.27. CADKEY part file: b0944a.prt	Megnevezés / Denomination: GAI Kontaktmanométer (egyenes) GAI Contact pressure gauge (linear)	GANZ TRANSELEKTRO 870944A



Dátum / Date: 2004.03.10.	Megnevezés / Denomination:	GANZ TRANSELEKTRO
CADKEY part file: b0945-.prt	GAI Kontaktmanométer (sarok) GAI Contact pressure gauge (corner)	870945


94
96
49
74
87
ø 99
ø 101
-1 bar 9
G 1/2" B
M20x1.5
Lt. 22
SW 22
ø 6
5
15.5
31
1.)
SF6 gáz sűrűségmérő
Típusa : 233.52.100 821.1.2.2 kontaktussal
(PS3. PS2. PS1)
Névleges átmérő : 100 mm
Mérési tartomány :-1 ÷ 9 bar
Feltöltési nyomás : 6,3 bar
Kalibráló nyomás pE: 5,5 bar
Érintkezők : lásd a táblázatot
Piros tartomány : -1 ÷ 5,5 bar
Zöld tartomány : 5,5 ÷ 9 bar
Pontossági osztály : 1%
Csatlakozás : G 1/2", alsó
Védettség : IP 65
Gyártó : WIKA
(Minden SF6 gáznyomás 20°C-on túlnyomásban értendő.)
SF6 gas density monitor
Type : 233.52.100 with 821.1.2.2 contacts
(PS3. PS2. PS1)
Nominal size : 100 mm
Scale range : -1 ÷ 9 bar
Filling pressure : 6,3 bar
Calibration pressure pE: 5,5 bar
Contacts : see the table
Red section : -1 ÷ 5,5 bar
Green section : 5,5 ÷ 9 bar
Accuracy : 1%
Connection : G 1/2", bottom entry
Protection: IP 65
Manufacturer : WIKA
(All pressure values are at 20°C in overpressure for SF6 gas.)
Érintkezők Contacts | Kapcsolási nyomás Switching point | Funkció és működési tartomány Function and working direction | Galvanikus szigetelés Galvanic isolation
1 | 5,5 bar | Bekapcsolás csökkenő sűrűségnél makes with falling density | igen yes
2 | 5,3 bar | Bekapcsolás csökkenő sűrűségnél makes with falling density | igen yes
3 | 5,3 bar | Kikapcsolás csökkenő sűrűségnél breakes with falling density | igen yes
db/rovat
IV. III. II. I.
Tétel szám
Rovat szám
Kész tömeg [kg]
11
11
47708700003011
Anyagszám-Rajzszám
Contact manometer
Kontakt manométer
Megnevezés
Szabv.sz-Techn.jel
1.)
Anyagminőség
Méret
0.85
Nettó tömeg [kg]
Bruttó tömeg [kg]
Alkatrész
Jel | Változás | Dátum | Aláírás
A | Lásd a 4. lapon | 2000.06. | Nagy E.
B | Jel 5 és 5. lap felvéve | 2002.08. | Nagy E.
C | Jel 6 és 6. lap felvéve | 2003.05. | Nagy E.
D | Pg 13,5 menet M20x1,5-re változott | 2003.11. | Nagy E.
E | WIKA típusjel javítva | 2005.04. | Nagy E.
Megjegyzés:
dö: 870000
CADKEY part file:
b0D03e11.prt
GANZ
Aláírás
Dátum
Tervező
Nagy E.
2000.01.28.
Rajzoló
Ellenőr
Felelős tervező
Ecseri
Megnevezés
Kontaktmanométer alsó G1/2" csatl.
Contact manometer with bottom connection
Technikai jel
G A I
Rajzszám
8 7 0 0 0 3
Törés
A B C D E
Lapszám
Oldal
11
Méretarány
1:1



1.)

SF6 gáz sűrűségmérő
Típusa : 233.52.100 821.2.2 kontaktussal
Névleges átmérő : 100 mm
Mérési tartomány :-1 ÷ 9 bar
Feltöltési nyomás : 5,2 bar
Kalibráló nyomás pE: 4,6 bar
Érintkezők : lásd a táblázatot
Piros tartomány : -1 ÷ 4,6 bar
Zöld tartomány : 4,6 ÷ 9 bar
Pontossági osztály : 1%
Csatlakozás : G 1/2", alsó
Védettség : IP 65
Gyártó : WIKA
(Minden SF6 gáznyomás 20°C-on túlnyomásban értendő.)

SF6 gas density monitor
Type : 233.52.100 with 821.2.2 contacts
Nominal size : 100 mm
Scale range :-1 ÷ 9 bar
Filling pressure : 5,2 bar
Calibration pressure pE: 4,6 bar
Contacts : see the table
Red section : -1 ÷ 4,6 bar
Green section : 4,6 ÷ 9 bar
Accuracy : 1%
Connection : G 1/2", bottom entry
Protection: IP 65
Manufacturer : WIKA
(All pressure values are at 20°C in overpressure for SF6 gas.)

Érintkezők Contacts	Kapcsolási nyomás Switching point	Funkció és működési tartomány Function and working direction	Galvanikus szigetelés Galvanic isolation
1	4,6 bar	Kapcsolás csökkenő sűrűségnél makes with falling density	igen yes
2	4,4 bar	Kapcsolás csökkenő sűrűségnél makes with falling density	igen yes

db/rovat				Tétel szám	Anyagszám-Rajzszám	Megnevezés	Szabv.sz-Techn.jel	Anyagminőség	Méret	Nettó tömeg [kg]	Bruttó tömeg [kg]
				4		Contact manometer					
				4	4770870003004	Kontakt manométer		1.)			0.85
IV.	III.	II.	I.	Rovat szám							

Alkatrész

Jel	Változás	Dátum	Aláírás	Jel	Változás	Dátum	Aláírás
A	Lásd a 4. lapon	2000.06.	Nagy E.	E	WIKA típusjel kiegészítve	2005.04.	Nagy E.
B	Jel 5 és 5. lap felvéve	2002.08.	Nagy E.				
C	Jel 6 és 6. lap felvéve	2003.05.	Nagy E.				
D	Pg 13,5 menet M20x1,5-re változott	2003.11.	Nagy E.				

Kész tömeg [kg]

Megjegyzés:

dö: 870001
870002

CADKEY part file:
b0D03e4.prt

GANZ TRANSELEKTRO Villamossági Rt.

	Aláírás	Dátum
Tervező	Nagy E.	2000.01.28.
Rajzoló		
Ellenőr		
Felelős tervező	Ecseri	

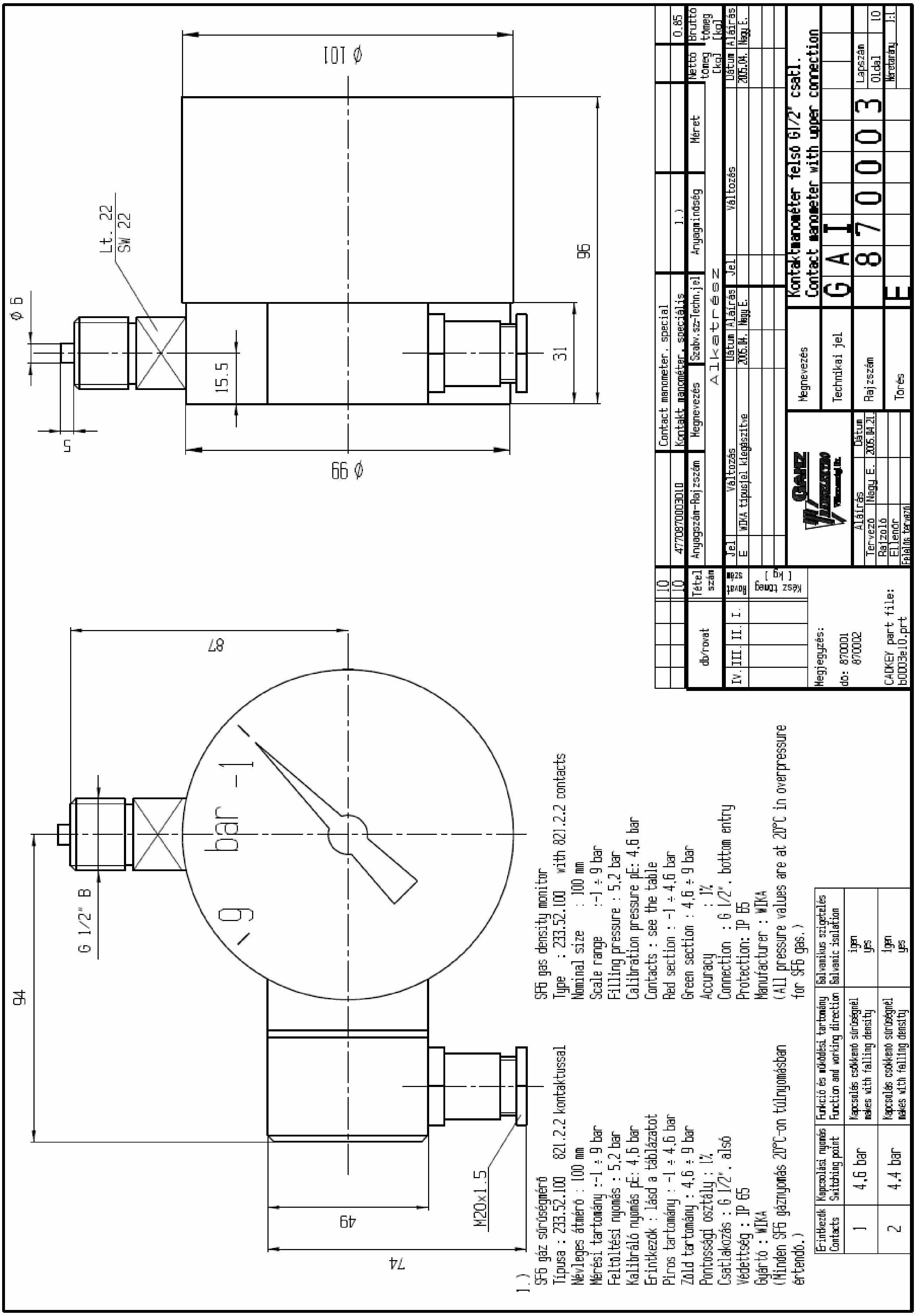
Megnevezés: Kontaktmanométer alsó GI/2" csatl. / Contact manometer with bottom connection

Technikai jel: G A I

Rajzszám: 8 7 0 0 0 3

Törés: A B C D E

Lapszám
Oldal 4
Méretarány 1:1


ø 101
ø 6
Lt. 22
SW 22
96
15.5
31
5
ø 99
87
94
G 1/2" B
bar
-1
9
M20x1.5
49
74
1.)
SF6 gáz sűrűségmérő
Típusa : 233.52.100 821.2.2 kontaktussal
Névleges átmérő : 100 mm
Mérési tartomány :-1 ÷ 9 bar
Feltöltési nyomás : 5,2 bar
Kalibráló nyomás pE: 4,6 bar
Érintkezők : lásd a táblázatot
Piros tartomány : -1 ÷ 4,6 bar
Zöld tartomány : 4,6 ÷ 9 bar
Pontossági osztály : 1%
Csatlakozás : G 1/2". alsó
Védettség : IP 65
Gyártó : WIKA
(Minden SF6 gáznyomás 20°C-on túlnyomásban értendő.)
SF6 gas density monitor
Type : 233.52.100 with 821.2.2 contacts
Nominal size : 100 mm
Scale range :-1 ÷ 9 bar
Filling pressure : 5,2 bar
Calibration pressure pE: 4,6 bar
Contacts : see the table
Red section : -1 ÷ 4,6 bar
Green section : 4,6 ÷ 9 bar
Accuracy : 1%
Connection : G 1/2". bottom entry
Protection: IP 65
Manufacturer : WIKA
(All pressure values are at 20°C in overpressure for SF6 gas.)
Érintkezők Contacts | Kapcsolási nyomás Switching point | Funkció és működési tartomány Function and working direction | Galvanikus szigetelés Galvanic isolation
1 | 4,6 bar | Kapcsolás csökkenő sűrűségnél makes with falling density | igen yes
2 | 4,4 bar | Kapcsolás csökkenő sűrűségnél makes with falling density | igen yes
477087000301 0
Contact manometer, special
Kontakt manométer, speciális
Anyagszám-Rajzszám
Megnevezés
Szabv.sz-Techn.jel
Anyagminőség
Méret
Netto tömeg [kg]
Brutto tömeg [kg]
0.85
Alkatrész
Jel
Változás
Dátum
Aláírás
WIKA típusjel kiegészítve
2005.04.
Nagy E.
Tétel szám
db/rovat
Megjegyzés:
dö: 870001 870002
CADKEY part file:
b0003e10.prt
Tervező
Rajzoló
Ellenőr
Nagy E.
Megnevezés
Technikai jel
Rajzszám
Törés
Kontaktmanométer felső G1/2" csatl.
Contact manometer with upper connection
G A I
8 7 0 0 0 3
E
Lapszám
Oldal
Méretarány
1:1

5. Earthing

The earthing system of the GIS is designed according to the IEEE Guide for Safety in AC Substation Grounding (ANSI/IEEE Std 80-2000).

The earthing system of the GIS is not independent but a part of the substation earthing system. The substation earthing system includes the earthing grid, which have to provide the low step voltage in the whole area of the substation, including the buildings as well. For this reason all metal parts of the substation buildings (mainly the elements of reinforcement) have to be welded in the crossing points to each other and connected in several places to the substation earthing grid. Suitable connection points of the earthing grid have to be arranged close to each outdoor and indoor equipment and metal structure to provide earthing possibilities.

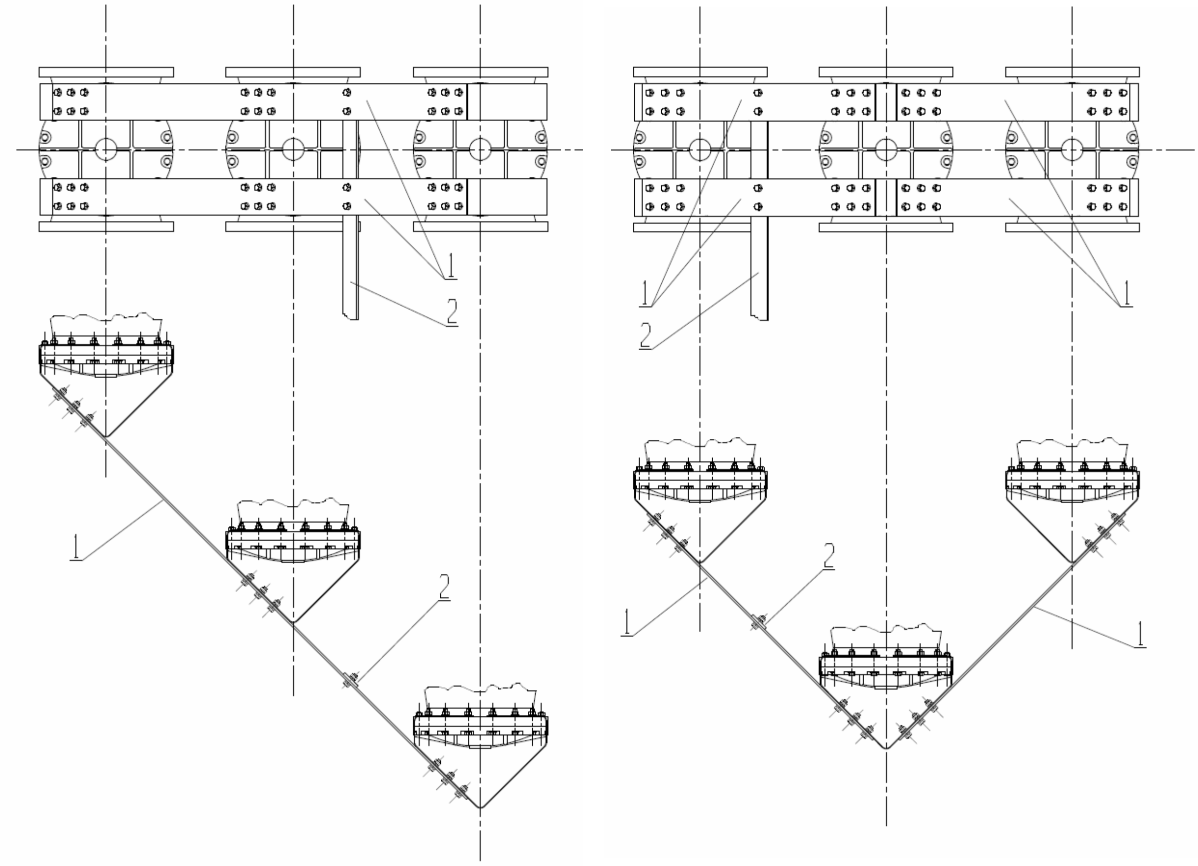
The earthing system of Bhilai 220 kV GIS needs several connections to the substation earthing system. These indoor connection points shall be placed in the four corners of the GIS room, and in the cable cellar, below the local control cubicles. (The optimal positions are below the two endpoints of the LCC line.)

5.1. Interconnections of single phase enclosures

The continuous (equipotential) enclosures of the single-phase enclosed busbars are interconnected at both ends. The interconnections are dimensioned to the 2500 A rated current of the busbars. There are two parallel copper current carrying bars with 120x3,5 mm cross-section, and two times 3 sets (6 pcs) of copper connecting plates with 120x2 mm cross sections between the flanges and the interconnections. Between the aluminium tubes and the copper connections can be found CUPAL plates to protect against the corrosion.

At the outer terminations of the incoming line and transformer bays, next to the triangular arranged cable sealing end enclosures the three phases are interconnected as well. These interconnections are dimensioned to the 2500 A rated current of the bays. The structures are similar, the cross section are the same as at the busbar ends.

The interconnections ensure the low touch voltage between the enclosures of different phases in the case of short circuit currents as well.



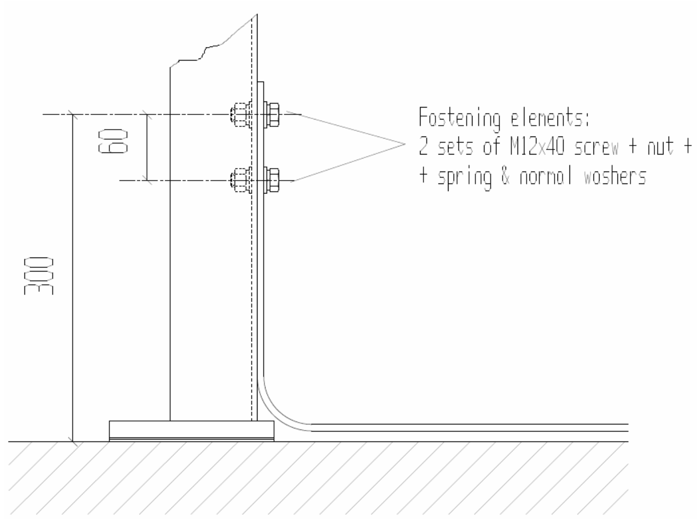
Interconnections of the single-phase enclosures at busbar and bay ends
1 – interconnecting bar; 2 – earthing conductor

5.2. Earthing ring and earthing bars

The earthing ring surrounds the GIS bays, and has to be connected to the substation earthing ring on four places at the corner points. The conductors of the earthing ring and the connections to the earthing grid are dimensioned to 50 % of the short-time withstand current (20 kA – 1 sec). Copper bars are applied for this reason, with 60x2.5 mm cross-section.

The interconnecting bars and the earthing terminals of the primary devices (voltage transformers or surge arresters) are connected by copper earthing bars to the earthing ring of the GIS. The earthing bars are dimensioned to the full short-time withstand current of the GIS (40 kA – 1 sec). The cross section of the applied copper earthing bars is 60x5 mm.

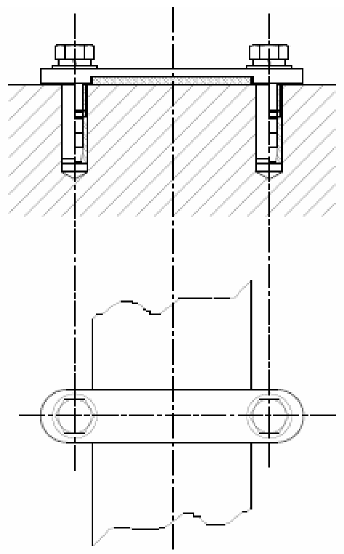
All the steel structures and the circuit breaker drives have to be earthed. The dimension of these earthing conductors shall be the same as the dimensions of the earthing ring.



Typical arrangement for earthing of steel structures

The local control cubicles (LCC) have to be connected with two parallel insulated copper stranded conductors (2 x 70 mm^2) and suitable cable shoes to the earthing ring section of the cable cellar.

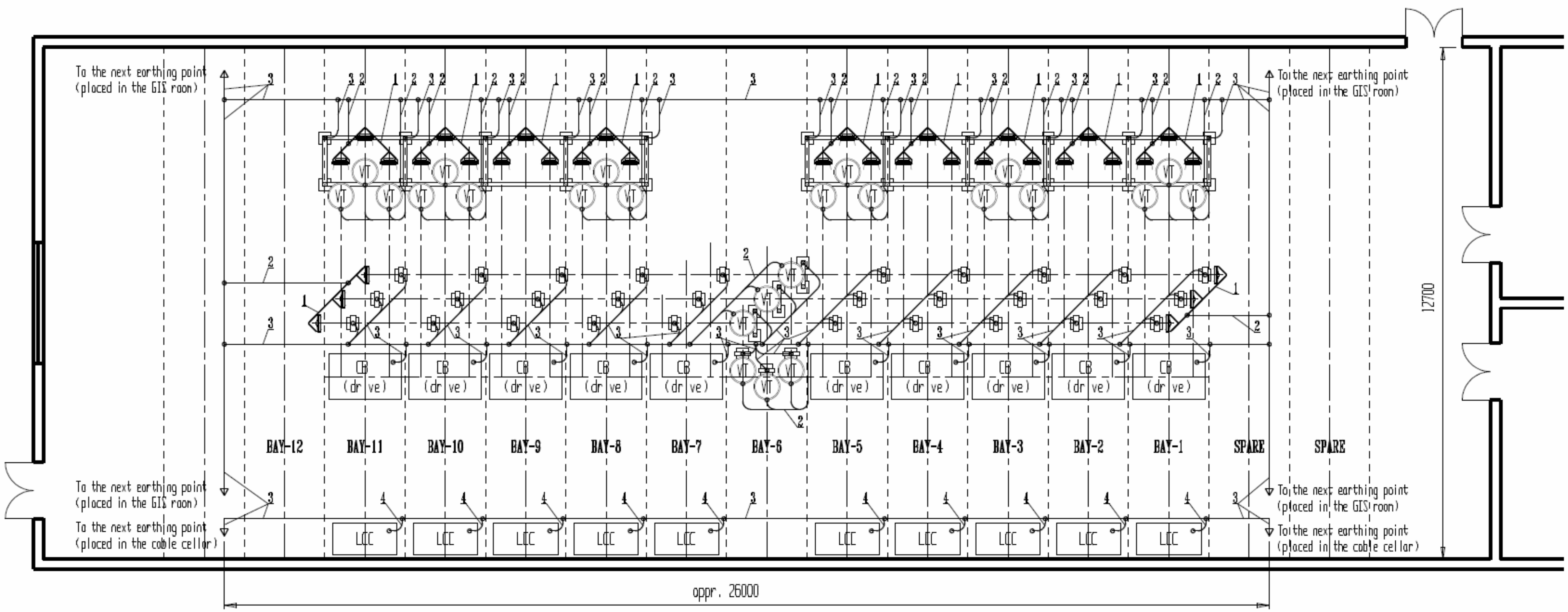
The earthing ring of the GIS room is fastened with fixation elements to the floor. Connections on the floor level (between the earthing ring and the earthing conductors) shall be brazed.



Fixation element of the earthing ring

The earthing bars and the earthing ring ensure the low touch voltage between enclosures and the earth. Providing of the low step voltage is the job of the substation earthing grid, which include the earthing ring of the GIS as well.

After erection the earthing materials (connecting bars, earthing bars, screws, fixations, etc.) have to be painted with green-yellow stripes.



Legend:

1 - 2x3,5x120 mm Copper bar (rated current: 2500 A)
Application: interconnections of busbar ends
interconnections at bay terminations
See Detail 1 & 2

2 - 60x5 mm Copper bar (short-circuit current: 40 kA/1 sec)
Application: earthing connectors of the GIS
See Detail 1 & 2

3 - 60x2,5 mm Copper bar (short circuit current: 20 kA/1 sec)
Application: earthing ring around the GIS and LCC cubicles,
earthing connectors of support structures
See Detail 3 & 4

4 - 70 sqmm Copper stranded conductor with PVC insulation
Application: earthing connectors of the LCC cubicles

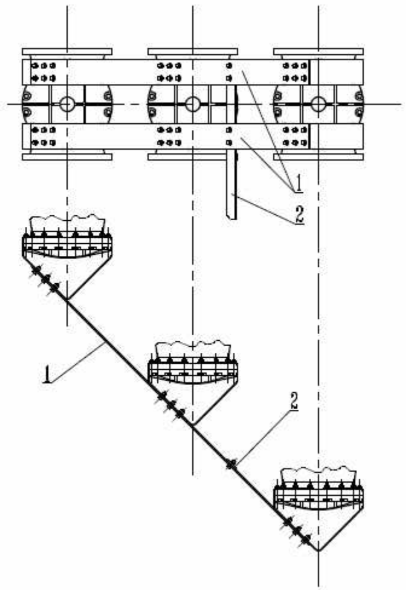
5 - Fixation elements
Application: fastening of one or two Copper bar
(earthing ring elements, earthing conductors)
See Detail 4

Remarks:

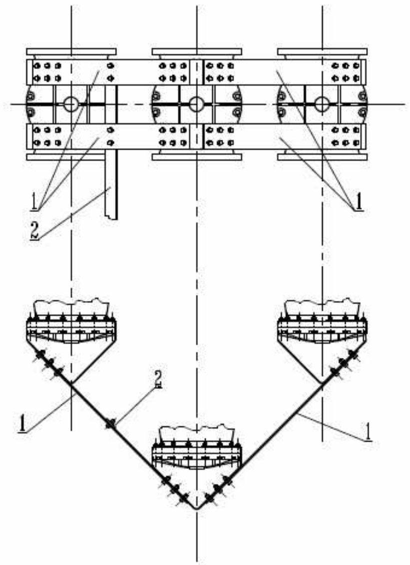
1) Details of the arrangement are symbolic only. The earthing connections shall be as short and as linear as possible. In case of more than one earthing connection possibilities, the most advantageous shall be used.
2) All connections between Copper bars on the ground level shall be brazed.
3) Distance between two fixation elements shall be max. 3 m approximately.
4) After all earthing connections are completed the copper bars shall be painted according to the painting instructions of the project.

Figure 9A: Earthing plan of BHILAI 220 kV GIS

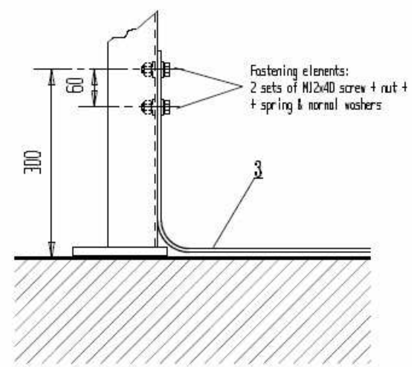
Detail 1:
Interconnection of busbar ends
(M 1:25)



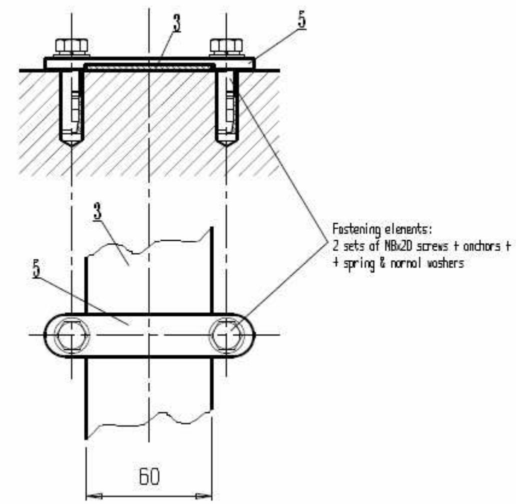
Detail 2:
Interconnection of cable terminations
(M 1:25)



Detail 3:
Typical arrangement for grounding
of steel support structures (M 1:5)



Detail 4:
Typical arrangement for fixation
of earthing bars to the floor (M 10:1)



Legend:

1 - 2x3,5x120 mm Copper bar (rated current: 2500 A)
    Application: interconnections of busbar ends
    interconnections at bay terminations
    See Detail 1 & 2
2 - 60x5 mm Copper bar (short-circuit current: 40 kA/1 sec)
    Application: earthing connectors of the GIS
    See Detail 1 & 2
3 - 60x2,5 mm Copper bar (short circuit current: 20 kA/1 sec)
    Application: earthing ring around the GIS and LCC cubicles,
    earthing connectors of support structures
    See Detail 3 & 4
4 - 70 sqmm Copper stranded conductor with PVC insulation
    Application: earthing connectors of the LCC cubicles
5 - Fixation elements
    Application: fastening of one or two Copper bar
    (earthing ring elements, earthing conductors)
    See Detail 4

Figure 9B: Earthing plane of BHILAI 220 kV GIS

ATTENTION!

All parts of the earthing system are very important because they provide the personal safety of the operating staff among normal and short-circuit conditions.

Don’t remove the interconnecting and earthing bars or any fixing screw of the earthing connections if it is not absolutely necessary. If the removing cannot be avoided provide temporary earthing of the related parts and rebuild the original earthing system as soon as possible.

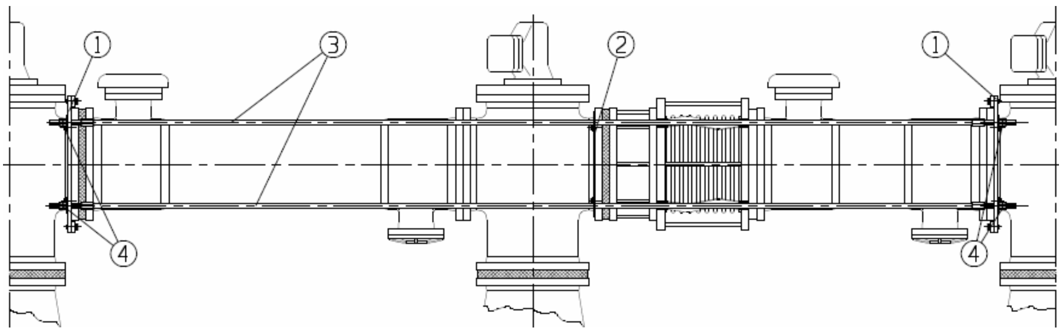
Check regularly the existence and the state of each element of the earthing system. If necessary, the screws of the connections shall be re-tightened by torque spanner. (The prescribed tightening torque of M12 size bolts and nuts is 64.8 – 80.1 Nm.) The missing or damaged parts of the system have to be replaced as soon as possible.

6. Steel Structures

The steel support and fixation system of Bhilai 220 kV GIS provide the suitable position and mechanical stability of the switchgear. General arrangement of all support structures belong to the 220 kV GIS and the calculated loads of them are given by figure 10. The main components are described in the followings.

6.1. Pulling rod system

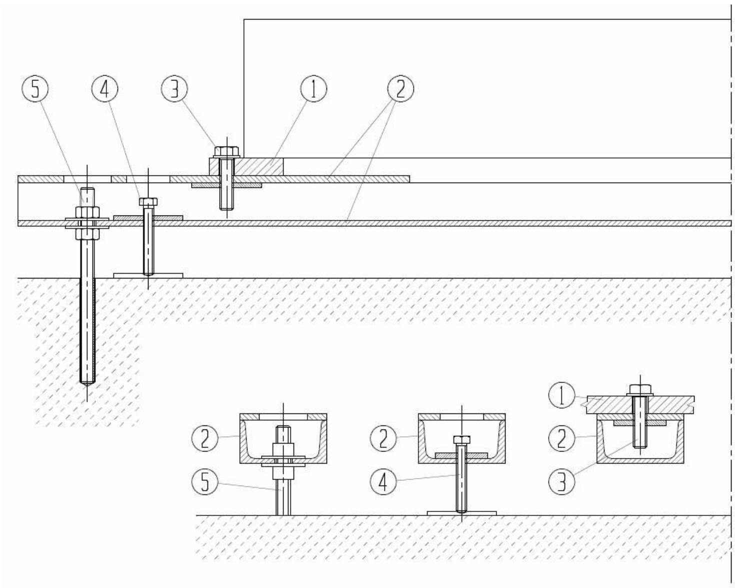
The **pulling rod system** gives possibility to adjust and fasten the nominal length of the two-bay-long sections of each busbar. Each busbar section includes a flexible part, which can compensate the thermal dilatation, the manufacturing tolerances of the included enclosure elements and the inaccuracies of the civil works. In this so-called variable busbar compensator metal below is combined with sliding tube. Its possible longitudinal dimension change is maximum ±18 mm which includes maximum ± 8 mm dynamic range of the below. The sliding part is set during the erection, but the below can move later as well. The fixing rods secure the adjusted length and counterweight the effect of the internal gas pressure. Thermal dilatation of each busbar section can happen between the adjusted limits only: the dimension change of the included aluminium enclosure elements (tubes, X-houses) is counterbalanced by the dimension change of the flexible metal below.



Arrangement of pulling rod system around a busbar section
1 – fixing plate; 2 – support plate; 3 – pulling rod; 4 – adjusting and fastening nuts

6.2. Circuit breaker supports

The **circuit breaker supports** represent one type of the rigidly fixed support structures belong to the GIS. These steel structures provide the suitable position (height) of the CB-s. Each support includes four uniform support beams, which are screwed by M16 size bolts on the bottom fixing plates of the CB drive. Both ends of these beams are fastened by M12 size adjusting and M16 size anchoring bolts to the concrete floor. In the first step of the erection the circuit breakers support beams are standing on the adjusting bolts only. Underlay plates protect the supporting points on the floor against overstress and damage. The holes of the anchoring bolts are drilled only after building up of the complete GIS and adjusting of all support structures. The drilling has to be fulfilled through the related holes of the beams. The holes shall have 125 mm depth and 18 mm diameter. The anchoring bolts are placed in the last step, through the holes of the steel beams. The 225 mm long threaded anchor rods are glued into the holes of the concrete floor.

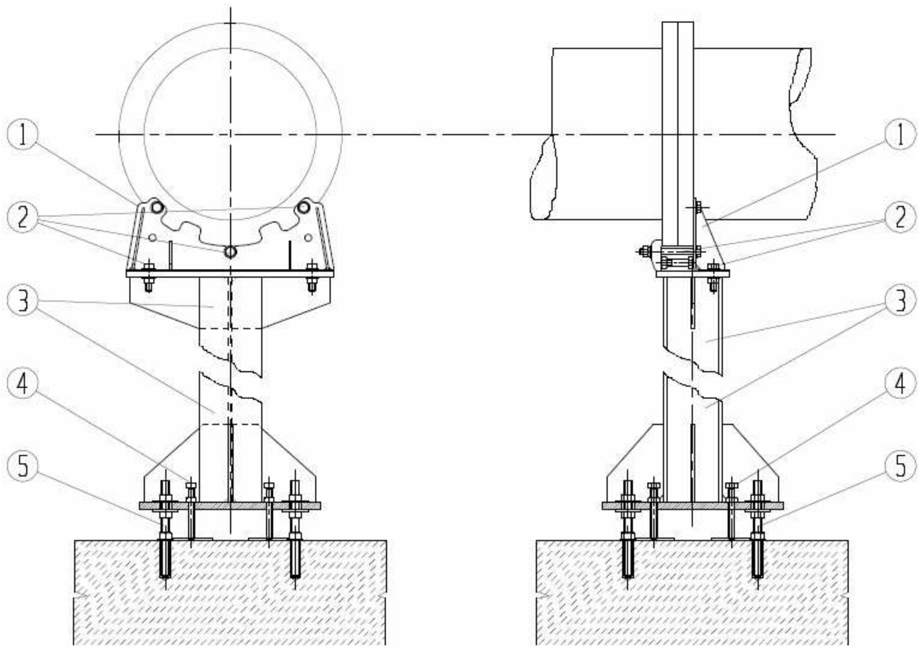


Arrangement of circuit breaker support
1 – fixing plate; 2 – support beam; 3 – M16 bolt;
4 – M12 adjusting screw; 5 – M16 glued anchor

6.3. Busbar supports

The **busbar supports** provide the suitable position (height) of the double busbars. There are two different versions: the **rigidly fixed** and the **sliding** types. The two versions are very similar, only the type of fixation between the steel support and the switchgear leg is different. The included fixing screws are in case of each fixed support normally tightened, and in case of each sliding support only slightly tightened and secured by second nuts. Such a way the oval holes of the switchgear legs give possibility to move several millimetres parallel to the centre line of the busbars, but in this direction only. The rigidly fixed busbar supports are arranged at each second bay below the ends of the pulling rods. The sliding busbar supports can be found at each second bay as well, between fixed busbar supports.

The busbar support structure is single phase unit. Each bay includes three peaces of them. Independent parts of the supports are the switchgear leg, the steel support and the fastening elements (M12 size fixing screws of the switchgear legs, M12 size adjusting screws with underlay plates, M16 size flush anchors with anchoring bolts and nuts). In the first step of the erection the busbar supports are standing on the adjusting bolts only. The underlay plates protect the supporting points on the floor against overstress and damage. The holes of the anchoring bolts are drilled only after building up of the complete GIS and adjusting of all support structures. The drilling has to be fulfilled through the related holes of the bottom base plates. The holes shall have 70 mm depth and 20 mm diameter. The flush anchors are placed trough the holes of the base plate. In the last step the 185 mm long threaded anchor rods are driven into flush anchors.



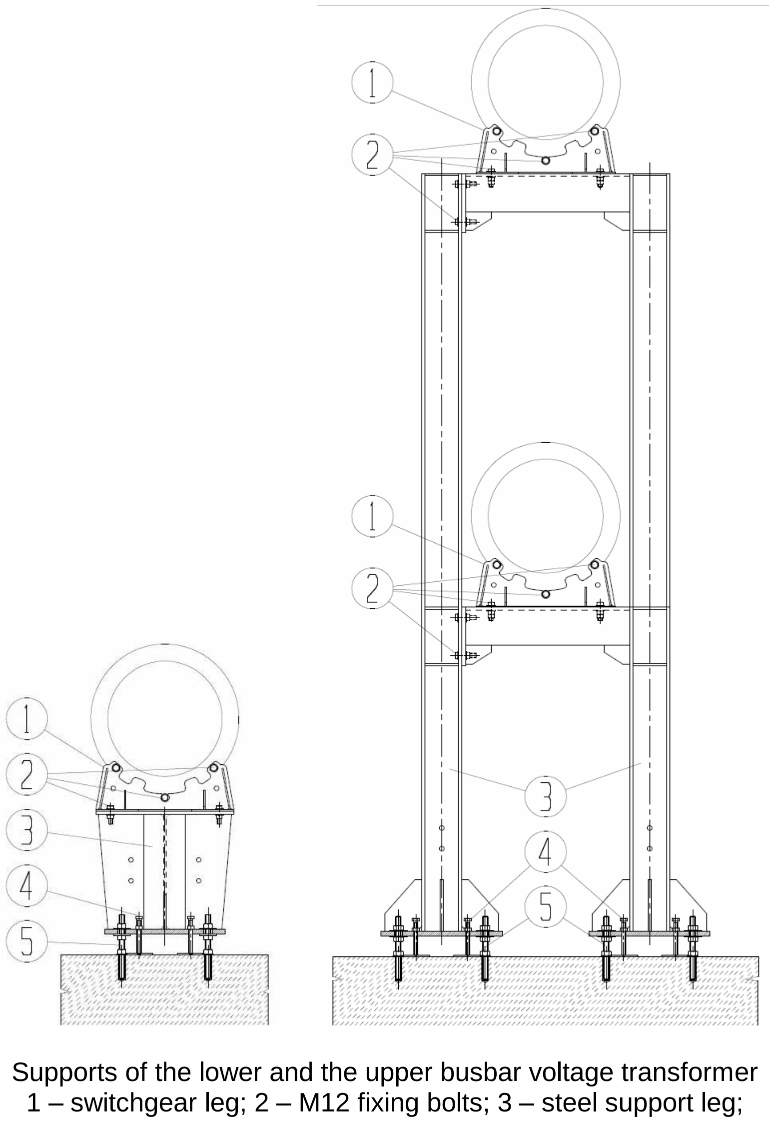
Arrangement of busbar support
1 – switchgear leg; 2 – M12 fixing bolts; 3 – steel support leg;
4 – M12 adjusting screw; 5 – M16 flush anchor with fixing screws

6.4. Supports of the busbar voltage transformers

The **supports of the busbar voltage transformers** are different. Both structures are single phase units. The busbar measuring bay includes one set / three peaces of them.

In case of the **lower busbars** these supports are very similar to the usual busbar support, only the height is much smaller. The structure, the main parts and the way of installation are the same.

In case of the **upper busbars** the structure is different, more difficult, because the connection between the enclosures of the two busbars is missing in the busbar measuring bay. For this reason both busbars and the upper voltage transformers have to be supported by the same structure. The position is between two rigidly fixed busbar supports, so as busbar support has to be sliding type.

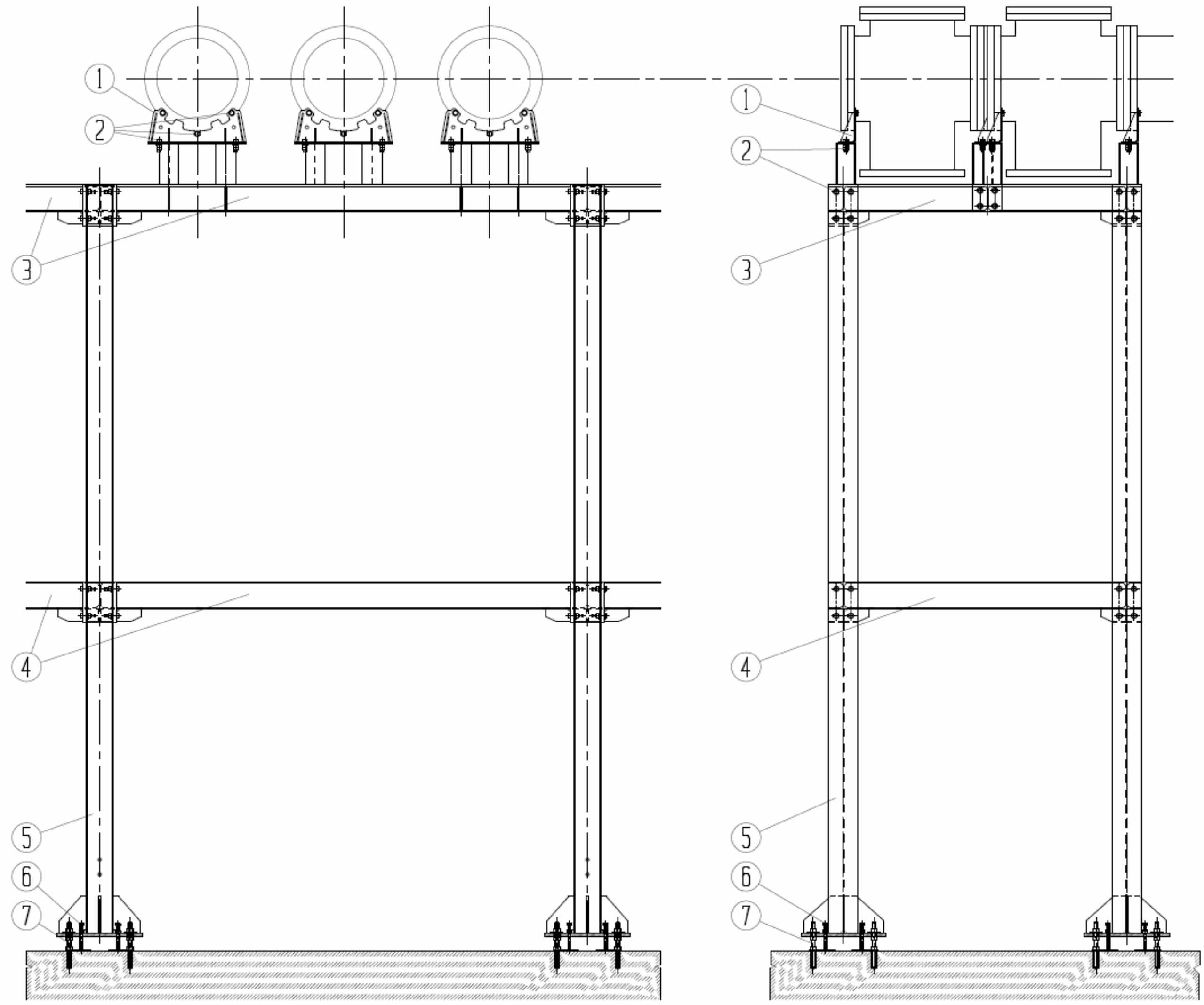


Supports of the lower and the upper busbar voltage transformer
1 – switchgear leg; 2 – M12 fixing bolts; 3 – steel support leg;
4 – M12 adjusting screw; 5 – M16 flush anchor with fixing screws

Independent parts of the supports are two switchgear legs, two vertical steel columns, two horizontal beams welded to one of the columns and fastening elements (M12 size fixing screws of the switchgear legs and horizontal beams, M12 size adjusting screws with underlay plates, M16 size flush anchors with anchoring bolts and nuts). The installation is similar as at the busbar supports, only the coupling of the two support columns means an additional job. The horizontal beams welded to one of the columns have to be bolted by M12 screws to the other one.

6.5. Supports of the cable terminations

The **supports of the cable terminations** are the highest and most difficult support structures of the GIS. These supports are not single-phase but three-phase ones. Each incoming line or tie bay and each transformer bay include such type steel support. Structures of the neighbouring bays are not independent, but they have got common support columns at their common border line.



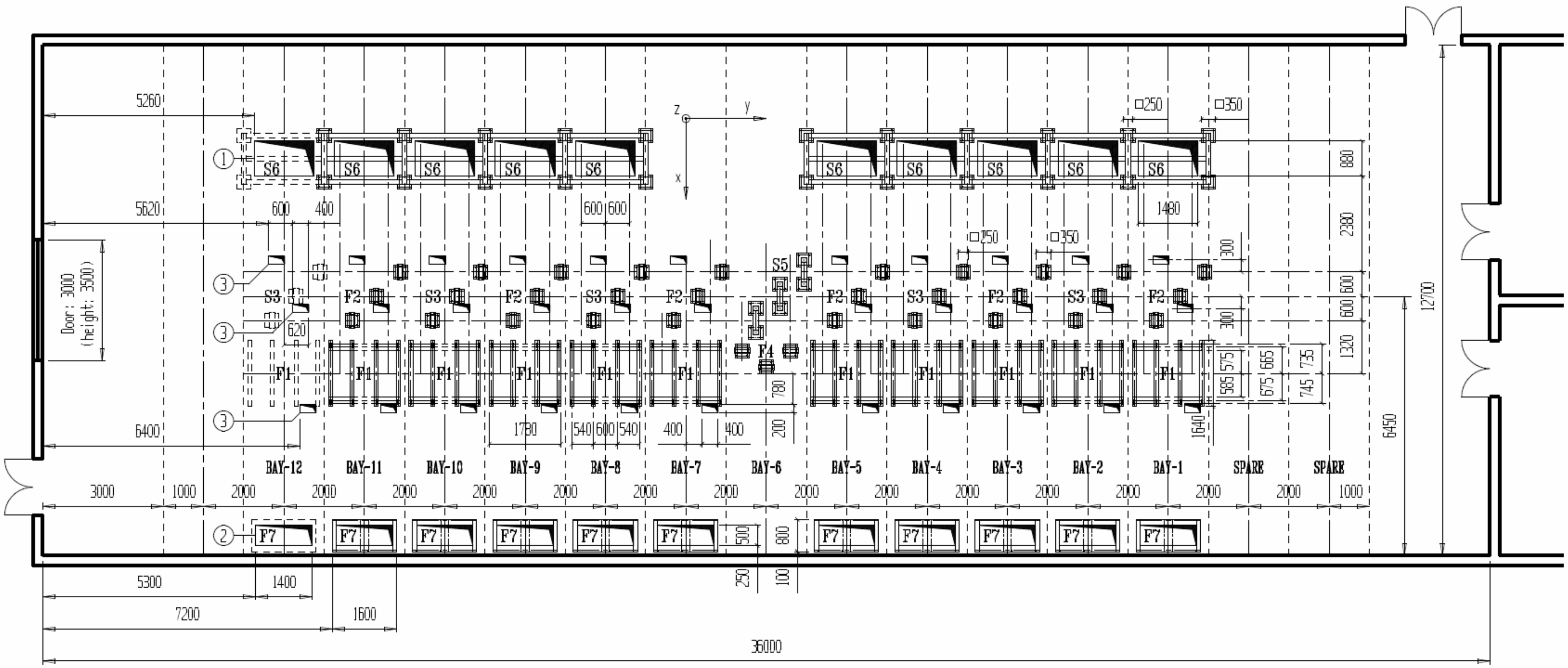
Support arrangement of the cable terminations
1 – switchgear leg; 2 – M12 fixing bolts; 3 – horizontal beam of the upper frame;
4 – horizontal beam of the stiffening; 5 – vertical column;
6 – M12 adjusting screw; 7 – M16 flush anchor with fixing screws

Independent parts of the supports are three switchgear legs, two or four vertical steel columns, five horizontal beams of the upper frame, four horizontal beams of the stiffening and the and fastening elements (M12 size fixing screws of the switchgear legs and the horizontal beams, M12 size adjusting screws with underlay plates, M16 size flush anchors with anchoring bolts and nuts). The shorter horizontal beams of the upper frame and the stiffening are welded to connected vertical columns. The longer horizontal beams of the upper frame and the stiffening are fastened by M12 size screws to the columns. The installation is similar as at the busbar supports.

6.6. Recommended tightening torque of fastening elements

To provide the designed quality of mechanical connections it is essential to apply the recommended tightening torques. The recommended stresses are 90 % of the permitted maximums. These values are summarized in the following table:

Tightening torques of bolts and nuts / Material quality: 8.8; A2; A4			
Supposed coefficient of friction (Minimal – Maximal): 0.100 – 0.140		Supposed quality of concrete: C20 / C25	
Dimension	Torque (Nm) Minimal – Maximal	Anchor Type & Dimension	Torque (Nm)
M8	18.9 – 23.4	HKD-S M12	31.5
M10	37.8 – 45.9	HKD-S M16	54.0
M12	64.8 – 80.1	HKD-S M20	108.0
M16	156.6 – 193.5	HVU+HAS M12	54.0
M20	306.0 – 378.0	HVU+HAS M16	108.0
M24	522.0 – 652.5	HVU+HAS M20	234.0
(Sources: Bossard and HILTI Product Catalogues)			



Floor openings:

① Hole for HV cables
(Below the HV cable terminations)
Size: 1480 x 880 mm; Quantity: 10 pcs

② Hole for secondary cables
(Below the Local Control Cubicles)
Size: 1400 x 500 mm; Quantity: 11 pcs

③ Hole for secondary cables
(Below the busbars and next to the CB-s)
Size: 400 x 200 mm; Quantity: 3 x 11 pcs

(Quantities include the future bay as well.)

Fixations and support structures:

F_: Fix type fixation
S_: Sliding type fixation
_n: Serial number

F1: Fixations of CB-s (10 sets = 40 pcs)
F2: Busbar supports (6 sets = 18 pcs)
S3: Busbar supports (4 sets = 12 pcs)
F4: Supports for VT-s of BB1 (1 set = 3 pcs)
S5: Supports for VT-s of BB2 (1 set = 3 pcs)
S6: Supports for terminations (9 pcs)
F7: Fixations of LCC-s (10 pcs)

(Quantities are without the future bay)

Data for overhead crane:
- Maximum load: 32 kN (= 3,2 ton)
- Min. height of the hook: 5.5 m

Remarks:
1) Surface of the concrete floor in the GIS room must have a tolerance of +0 / -10 mm.
2) Steel structures will be fixed to the floor by HILTI type anchoring bolts.

Figure 10A: Civil data drawing of BHILAI 220 kV GIS

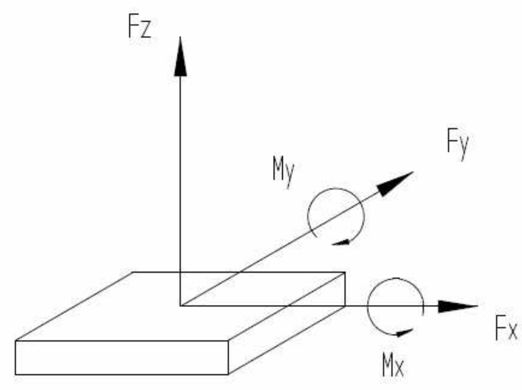
Estimated loads at the fixation places for complete (3-phase) structures or fixations

Static value (weight) / Dynamic value because operation / Dynamic value because earthquake

Location	Fx (kN)	My (kNm)	Fy (kN)	Mx (kNm)	-Fz (kN)
F1	-/-/±70	-/-/±174	-/-/±70	-/-/±174	46/±25/±19
F2	-/-/±24	-/-/± 44	-/-/±24	-/-/± 44	32/ - /±13
S3	-/-/± 6	-/-/± 6	-/-/± 6	-/-/± 6	32/ - /±13
F4	-/-/±32	-/-/± 61	-/-/±32	-/-/± 61	18/ - /± 7
S5	-/-/± 5	-/-/± 8	-/-/± 5	-/-/± 8	47/ - /±19
S6	-/-/± 6	-/-/± 20	-/-/± 6	-/-/± 20	55/ - /±22
F7	-/-/± 3	-/-/± 4	-/-/± 3	-/-/± 4	6/ - /± 3

Note: Loads of the different bays are not exactly the same in the similar loading points.
For the reason of simplification in the table the maminum values are given (rounded up).
(F1&S6 are from the incoming-, F2&S3 from the bus coupler-, F4&S5 from the measuring bay)

Directions of Forces & Moments:



Calculated weigth of the different bays:

Incoming bay:	appr. 9700 kg
Transformer bay:	appr. 8000 kg
Bus Coupler bay:	appr. 6600 kg
Measuring bay:	appr. 5600 kg

(GIS only, without cables, cable sealing ends, support structures, LCC, etc.)

Figure 10B: Civil data drawing of BHILAI 220 kV GIS

7. Erection and commissioning

7.1. Site erection of the GIS

The site erection can start if all the civil works are ready, and includes the following jobs:

- assembly of the steel support structures
- mounting of the GIS from shipping units, which were fitted up and tested in the factory before
- installation of the local control cubicles
- secondary cabling between GIS and LCC-s
- establishing of the earthing system

The site erection usually is carried out with the supervision of GANZ TRANSELEKTRO Ltd.

7.2. Gas handling

The most important component of the GIS is the suitable insulating and arc quenching medium: the sulphur hexafluoride gas.

As the critical temperature and pressure of SF6 are 45.54 ℃ and 3.759 MPa respectively, it can be liquefied by compression and is usually transported as a liquid in cylinders or containers.

ATTENTION!

As the gas is delivered in the form of compressed liquid, if large quantities of the gas are released rapidly, the temperature of both the gas and the container fall quickly. Frost and ice may form on metal parts. If this occurs, gas filling has to be immediately stopped until ice and frost are gone. Filling of SF6 must always be performed slowly. Personnel must be aware of the danger of freeze burns when touching iced and/or frozen metal parts.

The supplied gas shall meet the requirements of IEC 60376 (2005-06) and a certificate of compliance should accompany consignments.

7.2.1. General precautions

SF6 gas is heavier than air and will displace all air in low spots, such as tank bottoms or equipment wells, adequate ventilation must be provided because, although SF6 is non-toxic, it displaces all oxygen and could cause suffocation.

SF6 gas that has been subjected to arcing contains harmful by-products. These gases and any solid by-products must be handled with care to avoid injury to personnel. Maintenance personnel should be advised to wear protective equipment to avoid contact with these by-products.

All GIS equipment that may contain arc by-products shall be thoroughly cleaned prior to performing maintenance within the equipment.

All GIS equipment shall be thoroughly ventilated prior to the performance of maintenance within the equipment.

7.2.2. Storage

The cylinders shall be handled carefully and stored in a cool, dry, well-ventilated area away from flammable or explosive material. They should be protected from direct sunlight, mounted clear of wet ground and secured to prevent falling over, with their outlet valves upwards. Cylinders shall be clearly labelled to identify their contents; cylinders containing new gas should be physically separated from those containing used gas.

As with any pressurised gas, there is a risk of explosion of cylinders if they are excessively heated as might occur in a fire. Storage outdoors with suitable protection from weather and intense solar radiation is recommended.

7.2.3. Gas handling equipment

For aid in using of the supplied and stored SF6 are provided the so called "gas handling equipment". They can be applied to transfer, purifying and reclaiming of the gas and also the evacuation and filling of the gas compartments of the GIS. In case of Bhilai 230 kV and 132 kV substations the following common parts are supplied:

1.) 1 pc B120R61 type SF6-gas service cart for gaseous storage, mounted onto pressure tank

Including the following main components: compressor TM 2,5 B (11,4 m3/h, 23 bar); vacuum compressor (5.2 m3/h, < 50 mbar); vacuum pump 40 m3/h (final vacuum < 1 mbar); electric control with automatic process control; drying filter and particle filters; indicating instruments; fork lift openings; steering- and fixing rollers; different wrenches and operating instructions in English.

Paint: RAL 2004.

Operating voltage: 3 x 380 V, 50 Hz

Accessories: B043R01 type built-in pressure tank 600 l / 25 bar (105 kg SF_6); and 6-1017-R100 type rubber hose 10 m long, on both ends with coupling tongue parts DN20 VK/F-02620.

Dimensions (length x width x height): 1860 x 950 x 1750 mm

Net weight: 700 kg

Further details can be found in the “Operating Instructions” of the manufacturer.

2.) 1 pc 3-033-R002 Gas leak detector

Including the following components: microprocessor control with advanced digital signal processing; tricolour visual LED display and audible signal for leak indication; keypad control (7 levels of sensitivity); operating batteries (2 pcs of 1.5 V alkaline batteries); PVC carrier case and operating instructions in English

Operating voltage: 3 V, DC (batteries)

Dimensions: 229 x 65 x 65 mm

Fixed sensor length: 355 mm

Net weight: 560 g

Further details can be found in the “Operating Instructions” of the manufacturer.

3.) 1 pc checking manometer set for connection to DN20 valves

Including the following main components: pressure gauge (1...9 bar gauge; class 0.6); gauge connecting coupling (DILO: 3-328-R001); 2 m long flexible hose (DILO: 3-335-AD10-2000); transition piece (DILO: 3-240-R001); valve connecting coupling (DILO: VK/F-02/20) and sealing rings (DILO: 05-0068-R001 and 05-0091-R001).

7.2.4. Transport filling

For the time of transporting the circuit breaker poles are filled with SF6 gas, the other shipping units are filled with Nitrogen at a pressure (1,5 bar / abs) slightly higher than the atmospheric one to prevent penetration of the moisture. At the site before assembling the "transport pressures" have to be checked. The pressure reduction usually indicates some mistake or damage of the sealing system.

Assembly of the shipping units should happen very carefully. After checking the transport pressure the internal Nitrogen pressure of the gas compartment to be open should be equalised with the atmospheric one. All contaminations of the opened gas compartment should be reduced to minimum, for that reason the time of opening should be minimal. The sealing surfaces should be protected from all mechanical damage. Before fitting together the sealing O-ring between the joined flanges should be changed. The sealing surfaces and the sealing ring should be lubricated by silicon-grease. All the screws should be fastened regularly.

7.2.5. Vacuuming

After assembly together the gas compartment should be evacuated by the aid of the gas service cart. (The detailed instructions about it can be found in the Instruction Manual of the service cart.)

In the case of temporary vacuuming (if the gas compartment is not complete yet and will be later opened again) the absolute pressure should be reduced up to 5 mbar (500x10-3 kPa). This low vacuum should be kept up until the next opening of the gas compartment.

In the case of final vacuuming (if the gas compartment is complete and probably won't be opened again) the absolute pressure should be reduced up to 1 mbar (100x10-3 kPa). After waiting two hours the pressure should be measured again. If the pressure rise related to the starting value is greater than 0.4 mbar (40x10-3 kPa), all sealing of the tested gas compartment should be revised.

7.2.6. Revision of the sealing (leakage measurement)

To the revision of all sealing of the gas compartment can be used some form of the leakage measurement. According to the simplest method the gas compartment should be filled with SF6 gas up to the half of the rated pressure, and the place(s) of the leak(s) can be found by the aid of the supplied gas leak detector (see item: 7.2.2.). Before using this method the GIS room should be ventilated.

On the basis of the sounds given out by the measuring device the leak(s) can be found. (See the Instruction Manual of the gas leak detector.) After detection of the leak(s) the gas leakage has to be stopped, then the vacuuming has to be repeated.

7.2.7. Filling

After vacuuming the gas compartment should be filled up by the aid of the service cart in two steps with pure SF6 gas. (The detailed instructions about can be found in the Instruction Manual of the service cart.)

In the first step at the "pre-filling process" the gas pressure should be increased up to the half of the rated pressure. There is after pre-filling a relative long waiting time (between 24 hours and several weeks). During this waiting time the gas pressure should remain the same.

The second step of the filling starts with the measuring of the pre-filling pressure. If it's equal to the starting value the gas pressure should be increased up to the rated pressure. If the pressure was reduced all sealing of the gas compartment should be revised again. (See item 7.2.6)

After filling the gas pressure should be constant. The exact values of the filling pressures can be found in the Tables 1 and 2 as a function of the temperature:

- Table 1: Filling pressures of circuit breakers
- Table 2: Filling pressures of the other gas compartments

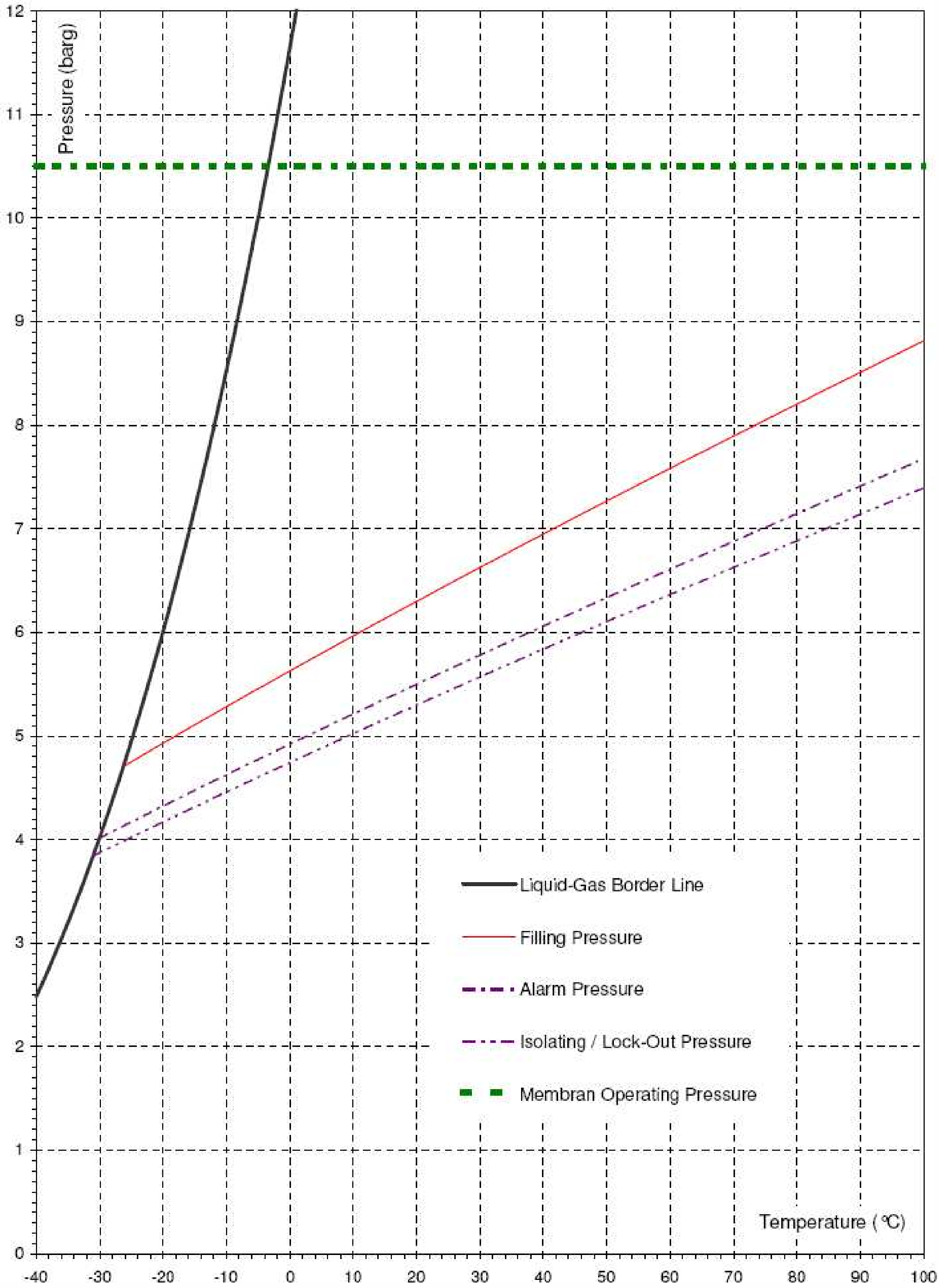
TABLE 1

The filling pressure of SF6 gas as a function of the temperature.
(Calculated according the theory of DÖRING.)

CIRCUIT BREAKERS:
The rated filling pressure is 6.3 bar gauge at 20 C°

The values are given in relative pressure. (1 bar = 100 kPa)
(The relative or gauge pressure is one bar lower than the absolute one.)

t (C°)	p (bar)	t (C°)	p (bar)	t (C°)	p (bar)	t (C°)	p (bar)	t (C°)	p (bar)
-19	4.731	1	5.551	21	6.339	41	7.100	61	7.841
-18	4.773	2	5.591	22	6.377	42	7.138	62	7.878
-17	4.815	3	5.631	23	6.416	43	7.175	63	7.915
-16	4.857	4	5.671	24	6.454	44	7.213	64	7.951
-15	4.898	5	5.711	25	6.493	45	7.250	65	7.988
-14	4.940	6	5.751	26	6.531	46	7.278	66	8.024
-13	4.981	7	5.791	27	6.570	47	7.325	67	8.060
-12	5.023	8	5.830	28	6.608	48	7.362	68	8.097
-11	5.064	9	5.870	29	6.646	49	7.399	69	8.133
-10	5.105	10	5.909	30	6.684	50	7.436	70	8.169
-9	5.146	11	5.949	31	6.722	51	7.473	71	8.206
-8	5.187	12	5.988	32	6.760	52	7.510	72	8.242
-7	5.228	13	6.027	33	6.798	53	7.547	73	8.278
-6	5.268	14	6.066	34	6.836	54	7.584	74	8.314
-5	5.309	15	6.105	35	6.874	55	7.621	75	8.350
-4	5.350	16	6.145	36	6.912	56	7.658	76	8.386
-3	5.390	17	6.183	37	6.950	57	7.695	77	8.422
-2	5.431	18	6.222	38	6.988	58	7.731	78	8.458
-1	5.471	19	6.261	39	7.025	59	7.768	79	8.494
0	5.511	**20**	**6.300**	40	7.063	60	7.805	80	8.530



Pressure diagram of GAI SC3 circuit breakers

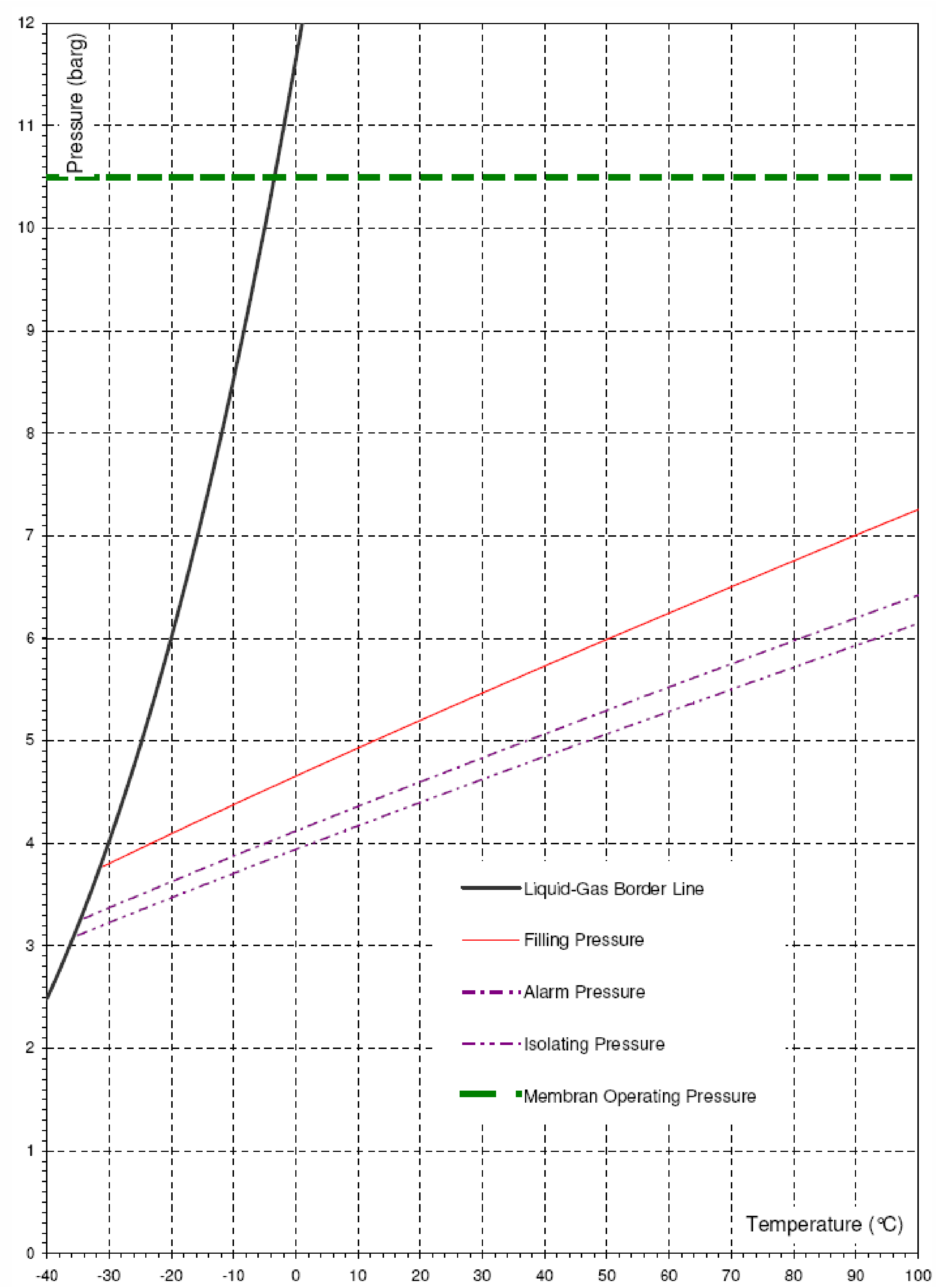
TABLE 2

The filling pressure of SF6 gas as a function of the temperature.
(Calculated according the theory of DÖRING.)

OTHER GAI-3 TYPE GAS COMPARTMENTS
The rated filling pressure is 5.2 bar gauge at 20 C°

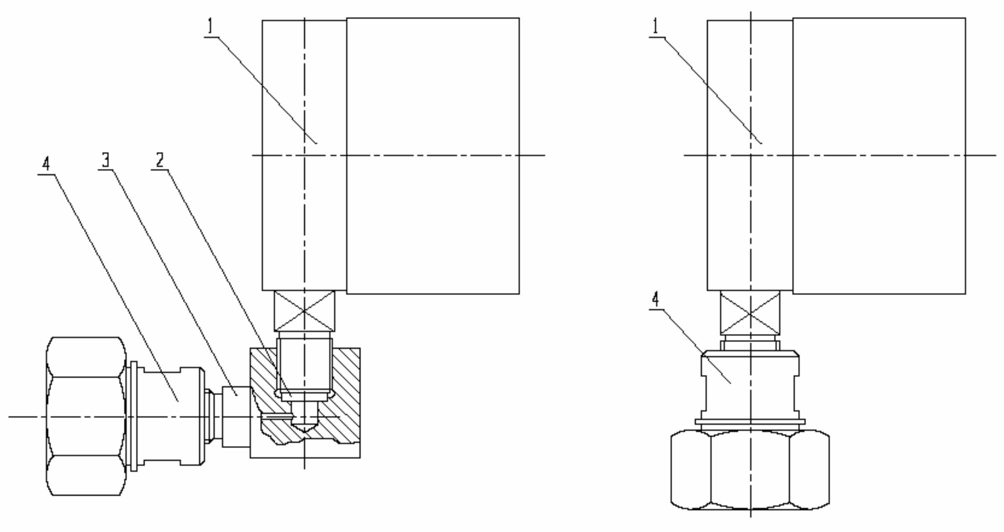
The values given in relative pressure. (1 bar = 100 kPa)
(The relative or gauge pressure is one bar lower than the absolute one.)

t (C°)	p (bar)	t (C°)	p (bar)	t (C°)	p (bar)	t (C°)	p (bar)	t (C°)	p (bar)
-19	3.902	1	4.579	21	5.232	41	5.866	61	6.485
-18	3.936	2	4.612	22	5.264	42	5.897	62	6.516
-17	3.971	3	4.645	23	5.296	43	5.929	63	6.546
-16	4.005	4	4.678	24	5.328	44	5.960	64	6.577
-15	4.040	5	4.711	25	5.360	45	5.991	65	6.607
-14	4.074	6	4.744	26	5.392	46	6.022	66	6.638
-13	4.108	7	4.777	27	5.424	47	6.053	67	6.668
-12	4.142	8	4.810	28	5.456	48	6.084	68	6.698
-11	4.176	9	4.843	29	5.488	49	6.115	69	6.729
-10	4.210	10	4.876	30	5.520	50	6.146	70	6.759
-9	4.244	11	4.908	31	5.551	51	6.177	71	6.790
-8	4.278	12	4.941	32	5.583	52	6.208	72	6.820
-7	4.311	13	4.973	33	5.615	53	6.239	73	6.850
-6	4.345	14	5.006	34	5.646	54	6.270	74	6.880
-5	4.379	15	5.038	35	5.678	55	6.301	75	6.911
-4	4.412	16	5.071	36	5.709	56	6.331	76	6.941
-3	4.446	17	5.103	37	5.741	57	6.362	77	6.971
-2	4.479	18	5.136	38	5.772	58	6.393	78	7.001
-1	4.513	19	5.168	39	5.803	59	6.424	79	7.031
0	4.546	**20**	**5.200**	40	5.835	60	6.454	80	7.061



Pressure diagram of other GAI-3 type gas compartments

7.2.8. Mounting of contact manometers



Mounting arrangement of contact manometers
1 – contact manometer; 2 – special sealing; 3 – matching piece; 4 – manometer connection

Each gas compartment is equipped with contact manometer, which is the sensor of the gas protection. The contact manometer is connected to the gas compartment via a matching piece (only if necessary), a manometer connection, and a normal self-closing gas valve (DN8 or DN20). The matching piece is necessary only if the centre line of the gas valve is not vertical: in this case the matching piece provides the rotation between the gas valve and the contact manometer, which centre line is always in vertical position. (See the enclosed figure.)

ATTENTION!

If the contact manometer has to be dismounted because any reason, only the connection between the gas valve and the manometer connection can be opened. In this case the gas valve will close automatically and the gas lost will be minimal. (In other cases the gas compartment will be opened!)

The shipping units don't include the contact manometers because they are very sensitive. They usually are mounted on the gas compartments at site, after the pre-filling process (at reduced pressure). The construction of the contact manometers identical for the CB and the other compartments, only the number of micro-switches and their setting levels are different. The setting levels of the micro-switches can be checked during the filling process if the secondary system is in suitable state.

7.3. Tests after erection on site

After erection, before putting into service, the gas-insulated metal-enclosed switchgear shall be tested to check the correct operation and the dielectric strength of the equipment. These tests and verifications comprise:

a.) Checks and verifications:	7.3.1
b.) Measurement of gas condition:	7.3.2
c.) Gas tightness tests:	7.3.3
d.) Resistance measurement of the main circuit:	7.3.4
e.) Checking of current transformer cores:	7.3.5
f.) Dielectric tests on auxiliary circuits:	7.3.6
g.) High voltage tests on the main circuits:	7.3.7

To reduce the risk of moisture and dust entering enclosures so preventing correct operation of the switchgear, no obligatory periodic inspections or pressure tests are specified or recommended when the gas-insulated substation is in service.

7.3.1. Checks and verifications

After erection before the high voltage tests the GIS should have a final inspection. The followings should be checked step by step:

1.) Conformity of the primary switchgear with the manufacturer's drawings (single line diagram, gas schematic diagram, layout, section drawings of the different bays)

2.) Conformity of the secondary control and protection circuits with the manufacturer's drawings (schematic diagrams, connection diagrams, cable plans)

3.) Conformity of the earthing system with the manufacturer's drawings (earthing plans)

4.) Proper function of the direct current (DC) and alternating current (AC) auxiliary supply systems

5.) Proper operation, alarm and position indication of each circuit breaker drive according to the manufacturer's instructions (operational tests)

6.) Proper operation and position indication of each disconnector and earthing switch drive according to the manufacturer's instructions (operational tests)

7.) Proper function of the interlocks operated locally from the local control cubicles. (The remote operation is to be checked together with the central control equipment.)

8.) Proper function of the measuring, protective and regulating equipment including the internal heating and lighting of drives and cubicles.

9.) Proper condition of each gas insulated flange connection (wholeness, cleanness, tightness of nuts and bolts, greasing if necessary)

7.3.2. Measurement of gas condition

The gas filling pressure of each gas compartment shall be checked.

The moisture content of the insulating gas shall be checked. The content shall not exceed the following limits after humidity measurement:

- 50 ppm (mass) for circuit breaker poles
- 100 ppm (mass) for other components

7.3.3. Gas tightness tests

Leakage test with gas leak detector has to be performed around the flanges.

7.3.4. Resistance measurement of the main circuit

During the erection the resultant resistance of all bays (in each phase) between the busbar(s) and the outgoing terminal shall be checked. The resistance shall be calculated from the voltage drop measured at 300 A direct current (DC) loading current:

$$R = \frac{\Delta U}{I} = \frac{\Delta U}{300}$$

The resistance should be compared with the prescribed values and tolerances given by the manufacturer. The increasing of the resistance usually indicates some problem about the contact conditions of the tested part. The exact reason should be find and eliminate because it can cause overheating and failure later, during the work of the GIS.

7.3.5. Checking of the current transformer cores

The ratio and the polarity of each CT core have to be checked. These data have to be checked by primary current injection. The check has to be made phase-by-phase. The measuring result shall be recorded in test report.

The current injection circuit can be established during two closed earthing switches (maintenance or high-speed types), which are placed on both sides of the tested current transformer. The housing of each earthing switch is insulated from the further part of the enclosure with a special disc. In normal work this insulating disc is bypassed by a removable connection. To the tests this connection shall be removed from the first earthing switch, and the test equipment shall be connected to the connection points on both sides of the insulating disc. The injected primary test current flows through the closed contact of the first earthing switch, the current carrying bar between the earthing switches, the closed contact of the second earthing switch and the enclosure between the earthing switches.

The test shall be made phase by phase and the bypass connection can be removed only at the place tested. Considering the high current, which is necessary for the test, special attention has to be made for the mechanical security of the connections, for the proper contacts, for the placing of the connecting wires and for the proper earthing of the equipment. After finishing the measurement, before the connecting to the other phase, the bypass connection has to be replaced onto the earthing switch.

ATTENTION!

It is prohibited to remove the bypass connection of any earthing switch if the equipment is under voltage! The bypass connection can be removed only during the primary current injection tests. Before the connection of the test device a warning sign has to be placed on the local control cabinet, showing:

OPERATION IS FORBIDDEN!

7.3.6. Dielectric tests on auxiliary circuits

After the cabling works of the secondary system are completed, for checking the correct wiring the voltage test is to be performed with high voltage DC testing equipment. 500 V DC voltage has to be applied between the terminal blocks and the earth point. The neutral point connection of the tested AC circuit has to be removed during the above mentioned procedure.

7.3.7. High voltage tests on the main circuits

Since it is exceptionally important for the gas insulated switchgear, the dielectric strength shall be checked in order to eliminate any causes (wrong fastening, damage during handling, transportation, storage and erection, presence of foreign bodies, etc.) which might give rise to an internal fault in the future.

The high voltage site tests are supplementary to the dielectric routine tests with the aim of checking the dielectric integrity of the completed installation and of detecting irregularities. Normally the dielectric test shall be made after the switchgear has been fully erected and gas-filled at the rated density preferably at the end of all site tests, when newly installed. Such a dielectric test is recommended to be performed also after major dismantling for maintenance. These tests are to be distinguished from the progressive voltage increase performed in order to achieve a kind of electrical conditioning of the equipment before commissioning.

The test voltage should be increased by three steps to the final value:

Step	Voltage	Duration
1	220 / √3 ≈ 127 kV	15 min
2	220 kV	3 min
3	380 kV	1 min

Some parts have to be disconnected or dismounted for the test, either because of their high charging current or because of their effect on voltage limitation, such as:

- high voltage cables

- power transformers and voltage transformers

In case of BHILAI 220 kV GIS the high-voltage cables are connected through plug-in type cable sealing ends to the GIS. Before the high-voltage site test the cables have to be disconnected. Each cable bushing of the tested phase or section has to be closed by dummy connector to provide the voltage withstand ability.

ATTENTION!

Without dummy connector the bushing of the plug-in type cable sealing end cannot withstand the prescribed standard test voltages.

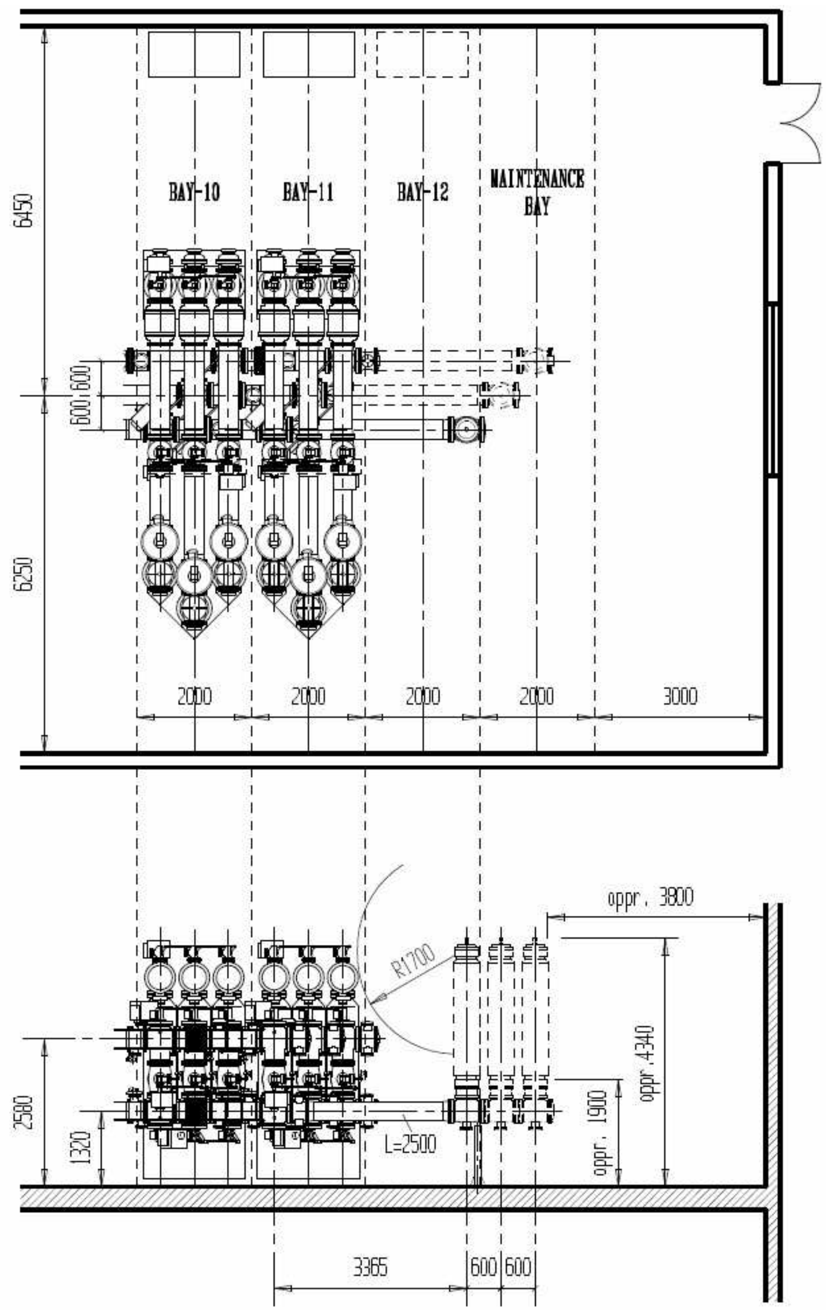
Each step of the dismounting and assembly work shall carefully follow the related instruction manual of the cable sealing end manufacturer.

The GIS can be divided into disconnected sections by opening of circuit breakers and/or disconnectors for the reason to limit the capacitive load on the test voltage source. The sections, which are not being tested in such cases, shall be earthed. Unless dismantled after routine test, no dielectric test across the open switching devices need be carried out on site. The exact sizes and limits of the sections can be determined according to the technical parameters of the high voltage test equipment, depending on the permissible capacitive load.

The estimated capacitances of the parts of BHILAI 220 kV GIS are according to the approximate calculations the followings:

Item	Denomination	Capacitance (pF)
1.	Lower busbar (No.1) without VT	1343 /phase
2.	Upper busbar (No.2) without VT	1343 /phase
3.	Bus Coupler bay (R/Y/B)	504 / 576 / 648
4.	Transformer bay without cables (R/Y/B)	800 / 872 / 872
5.	Incoming bay without cables and VT (R/Y/B)	813 / 885 / 885
6.	Complete GIS without cables and VT-s (R/Y/B)	10465 / 11185 / 11257
7.	Test adapter	534

The high-voltage tests of the sections can be carried out applied a test adapter which includes SF6-air bushing insulator. This adapter can be mounted to the end points of the lower busbars placed in BAY-11. See Figure No.11.



1) Site test of HV Cables

- The HV Cables shall be tested from the outer air-insulated cable sealing ends.
- Before the HV test the related cable shall be disconnected from the GIS.
  (The removable conductor element shall be removed, the connection places shall be shielded and the GIS side shall be earthed by earthing switch.)
- The test shall be fulfilled according to instructions of the cable supplier.
- After finishing the test to the original state of the GIS shall be restored.
- Before the normal work the equipment and the cable has to be in no-voltage, earthed state for 24 hours.

2) Site test of the 220 kV GIS

- The HV test equipment can be connected through test adapter and test bushing to the end of the lower busbars. See the enclosed arrangement drawings.
  (The related end-shielding of the busbar conductor shall be replaced by a tulip type contact, which is suitable to connect the HV part of the test adapter.)
- The GIS can be divided into sections to limit the capacitive load of the HV test equipment. The sections, which are not tested, in such cases shall be earthed.
- Before test the HV cables and the voltage transformers shall be disconnected.
  (VT-s shall be disconnected by hand-operated, single-phase disconnectors; the removable elements of HV cabels shall be removed, the connection places shall be shielded and the cables shall be earthed at the outer, air-insulated ends)
- The 220 kV GIS shall be tested according to the Switchgear Manual.
- After finishing the test to the original state of the GIS shall be restored.

Figure 11: Site test arrangement

ATTENTION!

The switching overvoltage can be dangerous for the tested equipment; therefore all switching operation is prohibited while the test voltage is connected to the GIS. For the high voltage test a board has to be placed on the local control cabinet with the notice:

OPERATION IS FORBIDDEN!

The switchgear shall be considered to have passed the test, if each section has withstood the specified test voltage without any disruptive discharge.

If a disruptive discharge occurs during the dielectric tests on site, the recommended procedures are the followings:

1.) If the disruptive discharge occurs along the surface of a solid insulation it is recommended that wherever practicable the compartment should be opened and the insulation carefully inspected for impairments. After taking any necessary remedial action the compartment should then be subjected to the specified dielectric test once more.

2.) A disruptive discharge in the gas may happen due to contamination or a surface imperfection, which may be burned away during the discharge. It can be acceptable therefore the repetition of the test at the same specified test voltage. If the repeated test fails again the procedure of item 1.) should be followed.

After the high voltage AC test the power supply cables, the power transformers and the voltage transformer can be mounted back.

ATTENTION!

The supplier prescribes the program and conditions of the site tests for the high voltage cables. These tests shall be carried out in disconnected state of the HV cables.

After finishing of the high voltage tests the original state of the GIS has to be restored, then the equipment has to be in no-voltage state for 24 hours. After that the equipment can start its normal work.

In the case of extensions, in general, the adjacent existing part of the switchgear should be de-energised and earthed during the dielectric test, unless special measures are taken to prevent disruptive discharges in the extension affecting the energised part of the existing switchgear.

Application of the test voltage may be necessary after repair or maintenance of major parts or after erection of extensions. The test voltage may then have to be applied to existing parts in order to test all sections involved. In those cases the same procedure should be followed as for newly erected switchgear.

8. Continuous operation

In normal service the GIS does not require any handling or maintenance.

In normal service the LOCAL-REMOTE selector switches are in "remote" control position, so the operation of any switches can happen from the control room. If the selector switch is turned into "local" control position, the switches of the concerned bay can be operated from the local control cubicle only. In emergency situation each switching process can be realised manually, by the aid of mechanical release (at circuit breaker) or hand crank (at disconnectors and earthing switches) immediately from the driving mechanism of the actuated switch.

The position signals of all switches appear in the mimic diagram of the local control cubicle and in the central control room as well. The real position and the general status of the disconnectors and earthing switches can be checked by visual inspection through the inspection window using the endoscope.

The alarm signals of the GIS go into the local control cubicle and the central control room at the same time.

Details of the above mentioned functions can be looked after in the detailed documentation and Instruction Manual of the Local Control Cubicles (LCC).

ATTENTION!

If any part (bay) of the high voltage gas-insulated switchgear is out of voltage for a relative long time, it is recommended to disconnect and earth the related high-voltage parts.

9. Inspection and maintenance

During the years of experience with GIS equipment in service proved that lifetime of the GIS is much longer than it was expected at the beginning of GIS manufacturing. The last estimations exceed 25-30 year lifetime. Development of GIS products also led to the reduction of maintenance requirements. Modern GIS equipment can be regarded as maintenance free.

However, there is always a small risk of failure that often can be avoided by proper monitoring and inspection of GIS. Operation Manuals of GIS devices contain all information necessary to perform inspections and Ganz Transelektro is ready to offer maintenance service and spare parts if any problem detected.

9.1. Inspections

Ganz Transelektro suggests to follow a time-condition based inspection program. Inspections are performed after a certain operation time or after reaching an operation number of specific equipment.

Inspection category	**Scope**	**Inspection schedule**	
		Indoor GIS	**Outdoor GIS**
Yearly inspection		Every year	
Minor inspection	Drives with operation No >= 50 / year	Every 5th year, or after 1000 operations*	Every 2nd year, or after 1000 operations*
	Drives with operation No < 50 / year	Every 10th year, or after 1000 operations*	
Detailed inspection		Every 20th year, or after 2000 operations*	
*If the inspection is fulfilled only because any switch reached the specified operation number, only the related equipment shall be inspected.			

The inspections should be performed according to the following table. Detailed instructions are given in the Operation Manuals of each device.

Inspection	Inspection work
Yearly inspection	Checking of gas densities in GIS compartments
	Checking of oil level in CB drive
	Overall external visual inspection of GIS
Minor inspection	One CO test operation from local control panel
	Checking of position indicators after operation
	Opening of LCC and drive enclosures for visual inspection
Detailed inspection	Measuring of operation times of equipment
	Checking of primer contacts of earthing switches and disconnectors by means of optical device (without opening GIS)
	Checking of switching pressures of SF6 density switches and hydraulic oil pressure switches.
	Visual inspection of cabling and multi-pin connectors between GIS and LCC

In case of any deviation detected, with the aid of the Operation Manual customer can identify the parts need to be maintained. Ganz Transelektro is ready to specify and offer all parts and maintenance service necessary to repair the GIS in the shortest time.

9.2. Maintenance

GIS is hermetically closed, all primary conductors, contacts are under protective gas atmosphere therefore no corrosion may occur due to external humidity. There are no internal or external parts designed to replace within the lifetime of GIS.

Our GIS is designed and type tested with 2000 operations of disconnector, earthing switch and circuit breaker. During the tests no adjustment or any other maintenance was necessary. According to our and international experience, number of operations of GIS equipment is low, significantly less than the operation number at type tests. When circuit breaker reaches the specified switched current sum, an overhaul of the circuit breaker is required. However, again, according to our practice this value is reached in very rarely, in case of circuit breakers with extremely high operation numbers.

We can assume that due to the design of our GIS and the low operation frequency we practically consider this GIS to be maintenance-free.

Therefore our Operational Manual does not contain any maintenance requirement.

Overhaul	**Schedule**	**Overhaul work**
Circuit breaker overhaul	after reaching 14400 $(kA)^2$ cumulative interrupting current capacity or after 10,000 operations	replacement of gas filters
		internal cleaning
		replacement of nozzles
		replacement of arcing contacts
		replacement of main contacts and multi-contact lamellas
		checking of operation time, operating currents
High-speed earthing switch overhaul	after two switching on short circuit	replacement of arcing contacts
		replacement of main contacts and multi-contact lamellas
		checking of operation time, operating current

Electrical lifetime of the circuit breaker is affected by each switching procedure. Each current breaking cause wears on nozzles and contacts which are depending on the fault current. The permitted cumulative current interrupting capacity of the circuit breaker:

I_q^2 (maximum) = 14400 $(kA)^2$

Breaker must be overhauled when this limit value is reached. The actual cumulative interrupted current value (I_q^2) can be calculated in the following way:

$$I_q^2 = \sum I_i^2 = I_1^2 + I_2^2 + I_3^2 + ...$$

Where I_1, I_2, I_3 etc are the actual currents interrupted by the breaker at a specific event.

9.3. Spare parts

Generally, Ganz Transelektro doesn’t recommend to stock spare parts for GIS products due to the low risk of failure.

However, if ordered, we are ready to offer spare parts. Taking into consideration, that all parts are designed to last up to the lifetime of GIS, selection can be done only on probability base or according to the decision of the customer.

In this case, spare parts stocked at customer may reduce a possible maintenance time.

Note, that some types of spare parts (for example: lubricants) have limited storage time.

9.4. Special tools

GIS is supplied with all necessary accessories for operation of GIS. There is no need for special tools to perform the inspections specified.