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ELECTRICAL SYSTEM OF AN URBAN DEVELOPMENT

by

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Author's declaration

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Chapter I: Background

1.1. INTRODUCTION

The electrical system that supplies energy to one town, it is possible to sum up briefly of the following way: the distribution of the energy from power substation to the different powerhouses of a town is after transformed and given to an urban development.

This development consists in several blocks, which have in turn some transformers stations to supply the buildings.

1.2. AIM OF THE PROJECT

The object of this project is the description of the facilities for the electrification of an urban development located in Villanueva de Gállego in the province of Saragossa.

By the study of the current infrastructure and the needs for electrical power for plot and of the conditions of supply given by the electricity supplier in the area (Endesa Distribución Eléctrica S.L.U.) has been decided in favour of the solution of constructing the following facilities:

- Three UNDERGROUND transformer stations that will pass to belong to the Company Endesa Distribución Eléctrica S.L.U. (it will serve to give supply in Low Voltage to the subscribers who wish it).

- Underground network of High Voltage to join in ring the transformer stations with the exterior network of Endesa Distribución Eléctrica S.L.U.

- Underground networks of Low Voltage, underground stretch of the cables in low voltage to supply the different blocks and panel boards with input / output of line and derivations to subscribers.

With this project, it is tried to establish the characteristics to which it will be necessary to fit the facilities, having present aesthetic safety criteria, technical, the quality of service and the development of the network.

1.3. DESIGN OVERVIEW

1.3.1. Connection with the exterior system of the company supplier

The electrical supply in Low Voltage to the urban development will be realised from future projected powerhouse. The connection with the exterior system of the company supplier will be carried out according to existing supply conditions, by means of Input and Output in the Underground Network of Medium Voltage that exists and joins the existing transformer stations of Endesa. Three new projected powerhouses will join in ring this connection point.

The Center of Transformation type “rural hut” also called "Reformatory", is going to be dismantled and substitute for another buried, because it works with a voltage of 10KV, which is a voltage that is trying to be changed actually to 15KV. The current connection to this transformer station (2 circuits of 3x1x150 mm2 Al, 12/20 KV) will keep on supporting in the new transformer station, joined to both line electrical panels. (1)

The proper Company Supplier will realise the junctions corresponding to the circuit of high existing voltage, according to drawings. The promoter will leave 15m of wires for the three in the emplacement of the junctions so that these could be realised without difficulty.

1.3.2. Loads forecast

The Area of Intervention is formed by four blocks destined for buildings (named R1, R2, R3 and R4), with 313 houses in whole and another plot for equipment named R-5.

According to circuits forecast for the blocks in Low Voltage:

- R1 BLOCK

- 58 houses with grade of basic electrification (5,750 W/house).
- 300 m2 for commercial use

- R2 BLOCK

- 48 houses with grade of basic electrification (5,750 W/house).

- R3 BLOCK

- 64 houses with grade of basic electrification (5,750 W/house).

- R4 BLOCK

- 143 houses with grade of basic electrification (5,750 W/house).
- 100 m2 for commercial use

- Equipment for R5 BLOCK (6,561.56 m2 of suitability for building), foreseeable powerhouse.

- Public lighting system

(2)

1.3.3. Characteristics of the facilities

The facilities to be executed are formed by:

• High Voltage Underground network (10 kV current, 15 KV in the future) in ring with Input and Output in the Underground Network of Medium Voltage (10-15 KV) that exists and joins the existing Powerhouses of Endesa, the electrical company in the area.

• Three underground transformer stations (Two for supplying to the new houses and one that will substitute the existing transformer station and will connect to the existing ring); this amount is the result of the calculations made in the measurements of load forecast.

• Underground networks of Low Voltage and fuse boards for derivation to subscribers.

Chapter II: Measurements

2.1. LOW VOLTAGE CIRCUITS FORECAST

R1 BLOCK

58 houses (6,753.52 m2 residential suitability for building)

300 m2 commercial use

The estimation would be about 5 stairwells of 10 houses each one and 1 stairwell of 8 houses.

5 x coefficient of Simultaneity (8.5) x 5,750 W/house = 5 stairwells x 48,875 W = 224,375 W

1 x coefficient of Simultaneity (7) x 5,750 W/house = 1 stairwell x 40,250W = 40,250W

- Load corresponding to general services:

Lighting, telecommunications, lifts, etc. (6 stairwell x 15KW/stairwell) = 90,000 W

- Load corresponding to commercial places: 300m2 in places (100 W/m2) = 30,000 W

- Load corresponding to the block garages R1:

3,144 m2 in garages with forced ventilation (20 W/m2) = 62,880 W

TOTAL POWER FOR R1 BLOCK 447,505 W

R2 BLOCK

48 houses (5,589.12 m2 residential suitability for building)

- 0m^2 commercial use

The estimation would be about 4 stairwells of 10 houses each one and 1 stairwell of 8 houses.

4 x coefficient of Simultaneity (8.5) x 5,750 W/house = 4 stairwells x 48,875 W = 195,500 W

1 x coefficient of Simultaneity (7) x 5,750 W/house = 1 stairwell x 40,250W = 40,250W

- Load corresponding to general services:

Lighting, telecommunications, lifts, etc. (5 stairs x 15KW/stairwell) = 75,000 W

- Load corresponding to the block garages R2:

2,567 m2 in garages with forced ventilation (20 W/m2) = 51,340 W

TOTAL POWER FOR R2 BLOCK 362,090 W

R3 BLOCK

64 houses (7,452.16 m2 residential suitability for building)

- 0m^2 commercial use

The estimation would be about 5 stairwells of 10 houses each one and 1 stairwell of 14 houses.

5 x coefficient of Simultaneity (8.5) x 5,750 W/house = 5 stairwells x 48,875 W = 244,375 W

1 x coefficient of Simultaneity (11.3) x 5,750 W/house = 1 stairwell x 64,400 W = 64,975 W

- Load corresponding to general services:

Lighting, telecommunications, lifts, etc. (6 stairwells x 15KW/stairwell = 90,000 W

- Load corresponding to the block garages R2:

3,425 m2 in garages with forced ventilation (20 W/m2) = 68,500 W

TOTAL POWER FOR R3 BLOCK **467,850 W**

R4 BLOCK

143 houses (16,652.03 m2 residential suitability for building)

- 100m^2 commercial use

The estimation would be about 11 stairwells of 13 houses each one.

11 x coefficient of Simultaneity (10.6) x 5,750 W/house = 11 stairwells x 60,950 W = 670,450 W

- Load corresponding to general services:

Lighting, telecommunications, lifts, etc. (11 stairwells x 15KW/stairwell). = 165,000 W

- Load corresponding to commercial places:

100 m2 in places (100 W/m2) = 10,000 W

- Load corresponding to the block garages R1:

6.708 m2 in garages with forced ventilation (20 W/m2) = 134,160 W

TOTAL POWER FOR R4 BLOCK **979,610 W**

- Equipment for **R5 BLOCK** (6,561.56 m2 of suitability for building), foreseeable powerhouse= 140,000 W in low voltage (630VA with particular transformer)

PUBLIC SYSTEM LIGHTING **41,000 W**

WHOLE REQUESTED IN LOW VOLTAGE **2,437 KW**

(Bearing in mind a future particular powerhouse for R5 BLOCK) **3,053 KW**

2.2. UNDERGROUND NETWORKS OF HIGH VOLTAGE (10/15 KV)

2.2.1. Tracing of the underground network

From the medium voltage circuit that Endesa has between two powerhouses, there will be realised the input/output to the powerhouse that we will call No.1 (it works like a disconnect switch. From this one, the powerhouse No.2 will be fed doing input/output. From the powerhouse No.2 projected, the powerhouse No.3 will be fed and from that one the circuit will turn to the powerhouse No.1 to join the existing ring.

All the high voltage cables used in this stretch will be RHZ1 12/20 KV Al 3x1x400 mm².

Its tracing has been projected under pavement.

Inside the powerhouse, the wires will end in unipolar terminals of interior to link into the line switchgear. (3)

Figure 1: Underground network

2.2.2. Type of cables

The cables used for the High Voltage Underground Network will be UNE RHZ1 12/20 kV Al.

These will be of Aluminium, unipolar, with interior polyethylene isolation chemically reticulated, intermediate metallic screen and covered exterior VEMEX. (4)

Cables 3x1x400 mm ², Aluminium

. Isolation / covering: PEX/VEMEX

. UNE designation: RHZ1

. Rated normal voltage of the wire: 12/20 kV

. Nature of the wire: Al

. Section: 400 mm2

Characteristics:

Average approximated diameter of the cable (mm):	43.1
Approximated weight (Kg/Km)	2,400
Maximum electrical Resistance at 20ºC (Ohm/Km)	0.0778
Resistance at 50 Hz a 90ºC (Ohm/Km)	0.102
Reactance at 50 Hz (Ohm/Km)	0.098
Maximum current in the air (A)	580
Maximum current in trench (A)	500
Maximum power (Installed in trench)	12,990 KVA

Table 1: Characteristics of the wires in High Voltage

2.2.3. Installation systems

All the tracing of the network of high voltage will be quite under the public pavement.

The trench for pavement will be 1.20m of depth and 0.7m of width, pulling the cables to a 1.10m depth. They will have to take a mechanical protection for badge PPC and a mesh of signalling as RU 0205.

The roadways crossings will be realised perpendicular to the pavement and every driver will have to go protected by pipe of PVC or 110mm PE of diameter in dice of concrete HM-20. In every crossing, there will be at least three free pipes (for forecast of another circuit).

2.2.4. Accessories

The terminals will be adapted to the nature, composition and section of the cables, without increasing the electrical resistance of these.

The cable terminations will have to be adapted also to the environmental characteristics (interior, exterior, contamination, etc.).

2.2.5. Grounding

The metallic shields of the cables will be connected to ground in their terminal boxes.

2.3. TRANSFORMER STATIONS

There is projected the laying of three Powerhouses of prefabricated and underground type.

Two of them (Powerhouse No.1, Powerhouse No.2 as drawings) will have capacity for two transformers each one.

The Powerhouse No.3 will have capacity for one transformer. (5)

2.3.1. Place and accesses

The Centres of Transformation will be located in private area, with public access. So that the Endesa staff has free and direct access from public road consolidated to the facilities that affects to his future development.

2.3.2. Type of Centre

The powerhouse will be built underground by means of a prefabricated building of civil work.

The ventilation is projected by grills in vertical. If later out necessary to modify them, it would be realised with the consensus of Endesa Distribución Eléctrica S.L.U.

Its dimensions will allow the movement and setting into them the elements and the machinery necessary for the suitable achievement of the installation, execution of the proper manoeuvres of the development in ideal conditions of safety and the maintenance of the material.

I. Constructive Characteristics

In its construction there will be born in mind acoustics conditions, moisture, pollutants and protection from external agents.

Both the powerhouse and its implantation, they will have to observe the Municipal ordinance of Noises and Vibrations.

The underground canalisations will allow the access of the cables to the interior of the powerhouse and inside it, the access of the cables to the switchgears, transformer and switchboards of low voltage.

Besides, the station will be provided with the necessary system of ventilation (ventilation grills in vertical).

II. Electrical Installation

SUPPLY

The supply in high voltage will be realised, in ring (every transformer station will be able to be supplied from two different inputs).

From the circuit of Medium Voltage that Endesa has joining between two existing powerhouses; there will be realised input/output to the powerhouse No.1 projected. From this one the powerhouse No.2 will be supplied and from this one the powerhouse No.3 will feed doing input/output and from the last one, the circuit will turn again to join the existing ring between the two existing powerhouses of the company supplier.

The elements of protection and manoeuvre will be installed inside a set of modular prefabricated switchgears or mono-block, being mounted as it continues:

- **IN THE PROJECTED TRANSFORMER STATION No.1**
    - Two ring main panels in SF_6 integral (One for the input from the existing circuit of Endesa and one for the output towards the projected station No.2)
    - Two modular transformer protection panels in SF6, according to drawings.
- **IN THE PROJECTED TRANSFORMER STATION No.2**
    - Two ring main panels in SF_6 integral (one for the input from the station No.1 and one for the output towards the station No.3)
    - Two transformer protection panels in SF_6, according to drawings.
- **IN THE PROJECTED TRANSFORMER STATION No.3**
    - Four ring main panels in SF_6 integral (One for the input from the projected station No.2, one for the output towards the existing circuit of Endesa plus two for keeping on the existing supply)
    - One transformer protection panel in SF_6, according to drawings.
    - One isolating switch panel in SF_6, according to drawings.

Figure 2: Underground transformer station

Chapter III: Specifications

3.1. RING MAIN PANEL

The characteristics of the panels to install will be the following ones for the electrical connection (line):

Rated normal current: 630A

Rated normal voltage: 24KV

Admissible rated current in a short duration: 20KA

Composed by the following elements:

- Power switch in SF6 integral for these characteristics
- Make proof grounding switch
- Unipolar terminals of inside (3 for cable of 400 mm²)

3.2. TRANSFORMER PANEL:

The characteristics of the cabin to install will be the following ones:

Rated normal current: 400A

Rated normal voltage: 24KV

Admissible rated current in a short duration: 20KA

. Composed by the following elements:

- Power switch in SF6 integral for these characteristics
- Fuse of high power of rupture of 63A, for a tension of 24 kV
- Isolating switches for putting to ground nailed with the control of the power switch
- Unipolar terminals of inside for cable of 95mm² in Aluminium

Figure 3: Interior of the transformer station

3.3. TRANSFORMERS

IN THE C.T. No. 1 PROJECTED

- Two transformers of 630 KVAs will be installed in the station No.1 projected

IN THE C.T. No. 2 PROJECTED

- Two transformers of 630 KVAs will settle in the station No.2 projected

IN THE C.T. No. 3 PROJECTED (SUBSTITUTE REFORMATORY STATION)

- One transformer of 630 KVAs will settle in the station No.3 projected.

The transformers of 630 KVAs will have the following characteristics:

Electric Power: 630 KVAs, DRY ENCAPSULATED

Voltage in the primary winding: 9,500-16,455 V

Voltage in the secondary winding: 420-230 V

Regulation: ±5 ±10 % +15

Group connection: Dyn11

Short circuit rated voltage: 4 %

(6)

The nucleus and the winding of the transformer will be encapsulated in epoxy resin.

ISOLATION LEVELS				
WINDING	**RATED VOLTAGE OF THE NETWORK (Un), [KV]**	**VOLTAGE MORE RAISED FOR THE MATERIAL (Um), [KV]**	**SUPPORTED VOLTAGE OF SHORT DURATION (1m) AT INDUSTRIAL FREQUENCY [KV]**	**VOLTAGE SUPPORTED TO IMPULSES TYPE BEAM [KV]**
HIGH VOLTAGE	10	12	28	75
	15	17.5	38	95
	20	24	50	125
	25	36	70	170
LOW VOLTAGE	0.23	1.1	10	30
	0.4	1.1	10	30

Table 2: Isolation levels in transformers

LOSSES AND NO LOAD CURRENTS				
	Um<=24 KV		Um=36 KV	
POWER RATING [KVA]	NO LOAD LOSELESS (*) [W]	LOAD LOSELESS AT 75º C [W]	NO LOAD LOSELESS (*) [W]	LOAD LOSELESS AT 75º C [W]
50	190	1,100	230	1,250
100	320	1,750	380	1,950
160	460	2,350	520	2,550
250	650	3,250	780	3,500
400	9,300	4,600	1,120	4,900
630	**1,300**	**6,500**	1,450	6,650

(*) The relation between the no load current to 110 % and to 100 % of the rated voltage will not exceed 3.

Table 3: Losses and no load currents

Level of noise:

The level of noise expressed by the transformer will not exceed the value indicated to continuation, expressed as the average of the values measured in 4 points, placed in the axes of the transformer and separated from it 0.3m as UNE 21315. (7)

NOISE LEVEL	
POWER RATING [KVA]	**NOISE LEVEL ACOUSTIC PRESSURE [dB]**
50	44
75	46
100	48
160	50
250	52
400	54
630	**56**

Table 4: Noise level in the transformers

Aptitude for supporting short circuits:

The transformer will be projected and constructed to support without deterioration thermal and dynamic effects from the exterior short circuits in the conditions specified in the Norm UNE 20101. The value of the over-current and its duration will be:

APTITUDE FOR SUPPORTING SHORT CIRCUITS		
POWER RATINGS [KVA]	**OVERCURRENT VALUES (EFFECTIVE VALUE) EXPRESSED IN MULTIPLE OF THE RATED CURRENT(*)**	**DURATION**
Up to 630 (12-17.5 Y 24 kV)	**25**	2
Up to 630 (36 kV)	22.2	

(*) The first peak amplitude of the asymmetric current of essay will be 2.55 times that of the symmetrical current.

Table 5: Aptitude for supporting short circuits

The constructive details with regard to not detailed specifications will fulfill with the established norms in RU 5201 C and UNE 2C138.

3.4. LOW VOLTAGE SWITCHBOARDS

Every Center of Transformation will be provided with enclosures of modular distribution for low tension, according to RU 6302, which function is to receive the Low Voltage circuit proceeding from the transformer and to distribute it in individual circuits.

These enclosures for distribution of 4 outputs will take a load indicator with maximeter, **switch on load of 4 x 1,600A approved** by Endesa Electrical distribution, S.L.U. even three pole bases type BTVC with cut on load and 12 fuses, transport, installation and hookup. Example: Mod. CBT-1600 AC-1 of PRONUTEC, or similar.

Figure 4: Low-voltage switchboards

3.5. CONNECTION WIRES IN HIGH VOLTAGE

The connection between panels and transformers will be realized by means of unipolar cables of Aluminum with dry isolation EPR, of the type 12/20 kV and section 95 mm².

The terminals will be of the fixed type as the norm UNE 21115.

Figure 5: Connection wires in high voltage

3.6. CONNECTION WIRES IN LOW VOLTAGE

The joint between the terminals of the transformer and the protection boxes of low voltage will be realized by means of unipolar wires with isolation type RV of 240 mm ² of section in Cu and isolation 0,6/1 KV.

It will be settled two wires for phase and two for the neutral one for a power foreseen in the transformer of 630 KVA.

It will be settled two wires for phase and two for the neutral one for a power foreseen in the transformer of 400 KVA.

3.7. NETWORK OF GROUNDS

Two installations of putting will get ready to ground independent between them, one grounding for the protection and another one for services (neutral, low voltage).

Protection Grounding:

The High and Low Voltage grounding, the metallic screens of the cables, screens or protection grids, metallic interior armors and metallic tank of transformers will get connected to an installation or ground electrode.

This electrode will be formed by pikes of steel with copper and bare conductor of 50 mm² Cu.

Figure 6: Box for checking the protection ground in the transformer station

Grounding of service (neutral BT):

Every transformer will have its neutral grounded independently.

The line of ground will go out from Low Voltage terminal of the neutral of transformer.

The putting to ground will be realized by isolated wire of Cu of 0.6/1 KV of $50mm^2$ of section and pikes of steel with copper.

The distance from the ground to the center of transformation will not be lower to 20m.

In the calculations, there is justified the election and configuration of the ground electrode to install, there is being used for it the method of calculation and project for grounding facilities for centres of transformation connected to networks of third category, approved by the General Direction of the Energy of Department of Industry, with date February 2 of 1,989.

Figure 7: Box for checking if neutral is connected to earth in the transformer

3.8. LIGHTING SYSTEM

It will be settled the necessary sources of light to obtain an average level of lighting of 150 lux for the interior lighting system of every transformer station.

3.9. UNDERGROUND NETWORKS IN LOW VOLTAGE

3.9.1. Characteristics

Rated voltage

The distribution in Low Voltage will be realized to the rated voltage of 400V in three-phase disposition (III+N).

Calculation of power

In the calculations chapter, the power is detailed for each plot.

Tracing of the network

The connections that will feed the plots will be realized directly from the Centers of Transformation, up to the boxes of general devices of protection, from where will go out the different individual derivations to every plot.

Wires

The wires to install will be of aluminum with isolation of ethylene-propylene with exterior covering of PVC, according to norm UNE 21123 and the Recommendation of UNESA 3304.

Cable: 3x1x240+1x240 mm², Aluminum FOR SUPPLYING TO DOORWAYS.

. Isolation / covering: EPR/PVC

. UNE Designation: RV 0.6 /1 KV

. Nature of the wire: Al

. Wire size: 240 mm.

Electrical characteristics:

. Maximum underground current: 430A

. Resistance: 0.125 Ω/Km

. Reactance: 0.081 Ω/Km

. Maximum power to transport (cosθ=1): 283 KW

(Buried installation)

Figure 8: Low-voltage underground cabling

3.9.2. Protections

The cables will be protected against short circuits by means of fuses of type gL, with characteristics as norm UNE 21103 arranged to such, in the picture of low voltage, arranged in the Center of Transformation as the origin of the connection.

The essays corresponding to the above mentioned wires will be realized as the Protocol of Electrical Endesa Distribución S.L.U. and the installation will be executed with materials approved by the Company.

Systems of installation

The low voltage connections will be of the type underground without canalizations, departing from the electrical panels of low voltage of the centers of transformation, they will pass completely in trenches.

The cables will be lodged in trenches of width and variable depth as regulation, laying the cables on 0.7m of depth.

Along the whole trench a mark tape will be placed of characteristics indicated in the RU 0205, to 30 cm. of the surface of the trench and for badges of PPC approved by Endesa (trenches by the sidewalk).

The necessaries essays of compression will be realized as norms of Endesa Electrical Distribution S.L.U.

Accessories

The terminals and junctions will be adapted to the nature, composition and section of the cables without must increase the electrical resistance of these.

General devices of protection

According to the distribution line, number of individual electrical connections, power and characteristics of the plots, electrical panel boards and sets of electrical protections and choppers will be settled.

These devices will be constructed of insulated enclosures, containing connection terminals, the bases for circuit breaker, fuses and choppers, in its case.

3.9.3. Enclosures, chopper and protection sets:

CSP-250-250/400: composed by a three-poles base of 400A for the network input and two three-poles bases of 250A for two derivations of the main line.

Crossings, parallelisms and proximities

The requisites for crossings, proximities and parallelisms that the cables will fulfill, it will be the conditions as consequence of the legal dispositions, than the competent affected Organisms impose, principally the **safety distances** prescribed by the Low Voltage Regulation**.**

Admitted Drop of Voltage

The low voltage networks have been projected so that the maxim voltage drop must not exceed 5% of the line voltage.

Chapter IV: Calculations

4.1. CALCULATIONS FOR LOW VOLTAGE

4.1.1. Low-voltage networks calculation

FORMULA SHEET

Data for the calculus:

Power to calculate: several

Power factor: 0.85

Maximum drop voltage: 5% (20 V)

Simultaneity coefficient: according to REBT

Formula:

$$I = \frac{P}{3 \times U \times \cos \varphi}$$

$$e = \frac{\left[ME \left(R + X \times \cos \varphi \right) \right]}{U} ; e(\%) = \frac{e \times 100}{400}$$

ME = electrical torque (P x L) in KW*m

e = drop voltage in V

e(%) = drop voltage in %

U = voltage between phases in the V

I = current in A

P = power in KW

L = length of the line in m

R = resistance in Ω / Km

X = reactance in Ω / Km

Applying these expressions to each of the stretches of the network, in accordance with the one-line diagram attached, the values of the maximum power to transport, maximum current and voltage drop are obtained.

4.1.2. Underground Network

Next there are described the justificatory calculations of each of the projected circuits in low voltage.

C.T. No. 1								
CIRCUIT No. 1								
			CALCULUS OF ELECTRICAL CIRCUITS					
		CIRCUITS DERIVED FROM C.T. No. 1 (VOLTAGE 400/230 V)						
POWER FACTOR =	0,85							
CIRCUIT No. 1								
ORIGIN:	C.T. No. 1							
CONDUCTOR:	**RV 0.6/1 KV 240 mm2 . - Al (Maximum admissible current= 430)**							
ELECTRICAL LAYING:	DIRECTLY IN TRENCH							
END:	C.S.P. (2b) IN THE "R-1" PLOT "							
LOADS								
20 HOUSES + G.S.	129	KW						
0 m2 COMMERCIAL USE	0	KW						
1,050 m2 GARAGES	21	KW						
FORESEEN POWER:	**150**	**KW**						
CIRCUIT	**POWER**	**CURRENT**	**SIZE**	**LENGTH**	**VOLTAGE**	**DROP**	**ACCUMUL.**	**DROP**
(STRETCH)	**(W)**	**(A)**	**(mm2)**	**(m)**	**(V)**	**VOLT. (V)**	**DROP (V)**	**VOLT.**
C.T. No. 1 - C.S.P. (1b)	150,000	254.72	**240 - Al**	150	400	6.70	6.70	**1.67%**
MAX. DROP OF VOLTAGE		1.67%	<	5	%			
MAX. POWER:		150,000	<	200,043	W			
MAX. CURRENT:		254.72	<	339.7	A (Imax. con coef.)			
CENTRE OF TRANSF. No. 1								
TRANSF. OF 630 + 630 KVAS			**FACTOR OF CORRECTION**					
			DISTANCE BETWEEN 3-CORE CABLE	NUMBER OF 3-CORE CABLES OF THE TRENCH				
CIRCUIT 1	150	Kw		2	3	4	5	6
CIRCUIT 2	150	kW	D=0	0.8	0.7	0.64	0.6	0.56
CIRCUIT 3	150	kW	d=0.07 m	0.85	0.75	0.68	0.64	0.6
CIRCUIT 4	178	kW	d=0.10 m	0.85	0.76	0.69	0.65	0.62
CIRCUIT 5	178	kW	d=0.15 m	0.87	0.77	0.72	0.68	0.66
CIRCUIT 6	178	kW	d=0.20 m	0.88	**0.79**	0.74	0.7	0.68
CIRCUIT 7	40	kW	d=0.25 m	0.89	0.8	0.76	0.72	0.7
CIRCUIT 8	219	kW						
CIRCUIT 9 PUBLIC LIGHT.	40	kW						
TOTAL=	**1,283**	**KW (POWER IN LOW VOLTAGE)**						
	630+630 KVAS	**TOTAL POWER FOR THE CENTER OF TRANSFORMATION**						

*C.S.P.: Secondary panel board **G.S.: General Services

Table 6: Circuit No.1 derived from C.T. No. 1

C.T. No. 1								
CIRCUIT No. 2								
			CALCULUS OF ELECTRICAL CIRCUITS					
		CIRCUITS DERIVED FROM C.T. No. 1 (VOLTAGE 400/230 V)						
POWER FACTOR =	0.85							
CIRCUIT No.2								
ORIGIN:	C.T. No. 1							
CONDUCTOR:	**RV 0.6/1 KV 240 mm2 . - Al (Maximum admissible current= 430)**							
ELECTRICAL LAYING:	DIRECTLY IN TRENCH							
END:	C.S.P. (2b) IN THE "R-1" PLOT							
LOADS								
20 HOUSES + G.S.	129	KW						
0 m2 COMMERCIAL	0	KW						
1,050 m2 GARAGES	21	KW						
FORESEEN POWER:	**150**	**KW**						
CIRCUIT	**POWER**	**CURRENT**	**SIZE**	**LENGTH**	**VOLTAGE**	**DROP**	**ACCUMUL.**	**DROP**
(STRETCH)	**(W)**	**(A)**	**(mm2)**	**(m)**	**(V)**	**VOLT. (V)**	**DROP (V)**	**VOLT. (%)**
C.T. No. 1 - C.S.P. (2b)	150000	216.51	**240 - Al**	100	400	4.46	4.46	**1.12%**
MAXIMUM DROP VOLTAGE:		1.12%	<	5	%			
MAXIMUM POWER:		150,000	<	200,043	W			
MAX. CURRENT:		216.51	<	339.7	A			
CENT. OF TRANSF. No. 1								
TRANSFORMERS OF 630 + 630 KVAS			**FACTOR OF CORRECTION**					
			DISTANCE BETWEEN 3-CORE CABLE	NUMBER OF 3-CORE CABLES OF THE TRENCH				
				2	3	4	5	6
CIRCUIT 1	150	KW	D=0	0.8	0.7	0.64	0.6	0.56
CIRCUIT 2	150	KW	d=0.07 m	0.85	0.75	0.68	0.64	0.6
CIRCUIT 3	150	KW	d=0.10 m	0.85	0.76	0.69	0.65	0.62
CIRCUIT 4	178	KW	d=0.15 m	0.87	0.77	0.72	0.68	0.66
CIRCUIT 5	178	KW	d=0.20 m	0.88	**0.79**	0.74	0.7	0.68
CIRCUIT 6	178	KW	d=0.25 m	0.89	0.8	0.76	0.72	0.7
CIRCUIT 7	40	KW						
CIRCUIT 8	219	KW						
CIRCUIT 9 PUBLIC LIGHT.	40	KW						
TOTAL=	**1,283**	**KW (POWER IN LOW VOLTAGE)**						

Table 7: Circuit No.2 derived from C.T. No. 1

PRIFYSGOL glyndŵr UNIVERSITY

C.T. No. 2

CIRCUIT No. 1

CALCULUS OF ELECTRICAL CIRCUITS

CIRCUITS DERIVED FROM C.T. No. 2 (VOLTAGE 400/230 V)

POWER FACTOR =	0.85							
CIRCUIT No. 1								
ORIGIN:	C.T. No. 2							
CONDUCTOR:	**RV 0.6/1 KV 240 mm2 . - Al (Maximum admissible current= 430A)**							
ELECTRICAL LAYING:	DIRECTLY IN TRENCH							
END:	C.S.P. (1b) IN THE "R-2" PLOT							
LOADS								
20 HOUSES + G.S.+ GARAGES	146	KW						
FORESEEN POWER :	**146**	**KW**						
CIRCUIT (STRETCH)	**POWER (W)**	**CURRENT (A)**	**SIZE (mm2)**	**LENGTH (m)**	**VOLTAGE (V)**	**DROP VOLT. (V)**	**ACCUMUL. DROP (V)**	**DROP VOLT. (%)**
C.T. No. 2 - C.S.P. (1b)	146,000	247.93	**240 - Al**	70	400	3.04	3.04	**0.76%**
MAXIMUM DROP VOLTAGE:		0.76%	<	5	%			
MAXIMUM POWER:		146,000	<	253,218	W			
MAX. CURRENT:		247.93	<	430	A			
CENT. OF TRANSF. No. 2								
TRANSFORMERS OF 630 + 630 KVAS			**FACTOR OF CORRECTION**					
			DISTANCE BETWEEN 3-CORE CABLE	NUMBER OF 3-CORE CABLES OF THE TRENCH				
CIRCUIT 1	146	KW		2	3	4	5	6
CIRCUIT 2	178	KW	D=0	0.8	0.7	0.64	0.6	0.56
CIRCUIT 3	178	KW	d=0.07 m	0.85	0.75	0.68	0.64	0.6
CIRCUIT 4	89	KW	d=0.10 m	0.85	0.76	0.69	0.65	0.62
CIRCUIT 5	140	KW	d=0.15 m	0.87	0.77	0.72	0.68	0.66
CIRCUIT 6	156	KW	d=0.20 m	0.88	0.79	0.74	0.7	0.68
CIRCUIT 7	156	KW	d=0.25 m	0.89	0.8	0.76	0.72	0.7
CIRCUIT 8	156	KW						
TOTAL=	**1,199**	**KW (POWER IN LOW VOLTAGE)**						
	630+630 KVAS	**TOTAL POWER FOR THE CENTER OF TRANSFORMATION**						

Table 8: Circuit No.1 derived from C.T. No. 2

C.T. No. 2								
CIRCUIT No. 2								
			CALCULUS OF ELECTRICAL CIRCUITS					
		CIRCUITS DERIVED FROM C.T. No. 2 (VOLTAGE 400/230 V)						
POWER FACTOR =	0.85							
CIRCUIT No. 2								
ORIGIN:	C.T. No. 2							
CONDUCTOR:	**RV 0.6/1 KV 240 mm2 . - Al (Maximum admissible current= 430A)**							
ELECTRICAL LAYING:	DIRECTLY IN TRENCH							
END:	C.S.P. (2b) IN THE "R-4" PLOT							
LOADS								
26 HOUSES + G.S.	178	KW						
+ GARAGES								
FORESEEN POWER :	**178**	**KW**						
CIRCUIT	**POWER**	**CURRENT**	**SIZE**	**LENGTH**	**VOLTAGE**	**DROP**	**ACCUMUL.**	**DROP**
(STRETCH)	**(W)**	**(A)**	**(mm2)**	**(m)**	**(V)**	**VOLT. (V)**	**DROP (V)**	**VOLT. (%)**
C.T. No. 2 - C.S.P. (2b)	178,000	302.27	**240 - Al**	90	400	4.77	4.77	**1.19%**
MAXIMUM DROP VOLTAGE:		1.19%	<	5	%			
MAXIMUM POWER:		178,000	<	200,043	W			
MAX. CURRENT:		302.27	<	339.7	A			
CENT. OF TRANSF. No. 2								
TRANSFORMERS OF 630 + 630 KVAS			**FACTOR OF CORRECTION**					
			DISTANCE BETWEEN 3-CORE CABLE	NUMBER OF 3-CORE CABLES OF THE TRENCH				
CIRCUIT 1	146	KW		2	3	4	5	6
CIRCUIT 2	178	KW	D=0	0.8	0.7	0.64	0.6	0.56
CIRCUIT 3	178	KW	d=0.07 m	0.85	0.75	0.68	0.64	0.6
CIRCUIT 4	89	KW	d=0.10 m	0.85	0.76	0.69	0.65	0.62
CIRCUIT 5	140	KW	d=0.15 m	0.87	0.77	0.72	0.68	0.66
CIRCUIT 6	156	KW	d=0.20 m	0.88	**0.79**	0.74	0.7	0.68
CIRCUIT 7	156	KW	d=0.25 m	0.89	0.8	0.76	0.72	0.7
CIRCUIT 8	156	KW						
TOTAL=	**1,199**	**KW (POWER IN LOW VOLTAGE)**						
	630+630 KVAS	**POWER of the CT**						

Table 9: Circuit No.2 derived from C.T. No. 2

C.T. No. 2

CIRCUIT No. 3

CALCULUS OF ELECTRICAL CIRCUITS

CIRCUITS DERIVED FROM C.T. No. 2 (VOLTAGE 400/230 V)

POWER FACTOR = 0.85

CIRCUIT No. 3

ORIGIN:	C.T. No. 2
CONDUCTOR:	**RV 0.6/1 KV 240 mm2 . - Al (Maximum admissible current= 430A)**
ELECTRICAL LAYING:	DIRECTLY IN TRENCH
END:	C.S.P. (3b) IN THE "R-4" PLOT

LOADS

26 HOUSES + G.S.	17	KW
+ GARAGES		
FORESEEN POWER :	**17**	**KW**

CIRCUIT (STRETCH	POWER (W)	CURRENT (A)	SIZE (mm2)	LENGTH (m)	VOLTAGE (V)	DROP VOLT. (V)	ACCUMUL. DROP (V)	DROP VOLT. (%)
C.T. No. 2 - C.S.P. (3b)	178,000	302.27	**240 - Al**	90	400	4.77	4.77	**1.19%**

MAXIMUM DROP VOLTAGE:	1.19%	<	5	%
MAXIMUM POWER:	178,00	<	200,043	W
MAX. CURRENT:	302.27	<	339.7	A

CENT. OF TRANSF. No. 2

TRANSFORMERS OF 630 + 630 KVAS

			FACTOR OF CORRECTION					
			DISTANCE BETWEEN 3-CORE CABLE	NUMBER OF 3-CORE CABLES OF THE TRENCH				
CIRCUIT 1	146	KW		2	3	4	5	6
CIRCUIT 2	178	KW	D=0	0.8	0.7	0.64	0.6	0.56
CIRCUIT 3	178	KW	d=0.07 m	0.85	0.75	0.68	0.64	0.6
CIRCUIT 4	89	KW	d=0.10 m	0.85	0.76	0.69	0.65	0.62
CIRCUIT 5	140	KW	d=0.15 m	0.87	0.77	0.72	0.68	0.66
CIRCUIT 6	156	KW	d=0.20 m	0.88	0.79	0.74	0.7	0.68
CIRCUIT 7	156	KW	d=0.25 m	0.89	0.8	0.76	0.72	0.7
CIRCUIT 8	156	KW						
TOTAL=	**1,199**	**KW (POWER IN LOW VOLTAGE)**						
630+630 KVAS		**POWER of the CT**						

Table 10: Circuit No.3 derived from C.T. No. 2

C.T. No. 2

CIRCUIT No. 4

CALCULUS OF ELECTRICAL CIRCUITS

CIRCUITS DERIVED FROM C.T. No. 2 (VOLTAGE 400/230 V)

POWER FACTOR = 0.85

CIRCUIT No. 4

ORIGIN:	C.T. No. 2
CONDUCTOR:	**RV 0.6/1 KV 240 mm2 . - Al (Maximum admissible current= 430A)**
ELECTRICAL LAYING:	DIRECTLY IN TRENCH
END:	C.S.P. (4a) IN THE "R-4" PLOT

LOADS

13 HOUSES + G.S.+ GARAGES	89	KW
FORESEEN POWER :	**89**	**KW**

CIRCUIT (STRETCH)	POWER (W)	CURRENT (A)	SIZE (mm2)	LENGTH (m)	VOLTAGE (V)	DROP VOLT. (V)	ACCUMUL. DROP (V)	DROP VOLT. (%)
C.T. No. 2 - C.S.P. (4a)	89,000	151.13	**240 - Al**	110	400	2.91	2.91	**0.73%**

MAXIMUM DROP VOLTAGE:	0.73%	<	5	%
MAXIMUM POWER:	89,000	<	200,043	W
MAX. CURRENT:	151.13	<	339.7	A

CENT. OF TRANSF. No. 2

TRANSFORMERS OF 630 + 630 KVAS			**FACTOR OF CORRECTION**					
			DISTANCE BETWEEN 3-CORE CABLE	NUMBER OF 3-CORE CABLES OF THE TRENCH				
CIRCUIT 1	146	KW		2	3	4	5	6
CIRCUIT 2	178	KW	D=0	0.8	0.7	0.64	0.6	0.56
CIRCUIT 3	178	KW	d=0.07 m	0.85	0.75	0.68	0.64	0.6
CIRCUIT 4	89	KW	d=0.10 m	0.85	0.76	0.69	0.65	0.62
CIRCUIT 5	140	KW	d=0.15 m	0.87	0.77	0.72	0.68	0.66
CIRCUIT 6	156	KW	d=0.20 m	0.88	0.79	0.74	0.7	0.68
CIRCUIT 7	156	KW	d=0.25 m	0.89	0.8	0.76	0.72	0.7
CIRCUIT 8	156	KW						
TOTAL=	**1,199**	**KW (POWER IN LOW VOLTAGE)**						
	630+630 KVAS	**POWER of the CT**						

Table 11: Circuit No.4 derived from C.T. No. 2

C.T. No. 2

CIRCUIT No. 5

CALCULUS OF ELECTRICAL CIRCUITS

CIRCUITS DERIVED FROM C.T. No. 2 (VOLTAGE 400/230 V)

POWER FACTOR = 0.85

CIRCUIT No. 5

ORIGIN:	C.T. No. 2
CONDUCTOR:	**RV 0.6/1 KV 240 mm2 . - Al (Maximum admissible current= 430A)**
ELECTRICAL LAYING:	DIRECTLY IN TRENCH
END:	C.S.P. (5a) IN THE "R-5" PLOT (EQUIPMENTS)

LOADS

	140	KW
FORESEEN POWER :	**140**	**KW**

CIRCUIT (STRETCH)	POWER (W)	CURRENT (A)	SIZE (mm2)	LENGTH (m)	VOLTAGE (V)	DROP VOLT. (V)	ACCUMUL. DROP (V)	DROP VOLT. (%)
C.T. No. 2-C.S.P.PARC- R-5	140,000	202.08	**240 - Al**	50	400	2.08	2.08	**0.52%**

MAXIMUM DROP VOLTAGE:	0.52%	<	5	%
MAXIMUM POWER:	140,000	<	187,382	W
MAX. CURRENT:	202.08	<	318.2	A

CENT. OF TRANSF. No. 1								
TRANSFORMERS OF 630 + 630 KVAS			**FACTOR OF CORRECTION**					
			DISTANCE BETWEEN 3-CORE CABLE	NUMBER OF 3-CORE CABLES OF THE TRENCH				
				2	3	4	5	6
CIRCUIT 1	146	KW	D=0	0.8	0.7	0.64	0.6	0.56
CIRCUIT 2	178	KW	d=0.07 m	0.85	0.75	0.68	0.64	0.6
CIRCUIT 3	178	KW	d=0.10 m	0.85	0.76	0.69	0.65	0.62
CIRCUIT 4	89	KW	d=0.15 m	0.87	0.77	0.72	0.68	0.66
CIRCUIT 5	140	KW	d=0.20 m	0.88	0.79	0.74	0.7	0.68
CIRCUIT 6	156	KW	d=0.25 m	0.89	0.8	0.76	0.72	0.7
CIRCUIT 7	156	KW						
CIRCUIT 8	156	KW						
TOTAL=	**1,199**	**KW (POWER IN LOW VOLTAGE)**						
	630+630 KVAS	**POWER of the CT**						

Table 12: Circuit No.5 derived from C.T. No. 2

C.T. No. 2								
CIRCUIT No. 6								
			CALCULUS OF ELECTRICAL CIRCUITS					
		CIRCUITS DERIVED FROM C.T. No. 2 (VOLTAGE 400/230 V)						
POWER FACTOR =	0.85							
CIRCUIT No. 6								
ORIGIN:	C.T. No. 2							
CONDUCTOR:	**RV 0.6/1 KV 240 mm2 . - Al (Maximum admissible current= 430A)**							
ELECTRICAL LAYING:	DIRECTLY IN TRENCH							
END:	C.S.P. (6b) IN THE "R-3" PLOT							
LOADS								
23 HOUSES + G.S.	156	KW						
+ GARAGES								
FORESEEN POWER :	**156**	**KW**						
CIRCUIT	**POWER**	**CURRENT**	**SIZE**	**LENGTH**	**VOLTAGE**	**DROP**	**ACCUMUL.**	**DROP**
(STRETCH)	**(W)**	**(A)**	**(mm2)**	**(m)**	**(V)**	**VOLT. (V)**	**DROP (V)**	**VOLT. (%)**
C.T. No. 2 - C.S.P. (6b)	156,000	264.91	**240 - Al**	90	400	4.18	4.18	**1.04%**
MAXIMUM DROP VOLTAGE:		1.04%	<	5	%			
MAXIMUM POWER:		156,000	<	187,382	W			
MAX. CURRENT:		264.91	<	318.2	A			
CENT. OF TRANSF. No. 2								
TRANSFORMERS OF 630 + 630 KVAS			**FACTOR OF CORRECTION**					
			DISTANCE BETWEEN 3-CORE CABLE	NUMBER OF 3-CORE CABLES OF THE TRENCH				
CIRCUIT 1	146	KW		2	3	4	5	6
CIRCUIT 2	178	KW	D=0	0.8	0.7	0.64	0.6	0.56
CIRCUIT 3	178	KW	d=0.07 m	0.85	0.75	0.68	0.64	0.6
CIRCUIT 4	89	KW	d=0.10 m	0.85	0.76	0.69	0.65	0.62
CIRCUIT 5	140	KW	d=0.15 m	0.87	0.77	0.72	0.68	0.66
CIRCUIT 6	156	KW	d=0.20 m	0.88	0.79	0.74	0.7	0.68
CIRCUIT 7	156	KW	d=0.25 m	0.89	0.8	0.76	0.72	0.7
CIRCUIT 8	156	KW						
TOTAL=	**1,199**	**KW (POWER IN LOW VOLTAGE)**						
	630+630 KVAS	**POWER of the CT**						

Table 13: Circuit No.6 derived from C.T. No. 2

C.T. No. 2								
CIRCUIT No. 7								
			CALCULUS OF ELECTRICAL CIRCUITS					
		CIRCUITS DERIVADED FROM C.T. No. 2 (VOLTAGE 400/230 V)						
POWER FACTOR =	0.85							
CIRCUIT No. 7								
ORIGIN:	C.T. No. 2							
CONDUCTOR:	RV 0.6/1 KV 240 mm2 . - Al (Maximum admissible current=							
ELECTRICAL LAYING:	DIRECTLY IN TRENCH							
END:	C.S.P. (7b) IN THE "R-3" PLOT							
LOADS								
23 HOUSES + G.S.	156	KW						
+ GARAGES								
FORESEEN POWER :	**156**	**KW**						
CIRCUIT	**POWER**	**CURRENT**	**SIZE**	**LENGTH**	**VOLTAGE**	**DROP**	**ACCUMUL.**	**DROP**
(STRETCH	**(W)**	**(A)**	**(mm2)**	**(m)**	**(V)**	**VOLT. (V)**	**DROP (V)**	**VOLT. (%)**
C.T. No. 2 - C.S.P. (7b)	156,000	264.91	**240 - Al**	140	400	6.50	6.50	**1.63%**
MAXIMUM DROP VOLTAGE:		1.63%	<	5	%			
MAXIMUM POWER:		156,00	<	187,38	W			
MAX. CURRENT:		264.91	<	318.2	A			
CENT. OF TRANSF. No. 2								
TRANSFORMERS OF 630 + 630 KVAS			**FACTOR OF CORRECTION**					
			DISTANCE BETWEEN 3-CORE CABLE	NUMBER OF 3-CORE CABLES OF THE TRENCH				
CIRCUIT 1	146	KW		2	3	4	5	6
CIRCUIT 2	178	KW	D=0	0.8	0.7	0.64	0.6	0.56
CIRCUIT 3	178	KW	d=0.07 m	0.85	0.75	0.68	0.64	0.6
CIRCUIT 4	89	KW	d=0.10 m	0.85	0.76	0.69	0.65	0.62
CIRCUIT 5	140	KW	d=0.15 m	0.87	0.77	0.72	0.68	0.66
CIRCUIT 6	156	KW	d=0.20 m	0.88	0.79	0.74	0.7	0.68
CIRCUIT 7	156	KW	d=0.25 m	0.89	0.8	0.76	0.72	0.7
CIRCUIT 8	156	KW						
TOTAL=	**1,19**	**KW (POWER IN LOW VOLTAGE)**						
	630+630 KVAS	**POWER of the CT**						

Table 14: Circuit No.7 derived from C.T. No. 2

C.T. No. 2								
CIRCUIT No. 8								
			CALCULUS OF ELECTRICAL CIRCUITS					
		CIRCUITS DERIVADED FROM C.T. No. 2 (VOLTAGE 400/230 V)						
POWER FACTOR =	0.85							
CIRCUIT No. 8								
ORIGIN:	C.T. No. 2							
CONDUCTOR:	**RV 0.6/1 KV 240 mm2 . - Al (Maximum admissible current= 430A)**							
ELECTRICAL LAYING:	DIRECTLY IN TRENCH							
END:	C.S.P. (8b) IN THE "R-3" PLOT							
LOADS								
23 HOUSES + G.S.	156	KW						
+ P.P. DE GARAGES								
FORESEEN POWER :	**156**	**KW**						
CIRCUIT	**POWER**	**CURRENT**	**SIZE**	**LENGTH**	**VOLTAGE**	**DROP**	**ACCUMUL.**	**DROP**
(STRETCH	**(W)**	**(A)**	**(mm2)**	**(m)**	**(V)**	**VOLT. (V)**	**DROP (V)**	**VOLT. (%)**
C.T. No. 2 - C.S.P. (8b)	156,000	264.91	**240 - Al**	180	400	8.36	8.36	**2.09%**
MAXIMUM DROP VOLTAGE:		2.09%	<	5	%			
MAXIMUM POWER:		156,00	<	187,382	W			
MAX. CURRENT:		264.91	<	318.2	A			
CENT. OF TRANSF. No. 2								
TRANSFORMERS OF 630 + 630 KVAS			**FACTOR OF CORRECTION**					
			DISTANCE BETWEEN 3-CORE	NUMBER OF 3-CORE CABLES OF THE TRENCH				
CIRCUIT 1	146	KW		2	3	4	5	6
CIRCUIT 2	178	KW	D=0	0.8	0.7	0.64	0.6	0.56
CIRCUIT 3	178	KW	d=0.07 m	0.85	0.75	0.68	0.64	0.6
CIRCUIT 4	8	KW	d=0.10 m	0.85	0.76	0.69	0.65	0.62
CIRCUIT 5	140	KW	d=0.15 m	0.87	0.77	0.72	0.68	0.66
CIRCUIT 6	156	KW	d=0.20 m	0.88	0.79	0.74	0.7	0.68
CIRCUIT 7	156	KW	d=0.25 m	0.89	0.8	0.76	0.72	0.7
CIRCUIT 8	156	KW						
TOTAL=	**1,199**	**KW (POWER IN LOW VOLTAGE)**						
	630+630 KVAS	**POWER of the CT**						

Table 15: Circuit No.8 derived from C.T. No. 2

C.T. No. 1

CIRCUIT No. 3

CALCULUS OF ELECTRICAL CIRCUITS

CIRCUITS DERIVADED FROM C.T. No. 1 (VOLTAGE 400/230 V)

POWER FACTOR = 0.85

CIRCUIT No. 3

ORIGIN:	C.T. No. 1
CONDUCTOR:	**RV 0.6/1 KV 240 mm2 . - Al (Maximum admissible current= 430A)**
ELECTRICAL LAYING:	DIRECTLY IN TRENCH
END:	C.S.P. (3) IN THE PLOT a

LOADS

18 HOUSES + G.S.	118	KW
300 m2 COMMERCIAL USE	10	KW
1050 m2 GARAGES	21	KW
FORESEEN POWER :	**149**	**KW**

CIRCUIT (STRETCH)	POWER (W)	CURRENT (A)	SIZE (mm2)	LENGTH (m)	VOLTAGE (V)	DROP VOLT. (V)	ACCUMUL. DROP (V)	DROP VOLT. (%)
C.T. No. 1 - C.S.P. (3b)	150,000	216.51	**240 - Al**	60	400	2.68	2.68	**0.67%**

MAXIMUM DROP VOLTAGE:	0.67%	<	5	%
MAXIMUM POWER:	150,000	<	200,043	W
MAX. CURRENT:	216.51	<	339.7	A

CENT. OF TRANSF. No. 1

TRANSFORMERS OF 630 + 630 KVAS

CIRCUIT 1	150	KW
CIRCUIT 2	150	KW
CIRCUIT 3	150	KW
CIRCUIT 4	178	KW
CIRCUIT 5	178	KW
CIRCUIT 6	178	KW
CIRCUIT 7	40	KW
CIRCUIT 8	219	KW
CIRCUIT 9 (PUBLIC LIGHT.	40	KW
TOTAL=	**1,283**	**KW (POWER IN LOW VOLTAGE)**
	630+630 KVAS	**POWER of the CT**

FACTOR OF CORRECTION

DISTANCE BETWEEN 3-CORE CABLE	NUMBER OF 3-CORE CABLES OF THE TRENCH				
	2	3	4	5	6
D=0	0.8	0.7	0.64	0.6	0.56
d=0.07 m	0.85	0.75	0.68	0.64	0.6
d=0.10 m	0.85	0.76	0.69	0.65	0.62
d=0.15 m	0.87	0.77	0.72	0.68	0.66
d=0.20 m	0.88	0.79	0.74	0.7	0.68
d=0.25 m	0.89	0.8	0.76	0.72	0.7

Table 16: Circuit No.3 derived from C.T. No. 1

C.T. No. 1

CIRCUIT No. 4

CALCULUS OF ELECTRICAL CIRCUITS

CIRCUITS DERIVADED FROM C.T. No. 1 (VOLTAGE 400/230 V)

POWER FACTOR = 0.85

CIRCUIT No. 4

ORIGIN:	C.T. No. 1
CONDUCTOR:	**RV 0.6/1 KV 240 mm2 . - Al (Maximum admissible current= 430A)**
ELECTRICAL LAYING:	DIRECTLY IN TRENCH
END:	C.S.P. (4b) IN THE "R-4" PLOT

LOADS

26 HOUSES + G.S.	178	
+ GARAGES		
FORESEEN POWER :	**178**	**KW**

(STRETCH)	**(W)**	**(A)**	**(mm2)**	**(m)**	**(V)**	**VOLT. (V)**	**DROP (V)**	**VOLT. (%)**
C.T. No. 1 - C.S.P. (4b)	178,000	256.93	**240 - Al**	120	400	6.36	6.36	**1.59%**

MAXIMUM DROP VOLTAGE:	1.59%	<	5	%
MAXIMUM POWER:	178,000	<	200,043	W
MAX. CURRENT:	256.93	<	339.7	A

CENT. OF TRANSF. No. 1

TRANSFORMERS OF 630 + 630 KVAS			**FACTOR OF CORRECTION**					
			DISTANCE BETWEEN 3-CORE CABLE	NUMBER OF 3-CORE CABLES OF THE TRENCH				
CIRCUIT 1	150	KW		2	3	4	5	6
CIRCUIT 2	150	KW	D=0	0.8	0.7	0.64	0.6	0.56
CIRCUIT 3	150	KW	d=0.07 m	0.85	0.75	0.68	0.64	0.6
CIRCUIT 4	178	KW	d=0.10 m	0.85	0.76	0.69	0.65	0.62
CIRCUIT 5	178	KW	d=0.15 m	0.87	0.77	0.72	0.68	0.66
CIRCUIT 6	178	KW	d=0.20 m	0.88	0.79	0.74	0.7	0.68
CIRCUIT 7	40	KW	d=0.25 m	0.89	0.8	0.76	0.72	0.7
CIRCUIT 8	219	KW						
CIRCUIT 9 (PUBLIC LIGHT.	40	KW						
TOTAL=	**1,283**	**KW (POWER IN LOW VOLTAGE)**						
	630+630 KVAS	**POWER of the CT**						

Table 17: Circuit No.4 derived from C.T. No. 1

C.T. No. 1								
CIRCUIT No. 5								
			CALCULUS OF ELECTRICAL CIRCUITS					
		CIRCUITS DERIVADED FROM C.T. No. 1 (VOLTAGE 400/230 V)						
POWER FACTOR =	0.85							
CIRCUIT No. 4								
ORIGIN:	C.T. No. 1							
CONDUCTOR:	**RV 0.6/1 KV 240 mm2 . - Al (Maximum admissible current= 430A)**							
ELECTRICAL LAYING:	DIRECTLY IN TRENCH							
END:	C.S.P. (5b) IN THE "R-4" PLOT							
LOADS								
26 HOUSES + G.S.	178							
+ GARAGES								
FORESEEN POWER :	**178**	**KW**						
CIRCUIT	**POWER**	**CURRENT**	**SIZE**	**LENGTH**	**VOLTAGE**	**DROP**	**ACCUMUL.**	**DROP**
(STRETCH	**(W)**	**(A)**	**(mm2)**	**(m)**	**(V)**	**VOLT. (V)**	**DROP (V)**	**VOLT. (%)**
C.T. No. 1 - C.S.P. (5b)	178,000	256.93	**240 - Al**	80	400	4.24	4.24	**1.06%**
MAXIMUM DROP VOLTAGE:		1.06%	<	5	%			
MAXIMUM POWER:		178,00	<	200,043	W			
MAX. CURRENT:		256.93	<	339.7	A			
CENT. OF TRANSF. No. 1								
TRANSFORMERSS OF 630 + 630 KVAS			**FACTOR OF CORRECTION**					
			DISTANCE BETWEEN 3-CORE CABLE	NUMBER OF 3-CORE CABLES OF THE TRENCH				
CIRCUIT 1	150	KW		2	3	4	5	6
CIRCUIT 2	150	KW	D=0	0.8	0.7	0.64	0.6	0.56
CIRCUIT 3	150	KW	d=0.07 m	0.85	0.75	0.68	0.64	0.6
CIRCUIT 4	178	KW	d=0.10 m	0.85	0.76	0.69	0.65	0.62
CIRCUIT 5	178	KW	d=0.15 m	0.87	0.77	0.72	0.68	0.66
CIRCUIT 6	178	KW	d=0.20 m	0.88	0.79	0.74	0.7	0.68
CIRCUIT 7	4	KW	d=0.25 m	0.89	0.8	0.76	0.72	0.7
CIRCUIT 8	219	KW						
CIRCUIT 9 (PUBLIC LIGHT	4	KW						
TOTAL=	**1,283**	**KW (POWER IN LOW VOLTAGE)**						
	630+630 KVAS	**POWER of the CT**						

Table 18: Circuit No.5 derived from C.T. No. 1

C.T. No. 1								
CIRCUIT No. 6								
			CALCULUS OF ELECTRICAL CIRCUITS					
		CIRCUITS DERIVADED FROM C.T. No. 1 (VOLTAGE 400/230 V)						
POWER FACTOR =	0.85							
CIRCUIT No. 4								
ORIGIN:	C.T. No. 1							
CONDUCTOR:	**RV 0.6/1 KV 240 mm2 - Al (Maximum admissible current= 430A)**							
ELECTRICAL LAYING:	DIRECTLY IN TRENCH							
END:	C.S.P. (6b) IN THE "R-4" PLOT							
LOADS								
26 HOUSES + G.S.	178	KW						
+ GARAGES								
FORESEEN POWER :	**178**	**KW**						
CIRCUIT	**POWER**	**CURRENT**	**SIZE**	**LENGTH**	**VOLTAGE**	**DROP**	**ACCUMUL.**	**DROP**
(STRETCH)	**(W)**	**(A)**	**(mm2)**	**(m)**	**(V)**	**VOLT. (V)**	**DROP (V)**	**VOLT. (%)**
C.T. No. 1 - C.S.P. (6b)	178,000	256.93	**240 - Al**	110	400	5.83	5.83	**1.46%**
MAXIMUM DROP VOLTAGE:		1.46%	<	5	%			
MAXIMUM POWER:		178,000	<	200,043	W			
MAX. CURRENT:		256.93	<	339.7	A			
CENT. OF TRANSF. No. 1								
TRANSFORMERS OF 630 + 630 KVAS			**FACTOR OF CORRECTION**					
			DISTANCE BETWEEN 3-CORE	NUMBER OF 3-CORE CABLES OF THE TRENCH				
CIRCUIT 1	150	KW		2	3	4	5	6
CIRCUIT 2	150	KW	D=0	0.8	0.7	0.64	0.6	0.56
CIRCUIT 3	150	KW	d=0.07 m	0.85	0.75	0.68	0.64	0.6
CIRCUIT 4	178	KW	d=0.10 m	0.85	0.76	0.69	0.65	0.62
CIRCUIT 5	178	KW	d=0.15 m	0.87	0.77	0.72	0.68	0.66
CIRCUIT 6	178	KW	d=0.20 m	0.88	0.79	0.74	0.7	0.68
CIRCUIT 7	40	KW	d=0.25 m	0.89	0.8	0.76	0.72	0.7
CIRCUIT 8	219	KW						
CIRCUIT 9 (PUBLIC LIGHT.	40	KW						
TOTAL=	**1,283**	**KW (POWER IN LOW VOLTAGE)**						
	630+630 KVAS	**POWER of the CT**						

Table 19: Circuit No.6 derived from C.T. No. 1

C.T. No. 1								
CIRCUIT No. 7								
			CALCULUS OF ELECTRICAL CIRCUITS					
		CIRCUITS DERIVADED FROM C.T. No. 1 (VOLTAGE 400/230 V)						
POWER FACTOR =	0.85							
CIRCUIT No. 7								
ORIGIN:	C.T. No. 1							
CONDUCTOR:	**RV 0.6/1 KV 240 mm2 . - Al (Maximum admissible current= 430A)**							
ELECTRICAL LAYING:	DIRECTLY IN TRENCH							
END:	C.S.P. (7) IN THE "R-5" EQUIPMENTS PLOT							
LOADS								
	140	KW						
FORESEEN POWER :	**140**	**KW**						
CIRCUIT	**POWER**	**CURRENT**	**SIZE**	**LENGTH**	**VOLTAGE**	**DROP**	**ACCUMUL.**	**DROP**
(STRETCH	**(W**	**(A)**	**(mm2)**	**(m)**	**(V)**	**VOLT.**	**DROP (V)**	**VOLT.**
C.T. No. 1-C.S.P.PARC- R-	140,000	202.08	**240 - Al**	50	400	2.08	2.08	**0.52%**
MAXIMUM DROP VOLTAGE:		0.52%	<	5	%			
MAXIMUM POWER:		140,000	<	222,832	W			
MAX. CURRENT:		202.08	<	378.4	A			
CENT. OF TRANSF. No. 1								
TRANSFORMERS OF 630 + 630 KVAS			**FACTOR OF CORRECTION**					
			DISTANCE BETWEEN 3-CORE CABLE	NUMBER OF 3-CORE CABLES OF THE TRENCH				
CIRCUIT 1	150	KW		2	3	4	5	6
CIRCUIT 2	150	KW	D=0	0.8	0.7	0.64	0.6	0.56
CIRCUIT 3	150	KW	d=0.07 m	0.85	0.75	0.68	0.64	0.6
CIRCUIT 4	178	KW	d=0.10 m	0.85	0.76	0.69	0.65	0.62
CIRCUIT 5	178	KW	d=0.15 m	0.87	0.77	0.72	0.68	0.66
CIRCUIT 6	178	KW	d=0.20 m	0.88	0.79	0.74	0.7	0.68
CIRCUIT 7	40	KW	d=0.25 m	0.89	0.8	0.76	0.72	0.7
CIRCUIT 8	219	KW						
CIRCUIT 9 (PUBLIC LIGHT.)	40	KW						
TOTAL=	**1,283**	**KW (POWER IN LOW VOLTAGE)**						
	630+630KVAS	**POWER of the CT**						

Table 20: Circuit No.7 derived from C.T. No. 1

C.T. No. 1								
CIRCUIT No. 8								
			CALCULUS OF ELECTRICAL CIRCUITS					
		CIRCUITS DERIVADED FROM C.T. No. 1 (VOLTAGE 400/230 V)						
POWER FACTOR =	0.85							
CIRCUIT No. 8								
ORIGIN:	C.T. No. 1							
CONDUCTOR:	**RV 0.6/1 KV 240 mm2 . - Al (Maximum admissible current= 430A)**							
ELECTRICAL LAYING:	DIRECTLY IN TRENCH							
END:	C.S.P. (8b) IN THE "R-2" PLOT							
LOADS								
30 HOUSES + G.S.	219							
+ GARAGES FORECAST								
FORESEEN POWER :	**219**	**KW**						
CIRCUIT	**POWER**	**CURRENT**	**SIZE**	**LENGTH**	**VOLTAGE**	**DROP**	**ACCUMUL.**	**DROP**
(STRETCH	**(W)**	**(A)**	**(mm2)**	**(m)**	**(V)**	**VOLT. (V)**	**DROP (V)**	**VOLT.**
C.T. No. 1 - C.S.P. (8b)	219,000	316.11	**240 - Al**	90	40	5.8	5.8	**1.47**
MAXIMUM DROP VOLTAGE:		1.47%	<	5	%			
MAXIMUM POWER:		219,00	<	200,043	W			
MAX. CURRENT:		316.11	<	339.7	A			
CENT. OF TRANSF. No. 1								
TRANSFORMERS OF 630 + 630 KVAS			**FACTOR OF CORRECTION**					
			DISTANCE BETWEEN 3-CORE CABLE	NUMBER OF 3-CORE CABLES OF THE TRENCH				
CIRCUIT 1	15	KW		2	3	4	5	6
CIRCUIT 2	15	KW	D=0	0.8	0.7	0.64	0.6	0.56
CIRCUIT 3	15	KW	d=0.07 m	0.85	0.75	0.68	0.64	0.6
CIRCUIT 4	17	KW	d=0.10 m	0.85	0.76	0.69	0.65	0.62
CIRCUIT 5	17	KW	d=0.15 m	0.87	0.77	0.72	0.68	0.66
CIRCUIT 6	17	KW	d=0.20 m	0.88	0.79	0.74	0.7	0.68
CIRCUIT 7	4	KW	d=0.25 m	0.89	0.8	0.76	0.72	0.7
CIRCUIT 8	21	KW						
CIRCUIT 9 (PUBL LIGHT.	4	KW						
TOTAL=	**1,283**	**KW (POWER IN LOW VOLTAGE)**						
	630+630 KVAS	**POWER of the CT**						

Table 21: Circuit No.8 derived from C.T. No. 1

C.T. No. 1								
CIRCUIT No. 9 (PUBLIC LIGHTING)								
			CALCULUS OF ELECTRICAL CIRCUITS					
		CIRCUITS DERIVADED FROM C.T. No. 1 (VOLTAGE 400/230 V)						
POWER FACTOR =	0.85							
CIRCUIT No. 4								
ORIGIN:	C.T. No. 1							
CONDUCTOR:	**RV 0.6/1 KV 240 mm2 . - Al (Maximum admissible current= 430A)**							
ELECTRICAL LAYING:	DIRECTLY IN TRENCH							
END:	C.S.P. PUBLIC LIGHTING							
LOADS								
PUBLIC LIGHTING	4	KW						
FORESEEN POWER :	**4**	**KW**						
CIRCUIT	**POWER**	**CURRENT**	**SIZE**	**LENGTH**	**VOLTAGE**	**DROP**	**ACCUMUL.**	**DROP**
(STRETCH	**(W)**	**(A)**	**(mm2)**	**(m)**	**(V)**	**VOLT. (V)**	**DROP (V)**	**VOLT.**
C.T. No.1 C.S.P.	40000	57.74	**240 - Al**	30	40	0.3	0.3	**0.09**
MAXIMUM DROP VOLTAGE:		0.09%	<	5	%			
MAXIMUM POWER:		40,00	<	200,043	W			
MAX. CURRENT:		57.74	<	339.7	A			
CENT. OF TRANSF. No. 1								
TRANSFORMERS OF 630 + 630 KVAS			**FACTOR OF CORRECTION**					
			DISTANCE BETWEEN 3-CORE CABLE	NUMBER OF 3-CORE CABLES OF THE TRENCH				
CIRCUIT 1	150	KW		2	3	4	5	6
CIRCUIT 2	150	KW	D=0	0.8	0.7	0.64	0.6	0.56
CIRCUIT 3	150	KW	d=0.07 m	0.85	0.75	0.68	0.64	0.6
CIRCUIT 4	178	KW	d=0.10 m	0.85	0.76	0.69	0.65	0.62
CIRCUIT 5	178	KW	d=0.15 m	0.87	0.77	0.72	0.68	0.66
CIRCUIT 6	178	KW	d=0.20 m	0.88	0.79	0.74	0.7	0.68
CIRCUIT 7	40	KW	d=0.25 m	0.89	0.8	0.76	0.72	0.7
CIRCUIT 8	219	KW						
CIRCUIT 9 (PUB.LIGHT.)	40	KW						
TOTAL=	**1,283**	**KW (POWER IN LOW VOLTAGE)**						
	630+630KVAS	**POWER of the CT**						

Table 22: Circuit No.9 derived from C.T. No. 1

4.1. CALCULATIONS FOR HIGH VOLTAGE

4.1.1. Underground circuit calculations for the current net (10KV)

- **Electrical characteristics of the cable and installation:**

- Cable:	**RHZ1 3x1x400mm² Al 12/20 KV**
- Resistance at 90ºC:	0.102 Ω/Km
- Reactance at 90ºC:	0.098 Ω/Km
- Permanent buried load:	500 A
- Cable length forecast:	300 m
- Rated Voltage of the net:	10 KV
- Total power installed in the new plot:	**2,437 KW**

- **Calculus:**

  -**Current forecast**

  I = P/(√3 x U x cosφ) = 2,437 / (1.73 x **10** x 0.9) = 156.33A

  -**Capacity of transport of the chosen cable:**

  P = √3 x U x I = √3 x **10** x 500 = 8,660 KW

  - **Drop Voltage** (for maximum capacity of the cable and loads placed more unfavorably):

  U(v) = √3 x I x L x (R x cosφ + X x senφ) = √3 x 500 x 0.3 x 0.131 = 34 V < 500 V (5% of 10 KV)

4.1.2. Underground circuit calculations for the current net (15KV)

- **Electrical characteristics of the cable and installation:**

- Cable:	**RHZ1 3x1x400mm² Al 12/20 KV**
- Resistance at 90ºC:	0.102 Ω/Km
- Reactance at 90ºC:	0.098 Ω/Km
- Permanent buried load:	500 A
- Cable length forecast:	300 m
- Rated Voltage of the net:	15 KV
- Total power installed in the new plot:	**2,437 KW**

- **Calculus:**

  -**Current forecast**

  I = P/(√3 x U x cosφ) = 2,437 / (1.73 x **15** x 0.9) = 104.22A

  -**Capacity of transport of the chosen cable:**

$P = \sqrt{3} \times U \times I = \sqrt{3} \times \mathbf{15} \times 500 = 12{,}990$ KW

- **Drop Voltage** (for maximum capacity of the cable and loads placed more unfavorably):

$$U(v) = \sqrt{3} \times I \times L \times (R \times \cos\varphi + X \times \text{sen}\varphi) = \sqrt{3} \times 500 \times 0.3 \times 0.131 = 34\ V < 750\ V\ (5\%\ \text{of}\ 15\ KV)$$

Therefore the size of the cable has been selected in such a way that it overcomes widely the needs for the network, as for losses of power, drops of voltage, capacity of transport, admissible overloads and currents of short circuit.

4.2. CALCULATION OF THE GROUND NETWORK IN THE C.T.

4.2.1. Justification of the selected ground electrode

(NEUTRAL ISOLATED)

a) REFERENCE OF THE C.T.

- Owner: SUELO Y VIVIENDA DE ARAGON S.L.U.
- City: Villanueva de Gállego.

b) INITIAL DATA

B.1. - Initial characteristics

- Voltage of service (future voltage): U = 15 kV
- Air network
  - Capacity: $C_a = 0.006$ μF/Km
  - Entire length: $L_a = 180$ Km
- Underground network
  - Capacity: $C_c = 0.25$ μF/Km
  - Entire length: $L_c = 2$ Km
- Duration of the fault
  - Relay on time independent: t = 6 s
  - Level of isolation of the facilities of low voltage in the center of transformation: $V_{lv} = 6{,}000$V

B.2. - Characteristics of the C.T.

- Dimensions: 9.6 x 2.62 m

4.2.2. Characteristics of the ground

- Resistivity of the ground: $\rho_s = 350$ Ωxm
- Resistivity in the C.T.: $\rho = 3000$ Ωxm

4.2.3. Calculus of the ground

4.2.3.1. - Maximum resistance of the earthed grounds of the C.T.(R_t) and fault current (I_d)

$$I_d \times R_t \leq V_{lv}$$

$$I_d = \frac{\sqrt{3} \times U \times \left(\omega \times C_a \times L_a + \omega \times C_c \times L_c\right)}{\sqrt{1 + \left(\omega \times C_a \times L_a + \omega \times C_c \times L_c\right)^2 \times \left(3R_t\right)^2}}$$

Therefore:

I_d = 12.89 A

R_t = 485 Ω

4.2.3.2. - Selection of the electrode type

- Maximum "unitary value" of the earthing resistance of the electrode:

$$K_r \leq \frac{R_t}{\rho_s}$$

$$K_r \leq \frac{R_t}{\rho_s} = \frac{485}{350} = 1.3857$$

- Horizontal electrode dimensions:

  a′ = 8 m

  b′ = 3 m

- Bare copper wire size: 50 mm^2
- Depth of the horizontal electrode: 0.8 m

  - Number of pikes: 8

  - Length of the pikes: 2 m

- Chosen electrode. Code of the configuration UNESA: **80-30/8/82**

Electrode typical parameter:

- Resistance of grounding: K_r = 0.067
- Maximum pass through voltage: K_p = 0.0102
- Maximum voltage of exterior access: K_{acc} = 0.0296

4.2.3.3. - Additional Security measure for avoiding contact voltages

So that exterior contact voltages neither interior do not appear, the following measurements of safety are adopted:

• The doors and metallic grills that give on the outside of the center will not have electrical contact with the conductive masses capable of remaining submitted to voltage due to defects or breakdowns.

• In the floor of the C.T. there will settle a grid covered by a layer of concrete of 10 cm. connected to the protection ground of the C.T.

• Use of insulating paving.

4.2.3.4. - Values of resistance of putting to ground (R'$_t$), fault current (I'$_d$) and through voltage (V'$_p$) and access voltage (V'$_{acc}$) of the electrode chosen type, for the resistivity of the area measured (ρ)

- Ground resistance:

$$R'_t \le R_t$$

$$R'_t = K_r \times \rho_s = 23.45\Omega < 485\Omega$$

- Fault current:

$$I_d = \frac{\sqrt{3} \times U \times (\omega \times C_a \times L_a + \omega \times C_c \times L_c)}{\sqrt{1 + (\omega \times C_a \times L_a + \omega \times C_c \times L_c)^2 \times (3 \times R'_t)^2}} = 12.89A$$

- Pass through voltage:

$$V'_p = K_p \times \rho \times I'_d$$

$$V'_p = K_p \times \rho \times I'_d = 0.0178 \times 3,000 \times 12.89 = 394.4V$$

- Pass through voltage in the access of the C.T.:

$$V'_{acc} = K_c \times \rho \times I'_d$$

$$V'_{acc} = K_c \times \rho \times I'_d = 0.0545 \times 3,000 \times 12.89 = 1,144.6V$$

- Fault voltage:

$$V'_d = R'_t \times I'_d$$

$$V'_d = R'_t \times I'_d = 23.45 \times 12.89 = 302.2V$$

4.2.3.5. - Entire duration of the fault

• Relay on time independent: t' =6 s

• Resettable on time independent: t'' = 6 s

4.2.3.6. - Separation between the systems of putting to protection ground (mass) and of service (neutral of Low Voltage)

- Minimal distance of separation:

$$D > \frac{\rho \times I'_d}{2\pi \times 1,000}$$

$$D > \frac{\rho \times I'_d}{2\pi \times 1,000} = \frac{3,000 \times 12.89}{2\pi \times 1,000} = 6.15m$$

In any case it will not be lower than 20 m.

- Pass through voltage in the exterior:
  - For t > 5s

$$\frac{K}{t^n} < 50V$$

$$V_p = \frac{10K}{t^n} \times \left(1 + \frac{6\rho}{1,000}\right) = 9,500V$$

- Pass Through voltage in the access of the C.T.:

$$V_{acc} = \frac{10K}{t^n} \times \left(1 + \frac{3\rho + 3\rho_s}{1,000}\right) = 5,525V$$

4.3. CHECK IF THE CALCULATED VALUES SATISFY THE CONDITIONS

- Pass through and contact voltages inside:

  The doors and metallic grills that give on the outside are not put to ground and the paving is insulating.
- Contact voltages in the exterior:

  The doors and metallic windows that give on the outside are not put to ground for what the voltage of contact will be practically a zero.
- Pass through voltage in the exterior and through voltage in the access of the center of transformation:
  - Pass through voltage in the exterior
    - Calculated value: V'_p = 394.4 V
    - Admissible value: V_p''= 9500 V
  - Pass through voltage in the access of the C.T.
    - Calculated value: V'_{acc} = 1,144.6 V
    - Admissible value: V_{acc}''= 5,525 V
  - Fault voltage
    - Calculated value: V'_d = 302.2 V
    - Admissible value: V_d''= 6,000 V

Conclusions

With the exposed thing, the enclosed calculations and drawings, the installation to realize is considered sufficiently described, requesting the administrative authorizations foreseen in the current legislation, for its installation and putting in service.

On the other hand, this project has helped me to learn how to design the medium voltage network and settle my knowledge in low voltage also. This has been very interesting and challenging at the same time.

Recommendations

- The key point to decrease the budget would be to set power stations not undergrounded.
- Before than one year ago, only the cabins of the brand Ormazábal could be installed into an underground transformer station on the area in which this project is developed, but since then another brands can be used. Because of this, in the budget appears the expression “or similar” each time this brand is named.

  Therefore, this is another way to make lower the costs.

  For diminishing the total price, instead of buying the panels individually, there are panel blocks in which the ring main panels are joined, avoiding the handwork to join them. The only downside would be that if any panel is broken we should change the whole set.
- Project the public street lighting.

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9. **Pronutec.** Ormazabal Focus on Medium Voltage. [Online] 2009. http://www.pronutec.com/html/cast/productos/pdf/cuadros_pag_4.pdf.

Bibliography

For the making of the present project, as well as for the later execution of the facilities, there have been born in mind the following Regulations, Complementary Technical Instructions and Norms:

- Regulation on technical conditions and safety Guarantees in Power plants, Substations and Powerhouses.

- Regulation of Electro-technology for Low Voltage and Complementary Technical Instructions

- Regulation of Electro-technology of Air Electrical Lines of High Voltage

- Particular norms of Endesa Distribución Eléctrica S.L.U.

- UNE Norms

- UNESA Recommendations

- Royal decree 1955/2000, of December 1, by which the activities of transport, distribution, commercialisation, supply and procedures of authorisation of facilities of electric power are regulated.

On the next websites you can find the dispositions of the Spanish regulations regarding the type of product or installation that it has selected, and from which more information has been consulted.

- RITE: Reglamento de Instalaciones Térmicas en los Edificios (Regulation of thermal systems in the buildings)

  http://www.ffii.nova.es/PUNTOINFOMCYT/legislacionsi.asp?idregl=44

- CTE: Código Técnico de la Edificación (Technical code of buildings):

  http://www.ffii.nova.es/PUNTOINFOMCYT/decretos.asp?Code=4556

- Regulation of the Efficency Energy for the public lighting:

  http://www.ffii.nova.es/PUNTOINFOMCYT/decretos.asp?Code=4584

Appendices

Appendix A: Budget

1. CENTERS OF TRANSFORMATION

No.	Unit	Description	Measure.	Price	Cost
1.1	U	Prefabricated module of concrete to bury, normalized by ERZ S.A., model of Lekunbide or similar, of exterior dimensions 240x2900x3600mm., including 2 lids of transformer, 1 lid of material, 1 lid of personnel, grills protection of transformers and VERTICAL ventilations ON slope. Including the transport, leveling out and assembly.	2.00	£18,454.97	£36,909.95
1.2	U	Prefabricated module of concrete to bury, normalized by ERZ S.A., model of Lekunbide or similar, including 1 lid of transformer, 1 lid of material, 1 lid for personnel, grills protection of transformer and VERTICAL ventilations ON slope. Including transport, leveling out and assembly.	1.00	£18,450.36	£18,450.36
1.3	m3	Excavation for emplacement of centre of transformation by mechanical means, in any class of ground and depth, even timbering, pumping, refined and compression of the bottom, load and transport to dump of the remaining products.	303.75	£3.74	£1,136.72
1.4	m3	Concrete HA-25/P/22/IIa to arm, placed in work, vibrated and treated.	20.25	£65.54	£1,327.23
1.5	Kg	Special steel B 500 S, elaborated and placed in amours.	222.75	£0.87	£193.86
1.6	m3	Sand for seating and leveling out the hut, even extraction, load, transport, spread out and compression.	10.13	£10.17	£102.92
1.7	U	Cell of line (input to enclosure) prefabricated, CML of Ormazábal or similar containing: - 1 Chopper Switch, cut off in SF6. Un=24 KV and In=630 A for I_{th}=20 KA (1s.) and Id=50 KA, - 1 chopper of putting to ground, bus bar, installation, transport and connections.	4.00	£1,853.05	£7,412.21

No.	Unit	Description	Measure.	Price	Cost
1.8	U	Cell of line (output of the enclosure) prefabricated, CML of Ormazábal or similar containing: - 1 Chopper Switch, cut off in SF6. Un=24 KV and In=630 A for I_{th}=20 KA (1s.) and Id=50 KA, - 1 chopper of putting to ground, bus bar, installation, transport and connections.	4.00	£1,853.05	£7,412.21
1.9	U	Prefabricated switch cell with bars joints, CMIP of Ormazábal or similar containing: - 1 Chopper Switch, cut off in SF6. Un=24KV and In=630 A for I_{th}=20 KA (1s) and Id=50 KA, - 1 chopper of putting to ground, bus bar, installation, transport and connections.	1.00	£1,740.66	£1,740.66
1.10	U	Prefabricated cell of protection of transformer, Chopper-switch with cut off in SF6, series CMP-F of Ormazábal or similar, for protection of transformer, Un=24 KV, In=400A, 3 fusible cartridges of A.P.R. as DIN-43.625 of 63A, bus bar, transport, installation and connections.	5.00	£2,489.69	£12,448.47
1.11	U	Three-phase connection in High Voltage between the protection cell of the transformer and the power transformer, composed by: - 6 terminal unipolar bottles of interior 12/20 KV, for dry unipolar cable of 1x95 mm ² of Al. - 42 m. of dry unipolar cable 12/20 KV of 1x95 mm ² of Al. Transport, installation and connections.	5.00	£672.45	£3,362.23
1.12	U	Three-phase power transformer of 630 KVA, dry encapsulated with a relation 9,500-16,455±5 % ± 10 % + 15 % / 420V, constructed according to the Recommendation UNESA 5,201, even grid of separation and protection, frames for the settlement, transport, installation and putting to point.	5.00	£18,798.48	£93,992.40

No.	Unit	Description	Measure.	Price	Cost
1.13	U	Lines of interconnection between the power transformer and the panel board of protection in low voltage, realized by means of cables of 2x (3x1x240+1x240) mm² of section, RV 0.6/1KV of Cu, even terminals, completely got in touch.	8.00	£600.19	£4,801.55
1.14	U	Panel board of Low Voltage for protection of distribution networks in low voltage, with four outputs, Mod. CBT-1600 AC-4 of PRONUTEC, or similar, with chopper on load of 1,600A approved by Electrical Endesa Distribución, S.L.U. even 12 fuses, transport, installation and hook-up.	8.00	£2,175.87	£17,406.97
1.15	U	Panel board of Low Voltage for the enlargement of 4 outputs of low voltage, approved by ERZ-Endesa, even 12 fuses, transport, connection to the CBT-1600 AC-4, completely proven.	1.00	£1,131.40	£1,131.40
1.16	U	Ground of neutral of transformer, consist of 30 m. of cable of copper 50mm2 of section, with isolation RV 0,6/1 KV, pikes of coppered steel of 2.000x14 mm., box PVC, ground cross-check and clamps. Completely installed and hook-up up to obtaining less resistance than 15 ohms.	5.00	£133.37	£666.87
1.17	U	Ground network "for ironworks" formed of coppered steel of 2,000 x 14mm, main cable of ground of 50 mm ² of Cu and bared, box PVC, ground cross-check and clamps, completely installed and hook-up up to obtaining less resistance than 15 ohms.	5.00	£350.11	£1,750.56
1.18	U	Installation of normal and emergency system of illumination in the centre of transformation, consist of: 1 insulating and watertight light with 2 fluorescent lamps of 58 W each one, emergency light 140Lm, switch, socket and cut off switch and differential protection, completely got in touch and proved.	3.00	£427.92	£1,283.75

No.	Unit	Description	Measure.	Price	Cost
1.19	U	Regulatory material of protection and safety for C.T. of COMPANY, including: Instructions, badge for the first aid, insulating jumping pole of rescue, insulating stool, first aid closet, 1 couple of gloves 30 KV with chest and 5 precaution signs. Transportation and installation of the elements.	3.00	£311.21	£933.63
		TOTAL 1. CENTRES OF TRANSFORMATION			**£212,463.95**

2. HIGH VOLTAGE WIRES

No.	Unit	Description	Measure.	Price	Cost
2.1	m	Construction of trench in ground, of 0,6x1,2 m. to lodge Medium Voltage drivers, including excavation, filling of 40cm. of washed sand, protection badge of PPC(Polyester Powder coating) approved by Endesa, safety sign tape, filling with chosen products, compression by layers of 20 cm. to 98 % of the P.M. and transport to dump of the remaining products.	500.00	£10.28	£5,139.12
2.2	m	Opening and closing of trench in ground of 1.35 m. of depth with 0.90 m. of width, even compression of the bottom, 9 pipes (in two lines triangular distribution) of PVC of 110 mm. of diameter and 2.2mm of thickness, wrapped in prism of concrete HM-20/B/40/Qb, protection badge of PPC approved by Endesa, safety sign tape, filling of chosen products of the excavation, compression and transport to dump of the remaining products and ground compressed to 98 % of the P.M.	90.00	£43.41	£3,906.95
2.3	m2	Demolition and restoration of mixed paving composed by rigid and flexible road surfaces of any type, up to a thickness of 30 cm, even cropping of joints, load and transport of products to dump, even cannon of spilled.	36.00	£38.98	£1,403.31
2.4	m	Cable RHZ1, Al, 12/20 KV of 1x400 mm² of size stretched in trench.	3000.00	£12.55	£37,649.18
2.5	m	Cable RHZ1, Al, 12/20 KV of 1x150 mm² of size stretched in trench.	90.00	£8.47	£762.12
2.6	U	Unipolar terminal of interior for cable 1x400 mm², Al, 12/20 KV, completely got in touch to cable and cell of line, proved.	18.00	£110.70	£1,992.64
2.7	U	Unipolar terminal of exterior for cable 1x150 mm², Al, 12/20 kV, completely got in touch to cable and proved, even the installation of metal frame supports placed in withstand.	6.00	£166.05	£996.32
2.8	m	Flexible pipe of hard PVC of 225 mm. of diameter and smooth interior, GP-7, placed in underground inputs to C.T.	60.00	£4.51	£270.49

No.	Unit	Description	Measure.	Price	Cost
2.9	U	Digitization of the design of the lines of medium and low voltage, as determined of Electrical Endesa Distribución, S.L.U. and delivery to the Supplying Company in computer support and copies requested in role, even formation and monitoring of the dossier of the third party agreement.	1.00	£276.76	£276.76
2.10	U	Achievement of high voltage wires essays as determined Electrical Endesa Distribución, S.L.U., for stretch of each laid group of three.	6.00	£272.14	£1,632.86
	TOTAL 2. HIGH VOLTAGE WIRES				**£54,029.74**

3. LOW VOLTAGE WIRES

No.	Unit	Description	Measure.	Price	Cost
3.1	m	Construction of trench in ground, of 0.60x0.80m to lodge wires of low voltage, including excavation, filling of 20 cm. of washed sand, protection badge of PPC approved by Endesa, tape of signaling, filling with chosen products, compression for stretches of 20 cm. to 95 % of the P.M. and transport to dump of the remaining products.	780.00	£8.50	£6,632.21
3.2	m	Construction of trench in ground, of 0.90x1.10m to lodge wires of low voltage, including excavation, filling of 20 cm. of washed sand, protection badge of PPC approved by Endesa, tape of signaling, filling with chosen products, compression by layers of 20cm to 95 % of the P.M. and transport to dump of the remaining products.	150.00	£8.80	£1,319.81
3.3	m	Canalization in crossings of roadway for distribution in Low Voltage or Medium Voltage made up by two tubes of 225mm of diameter of smooth PVC, of pressure as Norm UNE-53112, of 2.2mm of minimal thickness, wrapped in a prism of concrete HM-15/B/40/IIa of 60x30 cm. in trench of 120cm of average depth, even mesh of signaling of green color of 40cm, earthworks and maintenance of the existing services, entirely finished.	15.00	£18.59	£278.84
3.4	m	Canalization in crossings of roadway for distribution in Low Voltage or Medium Voltage made up by four tubes of 225mm of diameter of smooth PVC, of pressure as Norm UNE-53112, of 2.2mm of minimal thickness, wrapped in a prism of concrete HM-20/B/40/IIa of 60x60cm in trench of 120cm of average depth, even mesh of signaling of green color of 40cm, earthworks and maintenance of the existing services, entirely finished.	10.00	£21.64	£216.44

No.	Unit	Description	Measure.	Price	Cost
3.5	m	Canalization in crossings of roadway for distribution in Low Voltage or Medium Voltage made up by six tubes of 225 mm. of diameter of smooth PVC, of pressure as Norm UNE-53112, of 2.2mm of minimal thickness, wrapped in a prism of concrete HM-15/B/40/IIa of 90x60cm in trench of 120cm of average depth, even mesh of signaling of green color of 40cm, earthworks and maintenance of the existing services, entirely finished.	25.00	£28.05	£701.24
3.6	m2	Demolition and restoration of mixed paving composed by rigid and flexible road surfaces of any type, up to a thickness of 30cm, even clipping of meetings, load and transport of products to dump, even cannon of spilled.	45.00	£38.98	£1,754.13
3.7	m	Wire of aluminum, with isolation RV 0.6/1 KV of 1x240mm², lied in trench.	10512.00	£2.92	£30,647.79
3.8	U	Achievement of wires' essays of low voltage as determined Electrical Endesa Distribución, S.L.U., for stretched circuit.	30.00	£166.05	£4,981.60
	TOTAL 3. LOW VOLTAGE WIRES				**£46,532.07**

4. PANEL BOARDS FOR CUTTING OFF AND PROTECTION

No.	Unit	Description	Measure.	Price	Cost
4.1	U	Chopper and protection set CSP 250/400 for 1 derivation of the main line up to 150 mm^2, with I/O of line up to 240 mm2, formed by 2 panel boards of 701x521x231mm, terminals and connections, metallic door IK-10 according to REBT, even padlocks of the supplying company. It will go fixed in the wall according to Norms of Electrical Endesa Distribución S.L.U.	32.00	£465.15	£14,884.78
4.2	U	Prefabricated monolith of concrete HM-20 of 1,675mm x 1,000mm x 365mm with a concrete enclosure approved by Endesa for assembly of chopper set and protection, even foundation and putting to point of auxiliary means, entirely installed.	32.00	£424.34	£13,578.91
	TOTAL 4. PANEL BOARDS FOR CUTTING OFF AND PROTECTION				**£28,463.68**

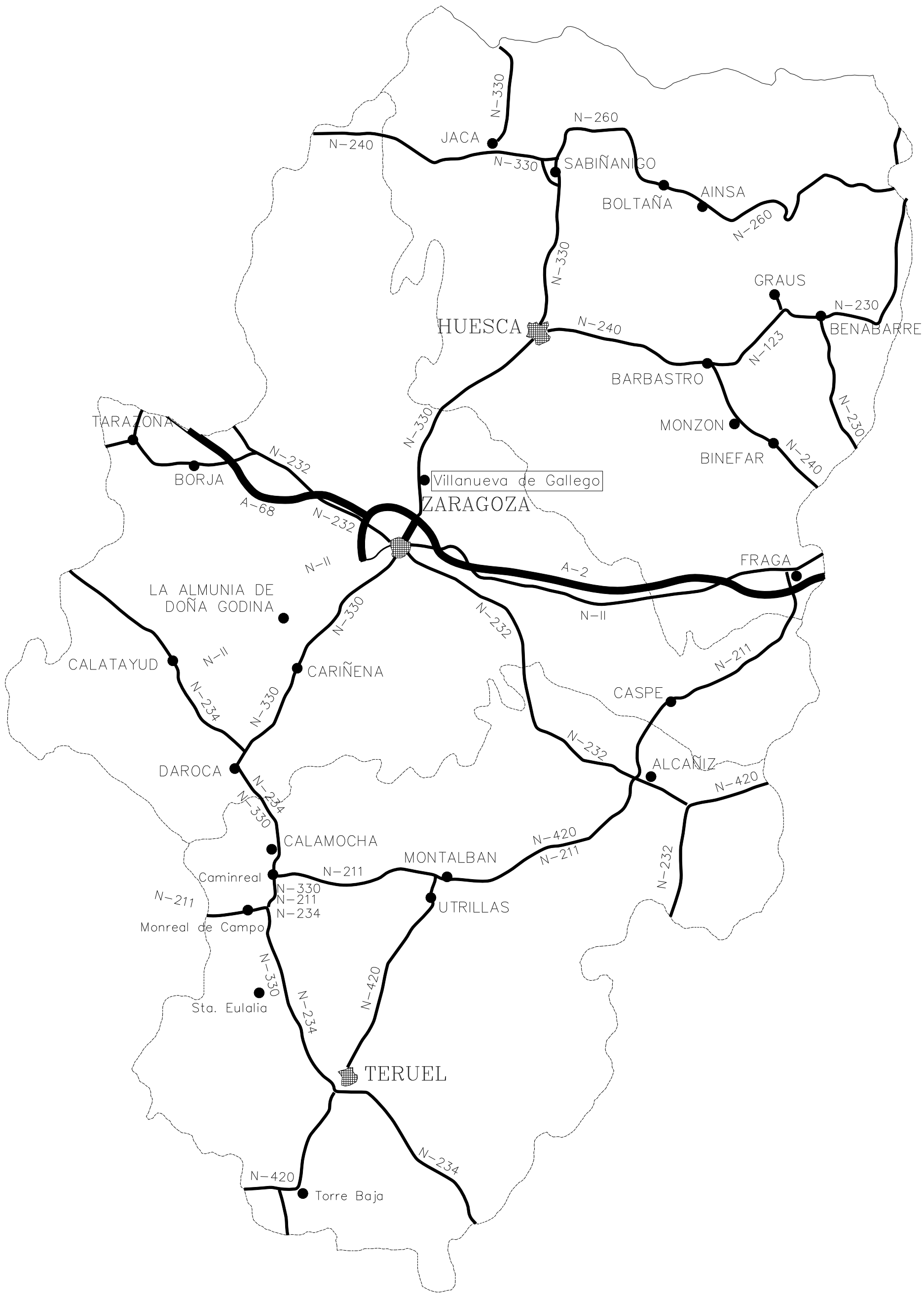
5. SAFETY AND HEALTH AND UNFORESEEN EXPENSES

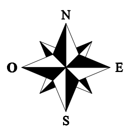
No.	Unit	Description	Measure.	Price	Cost
5.1	1	Item to justify (for measurements taken according to the Study of Safety and Health realized by the subcontracted company).	1.00	£3,481.19	£3,481.19
5.2	1	Item to justify (for unforeseen expenses during the course of the work).	1.00	£4,351.50	£4,351.50
5.3	1	Item to justify (for dismantling of air lines of high and low voltage, demolition of foundations, load and transport, even canon of management of residues).	1.00	£3,916.35	£3,916.35
		TOTAL 5. SAFETY AND HEALTH AND UNFORESEEN EXPENSES			**£11,749.04**

BUDGET OF MATERIAL EXECUTION	COST IN £
TOTAL 1. CENTRES OF TRANSFORMATION	£212,463.95
TOTAL 2. HIGH VOLTAGE WIRES	£54,029.74
TOTAL 3. LOW VOLTAGE WIRES	£46,532.07
TOTAL 4. PANEL BOARDS FOR CUTTING OFF AND PROTECTION	£28,463.68
TOTAL 5. SAFETY AND HEALTH AND UNFORESEEN EXPENSES	£11,749.04
TOTAL	**£353,238.48**

Appendix B: Drawings

List of Drawings





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Designed	07.05.10	Daniel Racionero		
Supervised				

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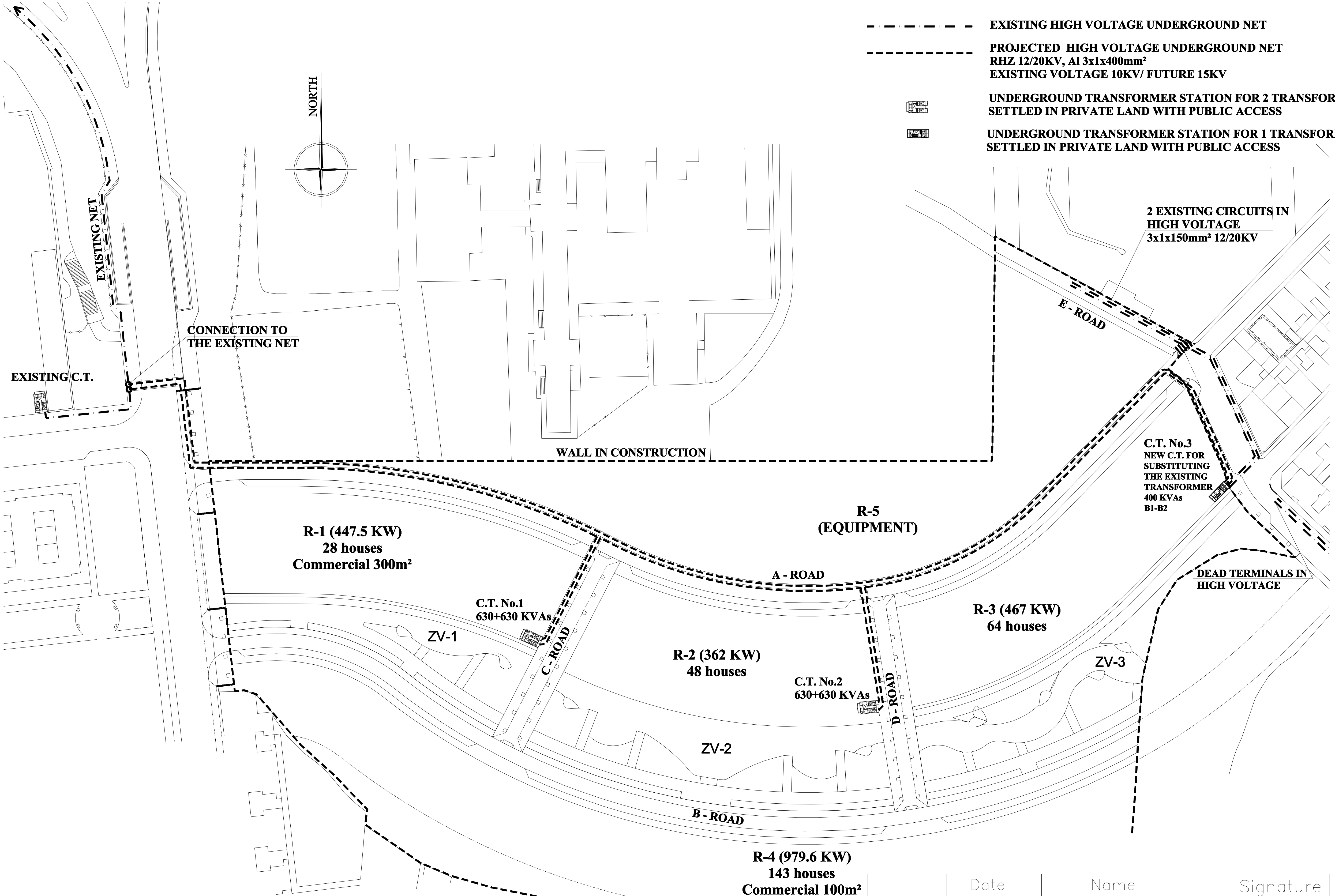

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Supervised				
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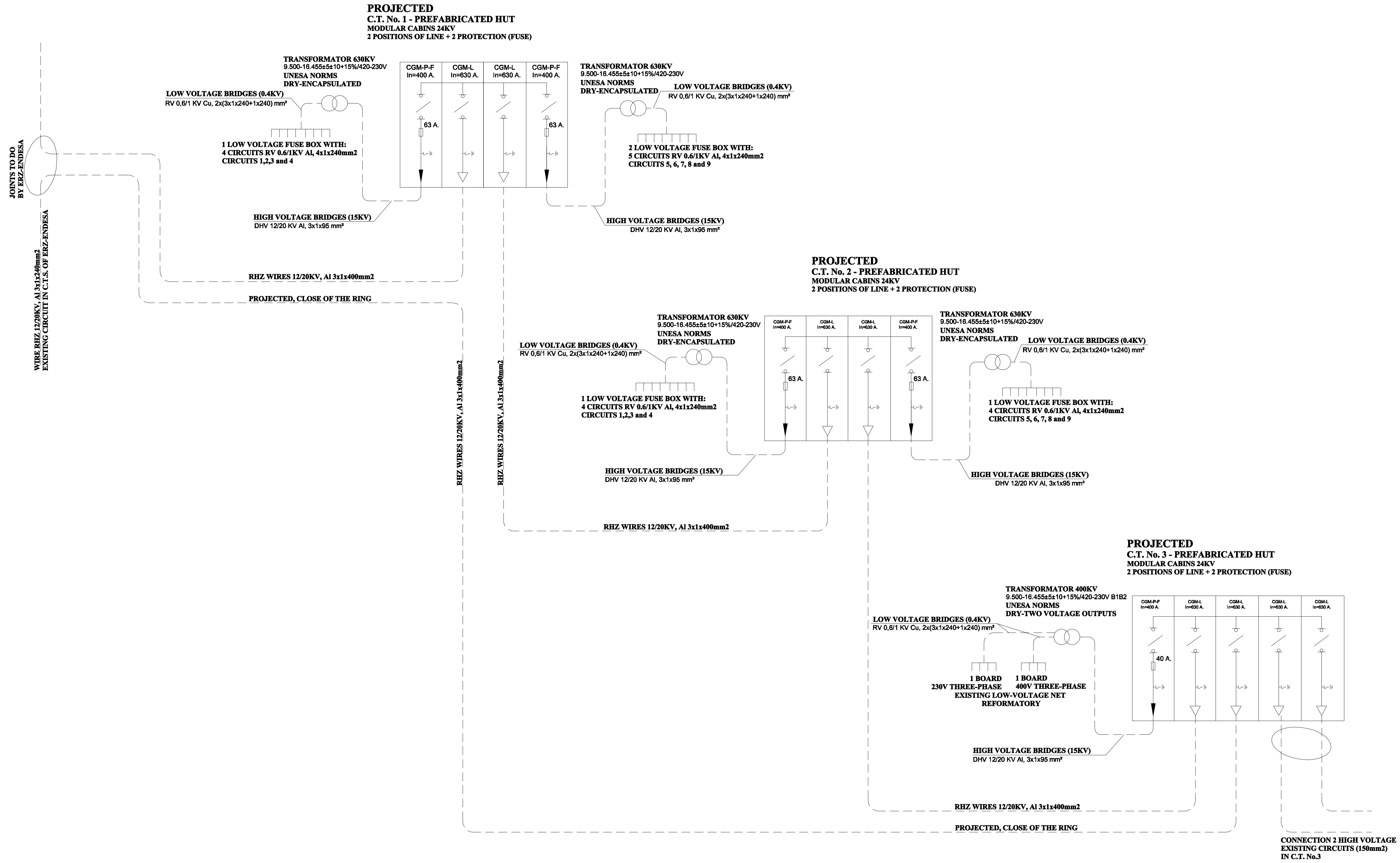

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Supervised				
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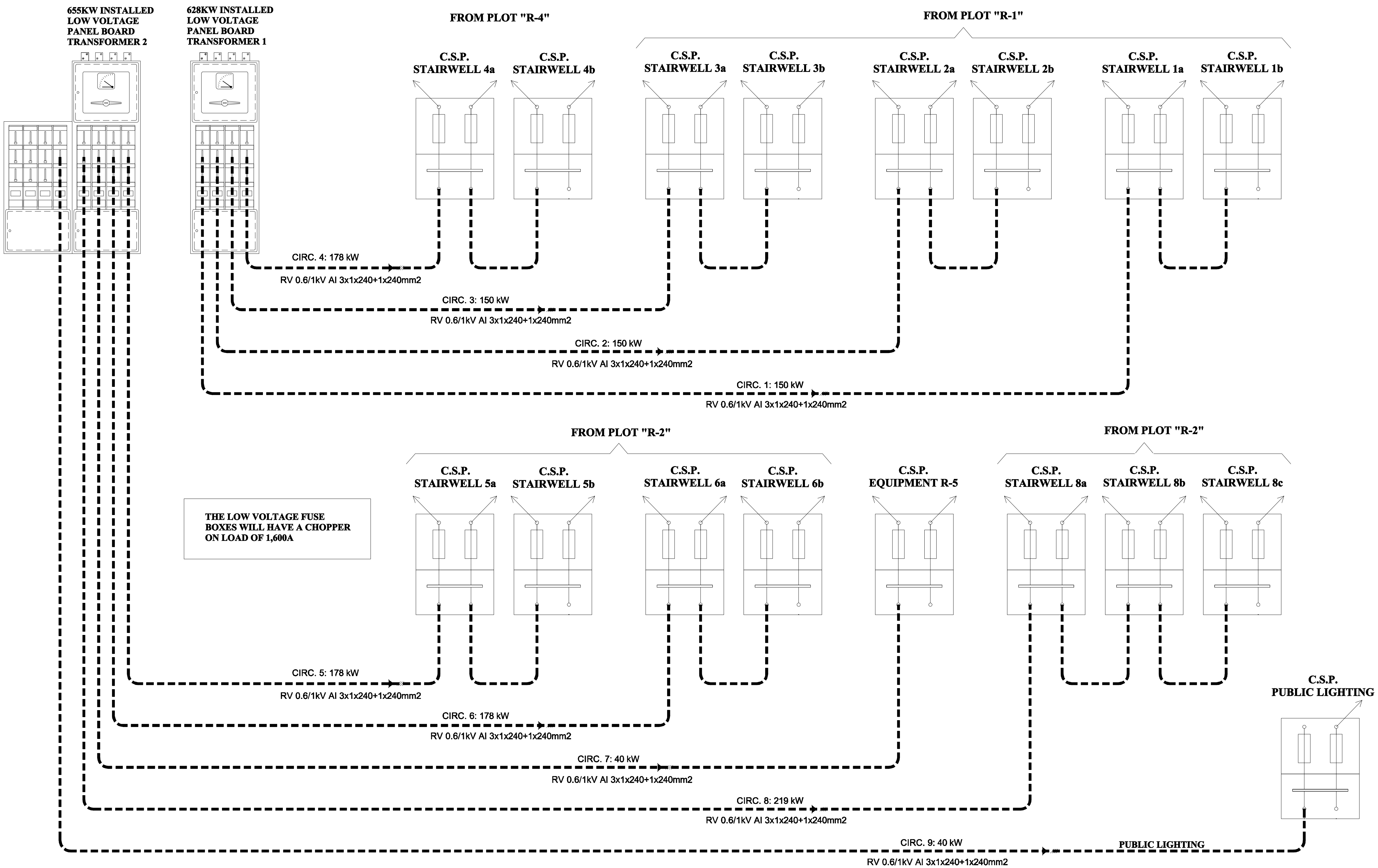

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Supervised				
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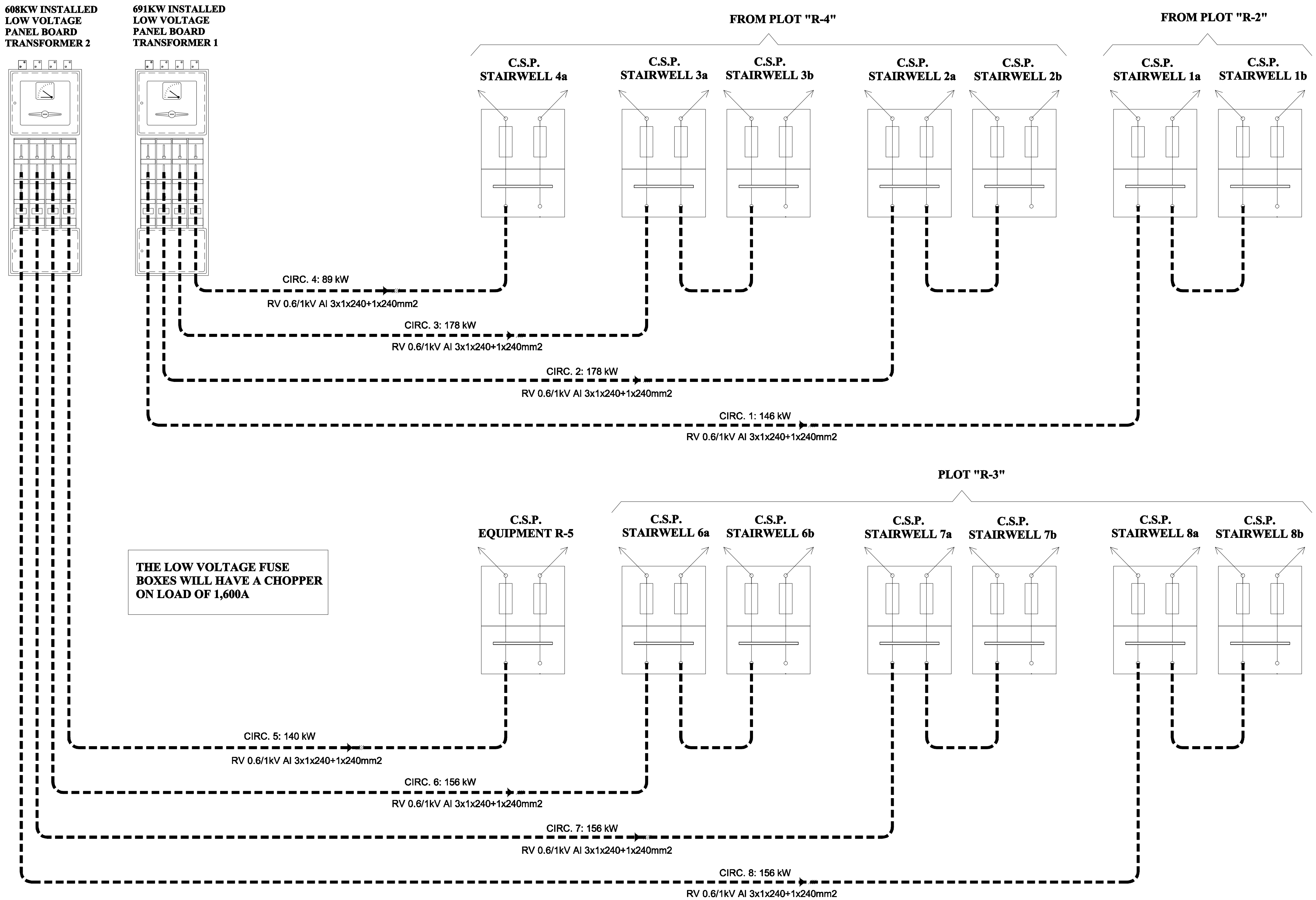

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Supervised				
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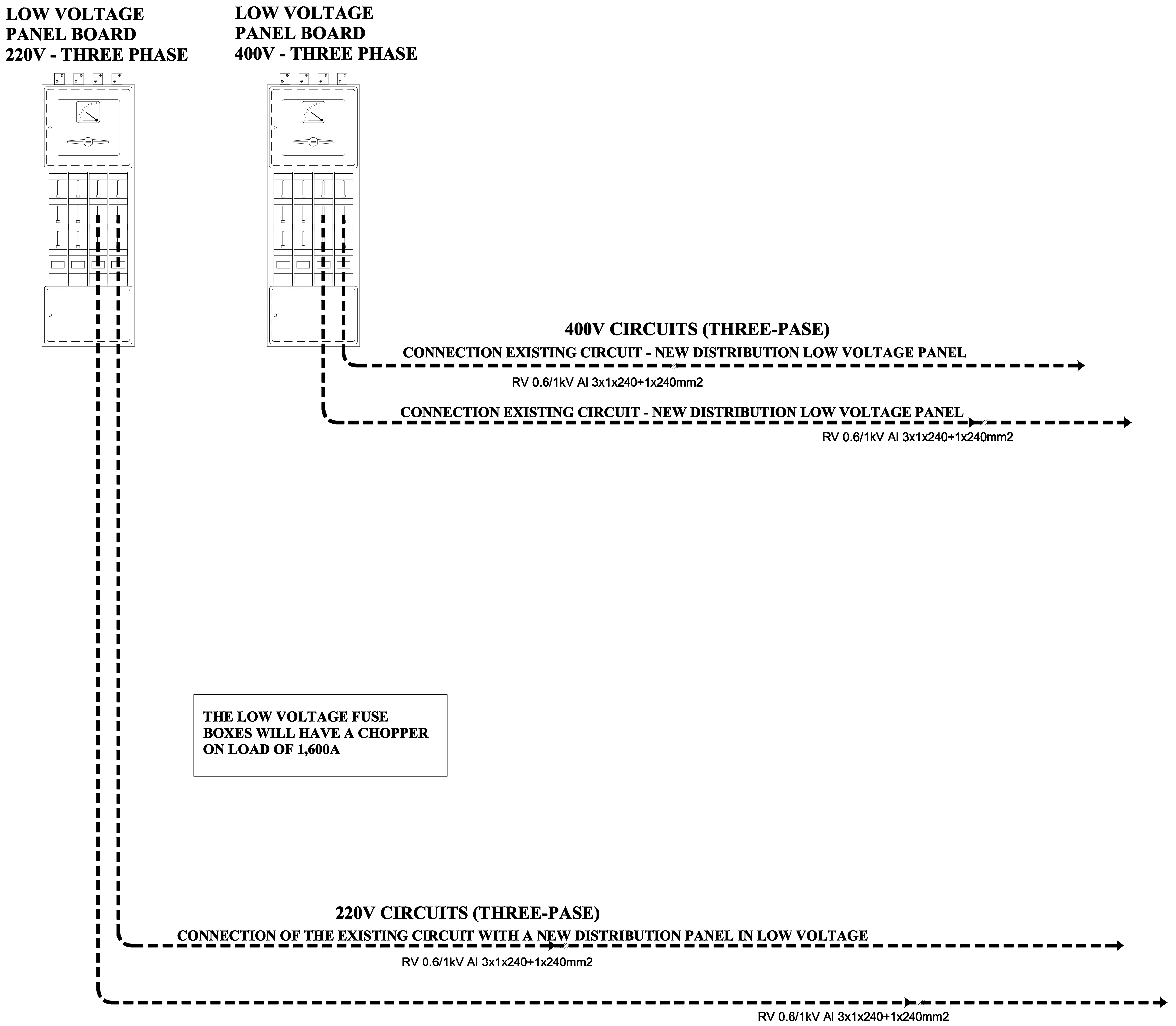
CENTRE OF TRANSFORMATION No.3



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Supervised				
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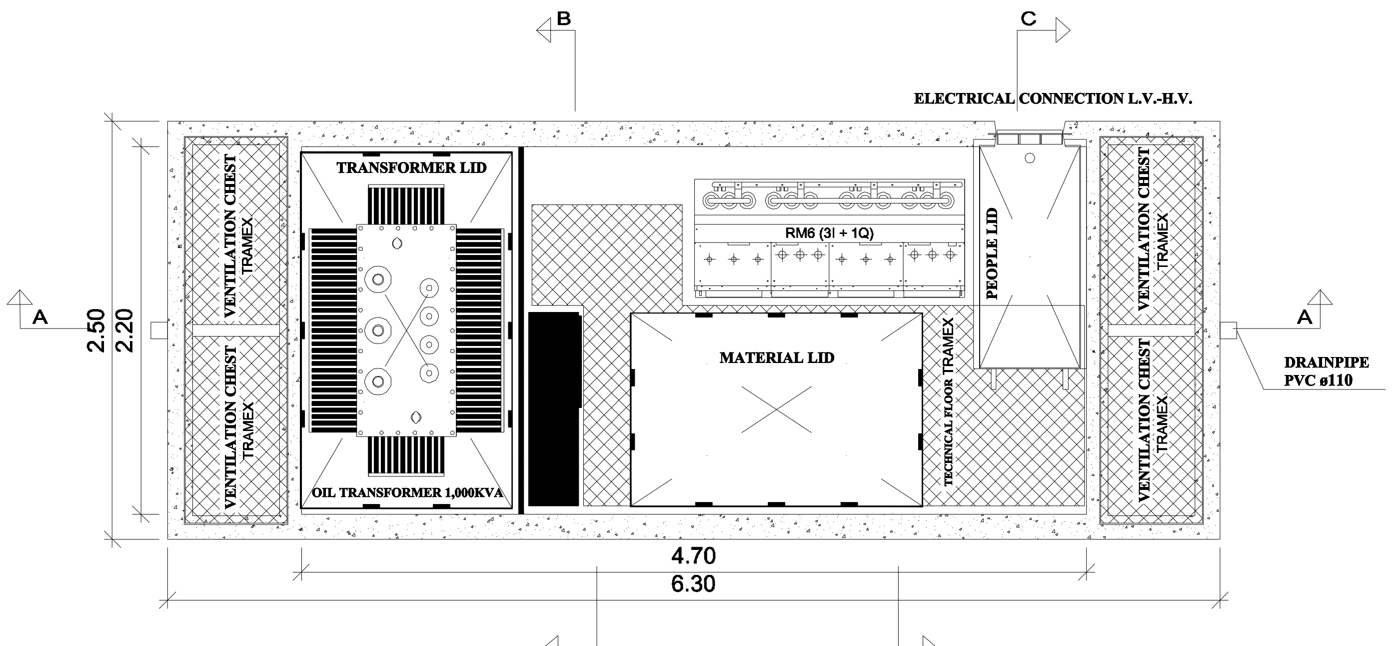
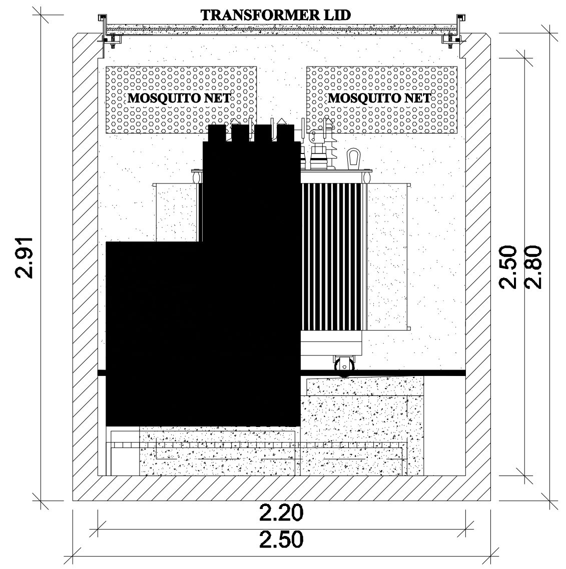
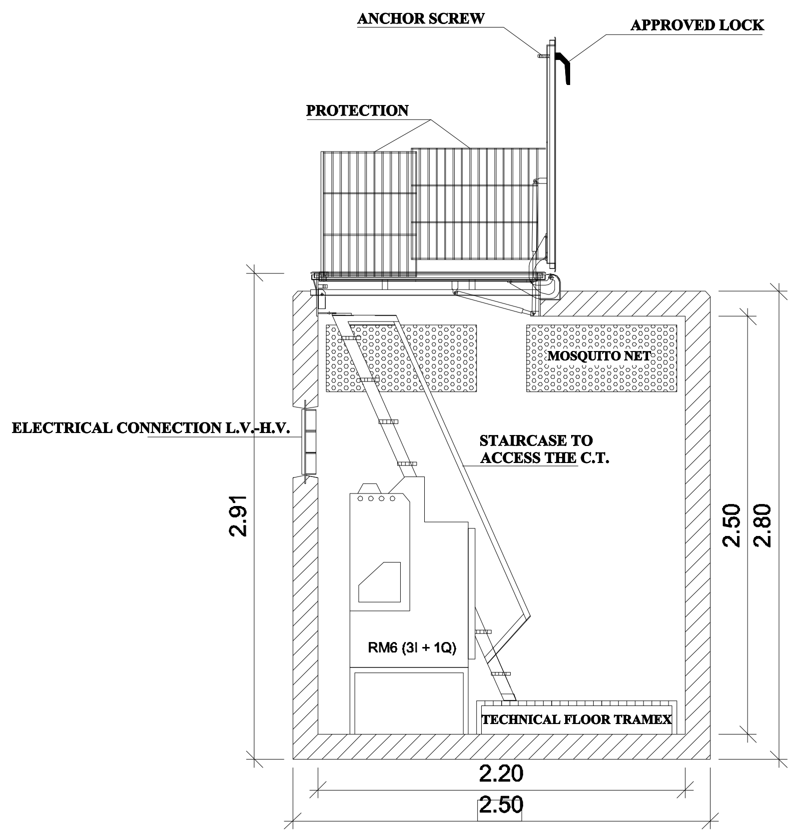


PLANT



CROSS SECTION B-B



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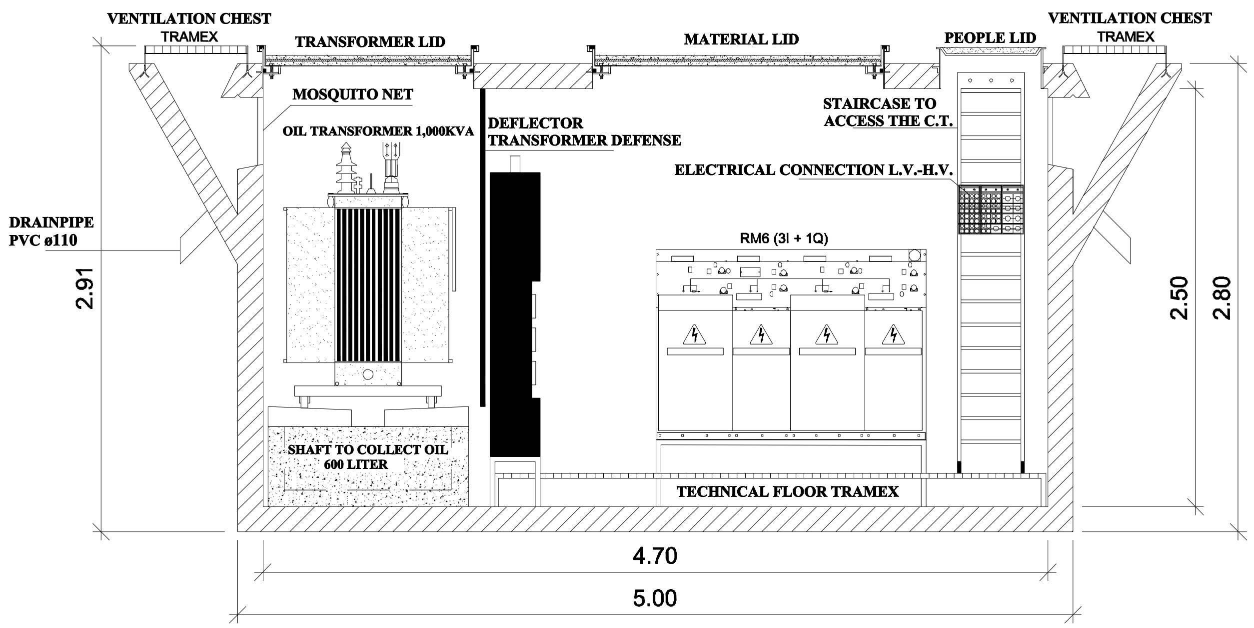

CROSS SECTION A-A

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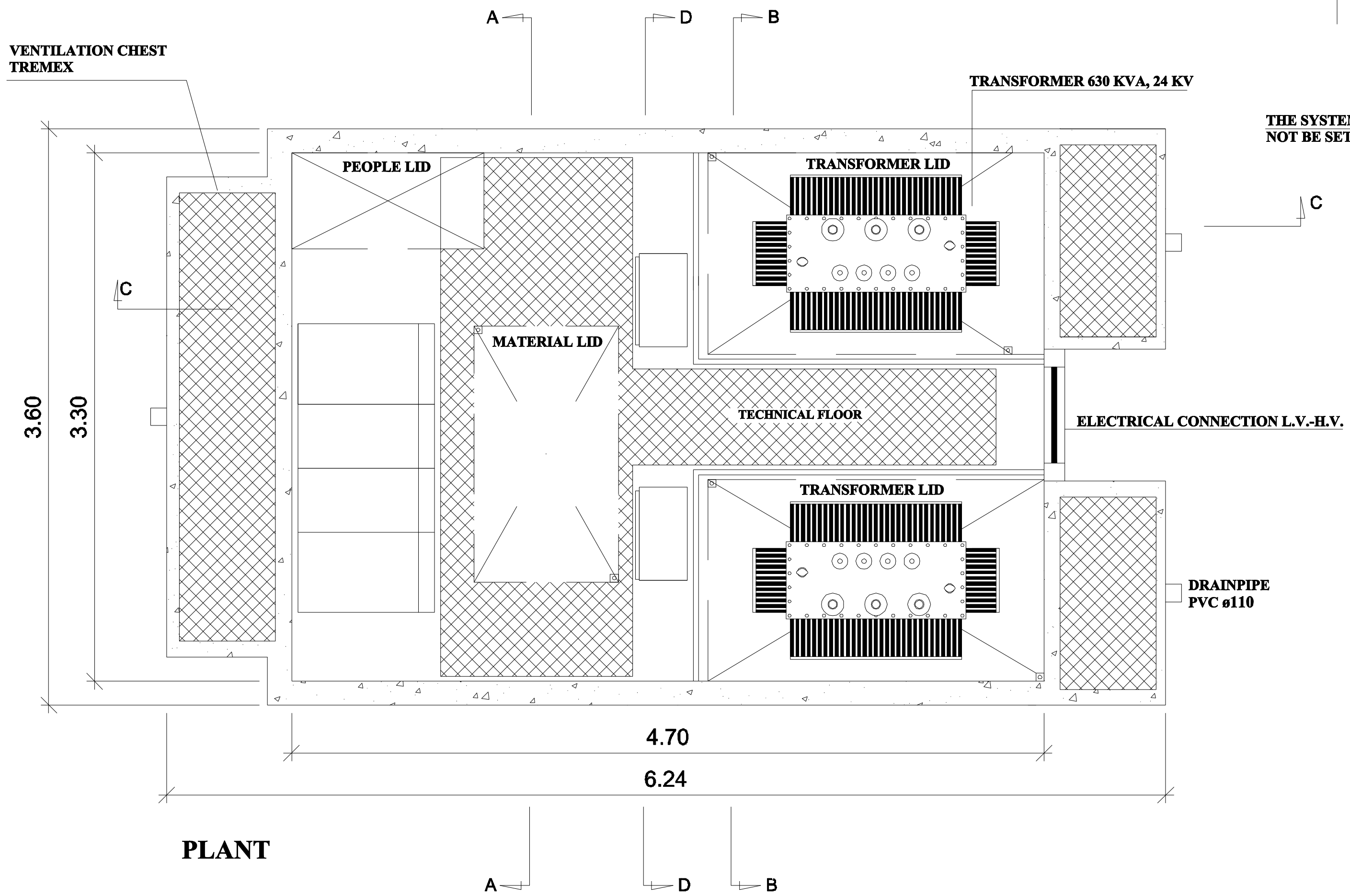

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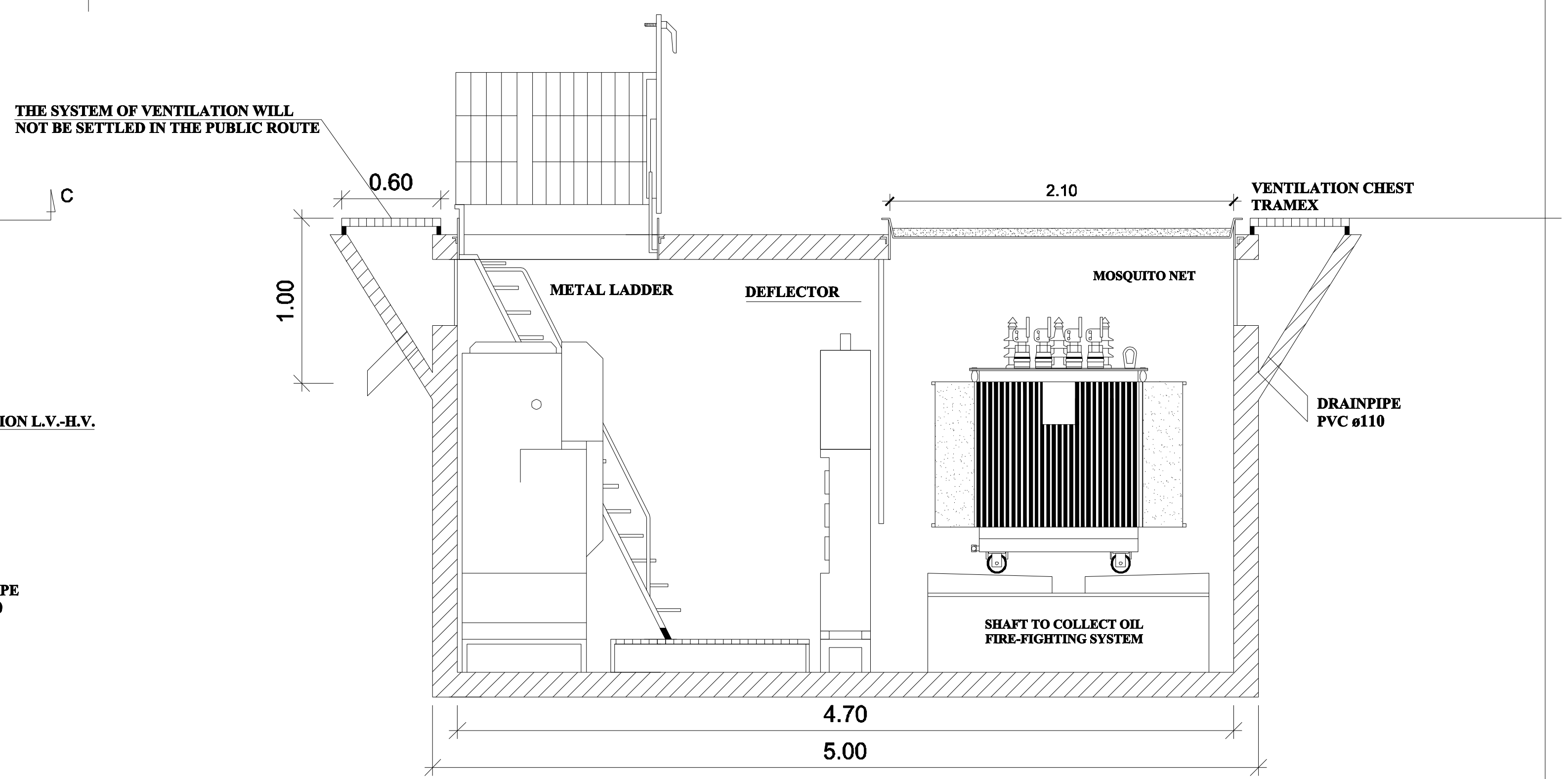

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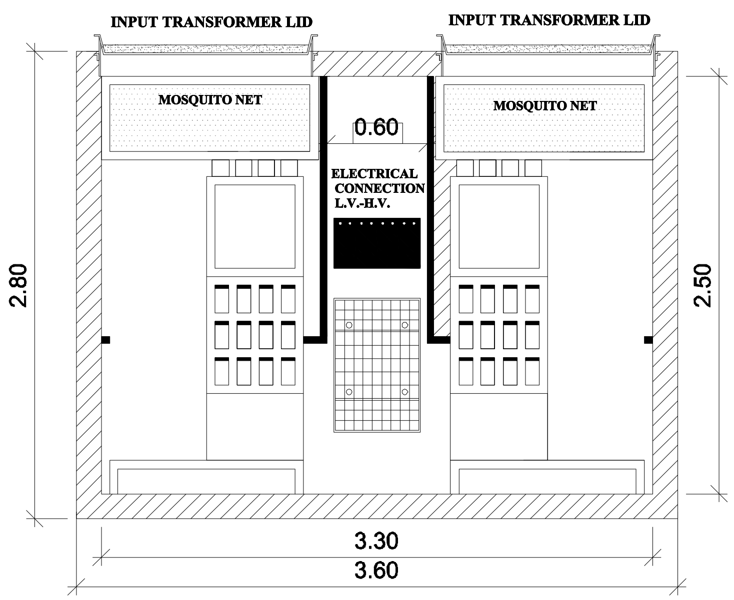

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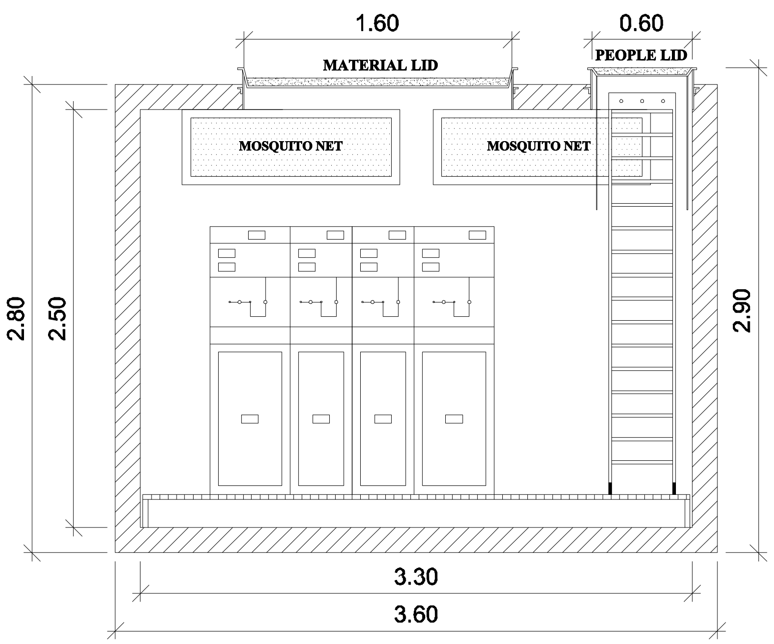

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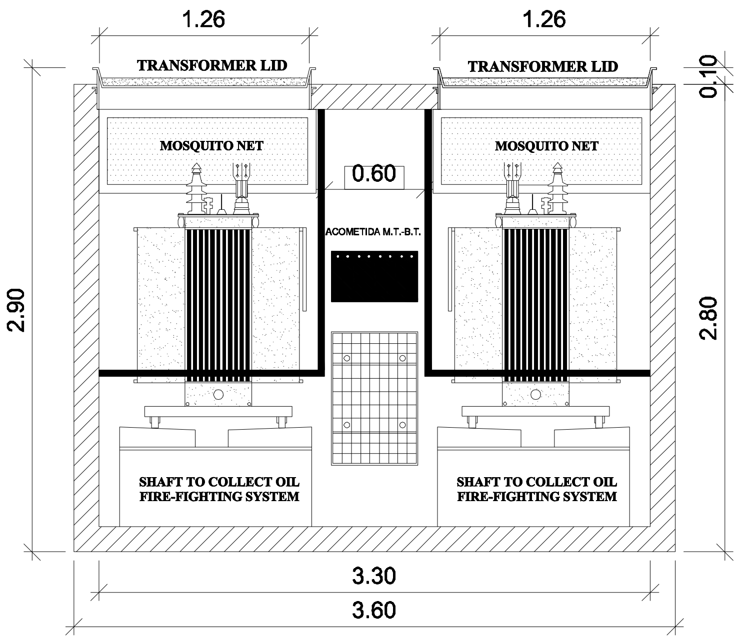

CROSS SECTION B-B

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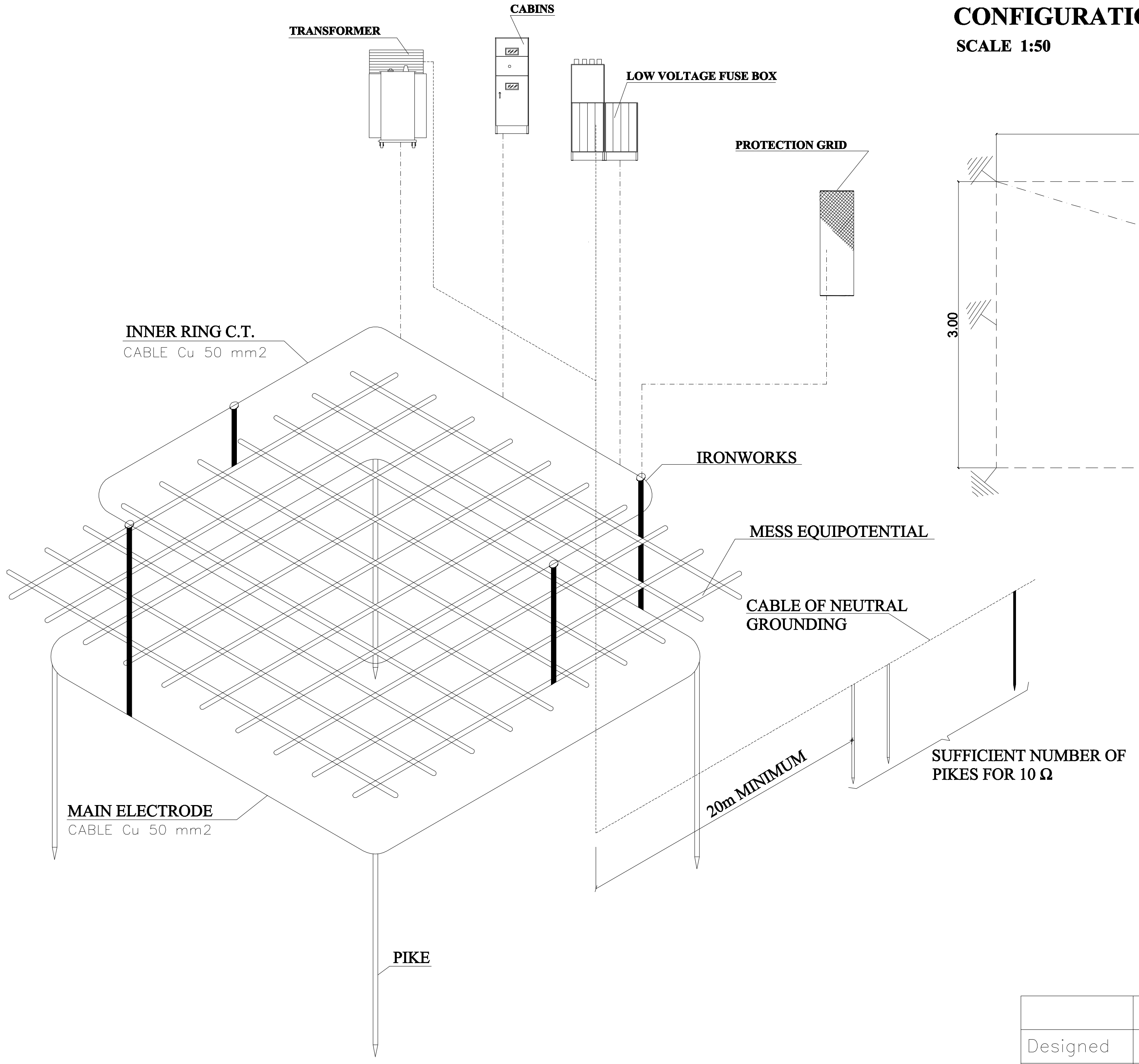
GROUND SKETCH



IRONWORK GROUND NET CONFIGURATION 80-30/8/82

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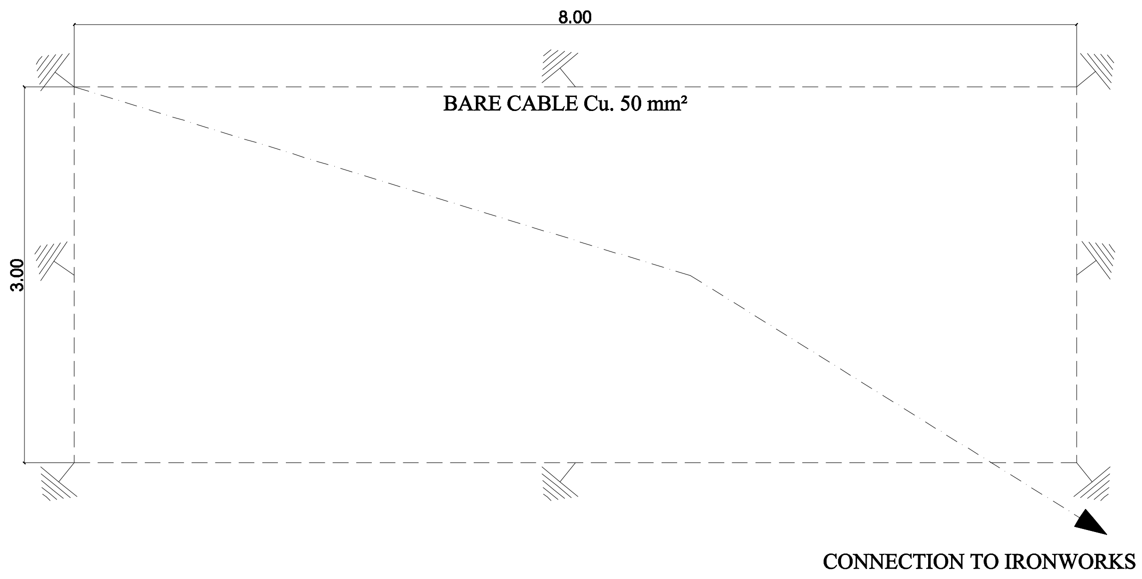

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Appendix C: Data sheets

List of datasheets:

- Medium Voltage Switchgear type 8DH10 up to 24KV. (8)
- Low voltage switchboard for the output of the transformer station. (9)

Contents

For further information, please refer to

- Catalog HA 40.1: (Switchgear Type 8DJ and 8DH, General Part)
- Supplements to Catalogs HA 45.31/41.11

Invalid: Catalog HA 41.11 · 2006

The products and systems described in this catalog are manufactured and sold according to certified quality and enviromental management system (acc. ISO 9001 and ISO 14001).
(DQS Certificate Reg. No. DQS 003473 QM UM).
The certificate is accepted in all IQNet countries.

Application, Requirements

Features

8DH10 switchgear is a factory-assembled, type-tested, three-pole, metal-enclosed, metal-clad single-busbar switchgear for in-door installation:

- Up to 24 kV
- Feeder currents up to 630 A
- Busbar currents up to 1250 A

Typical uses

8DH10 switchgear is used – even under severe environmental conditions – for power distribution in secondary distribution systems, such as

Substations, customer transfer substations, distribution substations and switching substations of power supply and public utilities

Industrial plants, such as:

- Wind power stations
- High-rise buildings
- Airports
- Lignite open-cast mines
- Underground railway stations
- Sewage treatment plants
- Port facilities
- Traction power supply systems
- Automobile industry
- Petroleum industry
- Chemical industry
- Cement industry
- Unit-type heating power stations
- Textile, paper and food industry
- Emergency power supply installations

Modular design

- Individual panels and panel blocks can be freely combined and extended – without gas work on site
- Low-voltage compartments can be supplied in two overall heights and are wired to the panel by means of plug-in connections

Reliability

- Type and routine-tested
- Standardized and manufactured using numerically controlled machines
- More than 430,000 8DJ/8DH panels in operation worldwide for many years

Quality and environment

Quality and environmental management system acc. to DIN EN ISO 9001 and DIN EN ISO 14001

Personal safety

- Safe-to-touch and hermetically sealed primary enclosure
- HV HRC fuses and cable sealing ends are only accessible when outgoing feeders are earthed
- Operation only possible when enclosure is closed
- Logical mechanical interlocking
- Capacitive voltage detecting system to verify safe isolation from supply
- Feeder earthing by means of make-proof earthing switches

Security of operation

- Hermetically sealed primary enclosure independent of environmental effects (such as pollution, humidity and small animals) – sealed for life:
  - Welded switchgear vessel
  - Welded-in bushings and operating mechanism
- Operating mechanism parts maintenance-free (IEC 60 694 / VDE 0670-1000)
- Operating mechanisms of switching devices located outside the switchgear vessel (primary enclosure)
- Switchgear interlocking system with logical mechanical interlocks
- Mechanical switch-position indicators integrated in the mimic diagram

Cost-efficiency

Extremely low "life-cycle costs" throughout the entire product service life as a result of:

- Maintenance-free concept
- Climatic independence
- Minimum space requirements
- Maximum availability

Security of investment

Innovative developments, such as:

- Modular design
- Switchgear extension without gas work on site
- Maintenance-free 3AH vacuum circuit-breaker
- SIPROTEC protection device family

Application

Typical uses

Technology

- Maintenance-free
- Climate-independent
- Partition class: Class PM (metallic partition)
- Three-pole primary enclosure, metal-enclosed
- Insulating gas SF_6
- Welded switchgear vessel without seals, made of stainless steel, with welded-in bushings for electrical connections and mechanical components
- Three-position switch-disconnector with load-break and make-proof earthing function
- Cable connection for bushings with outside cone
- Connection with cable plugs
  – In ring-main feeders and circuit-breaker feeders with bolted contact (M16)
  – In transformer feeders with plug-in contact
- Option: Connection with conventional cable sealing ends
  – For thermoplastic-insulated cables via elbow adapter AKE 20 / 630 (make Siemens)
  – For paper-insulated mass-impregnated cables via commercially available adapter systems
- Easy installation
- Option: Pressure absorber system
  – Maintenance-free
  – For rated short-time withstand current $I_k \leq 20$ kA
  – For single and multi-panel combinations of 700 mm to 2000 mm width (for panel type ME1 with max. 1 adjacent panel)
  – With 300 mm high pressure absorber duct below the switchgear and
  – With 115 mm deep pressure absorber duct for pressure relief upwards
  – With screwed-on cable compartment cover
  – Possible for switchgear with standard cable compartment cover Option: Deeper cable compartment cover: 105 or 300 mm
  – For overall height of switchgear, see page 6
  – Option: Free-standing arrangement, for overall height of switchgear 2300 mm and with rear cover

For further information concerning the pressure absorber system, please refer to page 39 and to Catalog HA 40.1

Standards

See page 41

Example
Customer transfer switchgear

Application
Customer transfer substation in an accessible switchgear building (transformers, medium-voltage and low-voltage in a factory-assembled building)

Application
Power supply of high-rise buildings

Technical Data

Electrical data

Common electrical data	Rated insulation level	Rated voltage U_r	kV	**7.2**	**12**	**15**	**17.5**	**24**
		Rated short-dur. power-freq. withstand voltage U_d:						
		– phase-to-phase, phase-to-earth, open contact gap	kV	20	28 [1)]	36	38	50
		– across the isolating distance	kV	23	32 [1)]	39	45	60
		Rated lightning impulse withstand voltage U_p:						
		– phase-to-phase, phase-to-earth, open contact gap	kV	60	75 [1)]	95	95	125
		– across the isolating distance	kV	70	85 [1)]	110	110	145
	Rated frequency f_r			50/60 Hz →				
	Rated normal current I_r [2)]	for busbar (standard)	up to A	630	630	630	630	630
		for busbar (option) *)	A	1250	1250	1250	1250	1250
Filling pressure, temperature, partition class and classification	Rated filling level p_{re}	for insulation		150 kPa (absolute) at 20 °C →				
	Min. functional level p_{me}	for insulation		130 kPa (absolute) at 20 °C →				
	Ambient air temperature T [3)]	Panels without secondary equipment	Class	"Minus 25 indoor" (-25 to +70 °C [4)]) →				
		Panels with secondary equipment, circuit-breaker panels	Class	"Minus 5 indoor" (-5 to +55 °C [4)]) →				
	Partition class		Class	PM (metallic partition) →				
	Loss of service continuity category [5)]	LSC (loss of service continuity)		LSC 2 →				

Panel data

Ring-main panel type RK, **bus sectionalizer panel** type LT2, **cable panel** type K	Rated normal current I_r [2)]	for feeder (for panel types RK ... and K ...)	A	400, 630	400, 630	400, 630	400, 630	400, 630
		for bus sectionalizer panel type LT2	A	400, 630	400, 630	400, 630	400, 630	400, 630
	Rated short-time withstand current I_k	for switchgear with t_k = 1 s	up to kA	20 / 25	20 / 25	20 / 25	20 / 25	20
		for switchgear with t_k = 3 s (option)	up to kA	– / –	20 / –	20 / –	20 / –	20
	Rated peak withstand current I_p		up to kA	50 / 63	50 / 63	50 / 63	50 / 63	50
	Rated short-circuit making current I_{ma}		up to kA	50 / 63	50 / 63	50 / 63	50 / 63	50

Transformer panel type TR	Rated normal current I_r [2)]	for feeder [6)]	A	200	200	200	200	200
	Rated short-time withstand current I_k	for switchgear with t_k = 1 s	up to kA	20 / 25	20 / 25	20 / 25	20 / 25	20
		for switchgear with t_k = 3 s	up to kA	– / –	20 / –	20 / –	20 / –	20
	Rated peak withstand current I_p [6)]		up to kA	50 / 63	50 / 63	50 / 63	50 / 63	50
	Rated short-circuit making current I_{ma} [6)]		up to kA	25 / 25	25 / 25	25 / 25	25 / 25	25
	Reference dimension "e" of the HV HRC fuse links		mm	292 [7)]	292	442	442	442

Circuit-breaker panel type LS, **bus sectionalizer** type LK/LT1	Rated normal current I_r [2)]	for feeder (for panel types LS ...)	A	400, 630	400, 630	400, 630	400, 630	400, 630
		for bus sectionalizer panel type LT1	A	400, 630	400, 630	400, 630	400, 630	400, 630
	Rated short-time withstand current I_k	for switchgear with t_k = 1 s	up to kA	20 / 25	20 / 25	20 / 25	20 / 25	20
		for switchgear with t_k = 3 s	up to kA	– / –	20 / –	20 / –	20 / –	20
	Rated peak withstand current I_p		up to kA	50 / 63	50 / 63	50 / 63	50 / 63	50
	Rated short-circuit making current I_{ma}		up to kA	50 / 63	50 / 63	50 / 63	50 / 63	50
	Rated short-circuit breaking current I_{sc} [8)]		up to kA	20 / 25	20 / 25	20 / 25	20 / 25	20
	Electrical service life of 3AH vacuum circuit-breakers	at rated normal current		10 000 operating cycles →				
		at rated short-circuit breaking current		50 breaking operations →				

*) Not for billing metering panels type ME1

1) According to some national requirements, higher values of the rated short-duration power-frequency withstand voltage available for I_k = 20 kA with:
– 42 kV for phase-to-phase, phase-to-earth and open contact gap as well as
– 48 kV across the isolating distance
Higher values of the rated lighting impulse withstand voltage (for I_K = 20 kA) :
– 95 kV for phase-to-phase, phase-to-earth and open contact gap as well as
– 110 kV across the isolating distance

2) The rated normal currents apply to ambient air temperatures of max. 40 °C. The 24-hour mean value is max. 35 °C (according to IEC 60 694 / VDE 0670-1000)

3) Operating conditions according to IEC 62 271-200. For application, see also pages 2 and 41 (climate and ambient conditions)

4) Temperature range, reduced normal currents at ambient air temperatures > +40 °C

5) Classification according to IEC 62 271-200 (see also page 42)

6) Depending on the HV HRC fuse link, observe the max. let-through current of the HV HRC fuse links

7) Extension tube (150 mm long) required additionally for fuse mounting 442 mm

8) For the 3AH vacuum circuit-breaker

Electrical data

Common electrical data	Rated insulation level	Rated voltage U_r	kV	**7.2**	**12**	**15**	**17.5**	**24**
		Rated short-dur. power-freq. withstand voltage U_d:						
		– phase-to-phase, phase-to-earth, open contact gap	kV	20	28 [1)]	36	38	50
		– across the isolating distance	kV	23	32 [1)]	39	45	60
		Rated lightning impulse withstand voltage U_p:						
		– phase-to-phase, phase-to-earth, open contact gap	kV	60	75 [1)]	95	95	125
		– across the isolating distance	kV	70	85 [1)]	110	110	145
	Rated frequency f_r			50/60 Hz →				
	Rated normal current I_r [2)]	for busbar (standard)	up to A	630	630	630	630	630
		for busbar (option) *)	A	1250	1250	1250	1250	1250
Filling pressure, temperature, partition class and classification	Rated filling level p_{re}	for insulation		150 kPa (absolute) at 20 °C →				
	Min. functional level p_{me}	for insulation		130 kPa (absolute) at 20 °C →				
	Ambient air temperature T [3)]	Panels without secondary equipment	Class	"Minus 25 indoor" (-25 to +70 °C [4)]) →				
		Panels with secondary equipment, circuit-breaker panels	Class	"Minus 5 indoor" (-5 to +55 °C [4)]) →				
	Partition class		Class	PM (metallic partition) →				
	Loss of service continuity category [5)]	LSC (loss of service continuity)		LSC 2 →				

Panel data

				7.2		12		15		17.5		24
Busbar earthing panel type SE, **busbar voltage metering panel** type MS1V/ME3	Rated short-time withstand current I_k	for switchgear with t_k = 1 s	up to kA	20	25	20	25	20	25	20	25	20
		for switchgear with t_k = 3 s (option)	up to kA	–	–	20	–	20	–	20	–	20
	Rated peak withstand current I_p		up to kA	50	63	50	63	50	63	50	63	50
	Rated short-circuit making current I_{ma}		up to kA	50	63	50	63	50	63	50	63	50

				7.2		12		15		17.5		24
Billing metering panels types ME1 and ME2	Rated normal current I_r [2)]	for transfer	up to A	630		630		630		630		630
		for feeder (T with cable panel as type ME1-K)	up to A	630		630		630		630		630
		for busbar metering	up to A	630		630		630		630		630
	Rated short-time withstand current I_k	for switchgear with t_k = 1 s	up to kA	–	25	20	25	20	25	20	25	20
		for switchgear with t_k = 3 s	up to kA	20	–	20	–	20	–	20	–	20
	Rated peak withstand current I_p		up to kA	50	63	50	63	50	63	50	63	50

*) Not for billing metering panels type ME1

1) According to some national requirements, higher values of the rated short-duration power-frequency withstand voltage available for I_k = 20 kA with:
– 42 kV for phase-to-phase, phase-to-earth and open contact gap as well as
– 48 kV across the isolating distance
Higher values of the rated lighting impulse withstand voltage (for I_k = 20 kA):
– 95 kV for phase-to-phase, phase-to-earth and open contact gap as well as
– 110 kV across the isolating distance

2) The rated normal currents apply to ambient air temperatures of max. 40 °C. The 24-hour mean value is max. 35 °C (according to IEC 60 694 / VDE 0670-1000)

3) Operating conditions according to IEC 62 271-200. For application, see also pages 2 and 41 (climate and ambient conditions)

4) Temperature range, reduced normal currents at ambient air temperatures > +40 °C

5) Classification according to IEC 62 271-200 (see also page 42)

Technical Data

Switchgear installation

Room planning

Switchgear installation

Wall-standing arrangement
– Single row
– Double row (for face-to-face arrangement)

Option: Free-standing arrangement

For room planning and switchgear installation, please note:
– Floor openings: Dimensions see pages 36 to 39
– Direction of pressure relief acc. to serial no. 13
– Respective pressure relief rooms

Room dimensions see opposite dimension drawings

Door dimensions

The door dimensions depend on the
– Number of panels in a transport unit
– Design with or without low-voltage compartment

Switchgear fastening

- For floor openings and fixing points of the switchgear, see pages 36 to 39
- Foundations:
  – Steel structure
  – Steel-reinforced concrete

Panel dimensions see p. 30 to 34

Weight

For details, please refer to page 7.

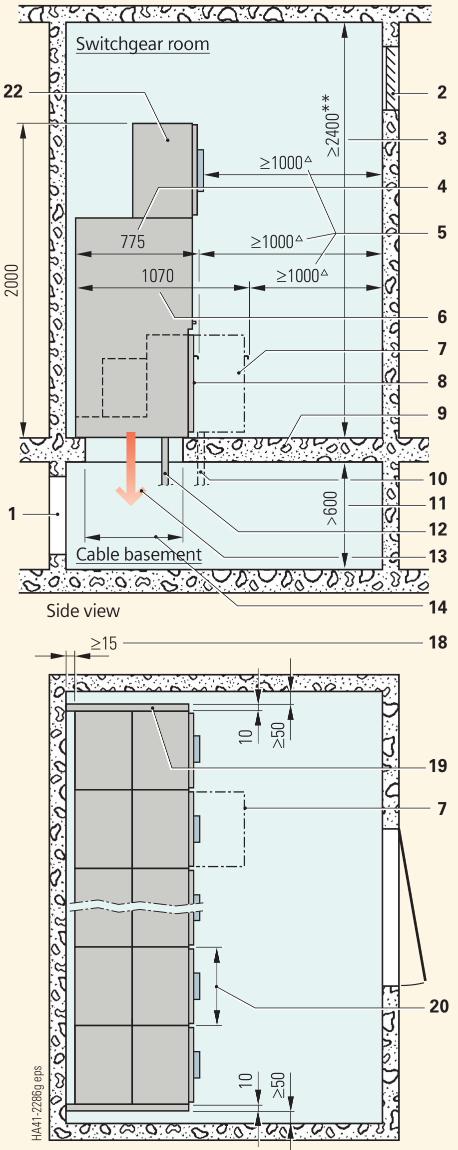
* Switchgear height for version with pressure absorber duct:
– For wall-standing arrangement
≥ 1950 mm (panel combination without metering panel ME1)
≥ 2300 mm (for combination with metering panel ME1)
– For free-standing arrangement
≥ 2300 mm (high end walls, rear wall and front covers, optional low-voltage compartment)

** Installation conditions for internal arc classification acc. to IEC 62 271-200

*** Height of pressure absorber duct 2100 mm with:
– Wall-standing arrangement with metering panel ME1
– Free-standing arrangement for all panel types

Δ Depending on national specifications:
– For extension/panel replacement: Control aisle ≥ 1000 mm recommended (for Germany ≥ 800 mm)

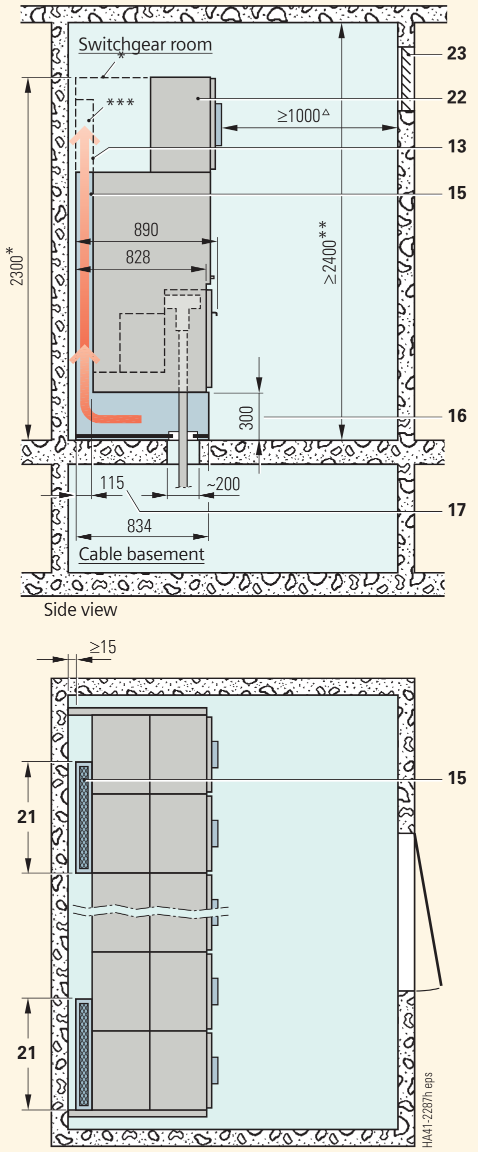
Switchgear installation with standard panels



Side view

Top view

Switchgear installation with rear-side pressure absorber duct (option)



Side view

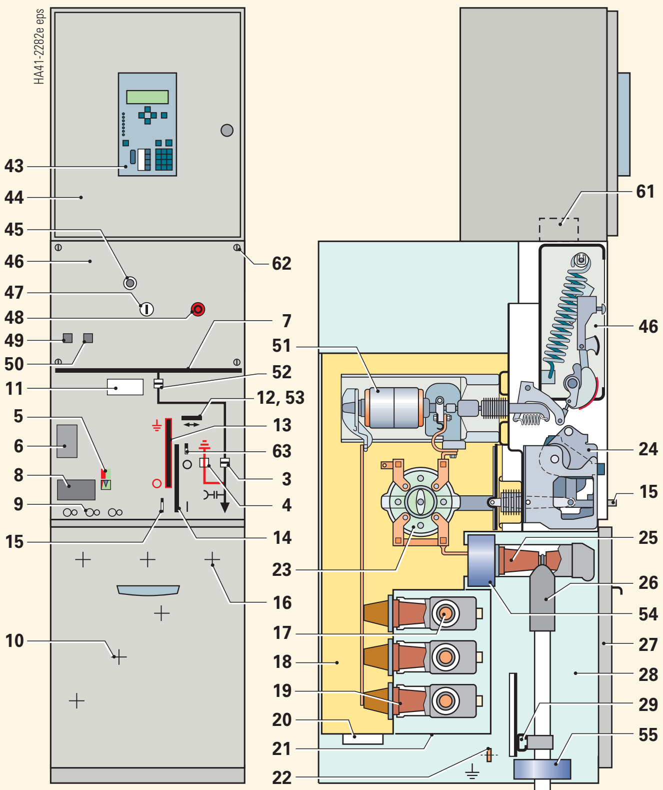
Top view

1 Relief opening
2 Opening (e.g. for ventilation as option)
3 Room height
4 Panel depth of the standard panel (may be 15 mm deeper for free-standing arrangement, depending on the panel design)
5 Control aisle Δ
6 Panel depth of panels with deep cable compartment cover
7 Deep cable compartment cover
8 Standard cable compartment cover
9 Foundation
10 2nd cable for connection with of double T-plugs in conjunction with larger floor opening and design with deep cable compartment cover
11 Height of the cable basement corresponding to the cable bending radius
12 Cable
13 Direction of pressure relief
14 Floor openings: Dimensions see pages 34 to 37
15 Option: Pressure absorber duct
16 Base height of the pressure absorber duct beneath the panel
17 Depth of the pressure absorber duct behind the panel
18 Wall distance
19 End wall
20 Panel width
21 Width of the pressure absorber duct
– 700 mm for panel combinations
– Approx. 850 mm for metering panels type ME1
22 Standard: Low-voltage compartment for circuit-breaker panels
Option:
– Low-voltage compartment for all other panel types or
– Front cover
23 Relief outlet

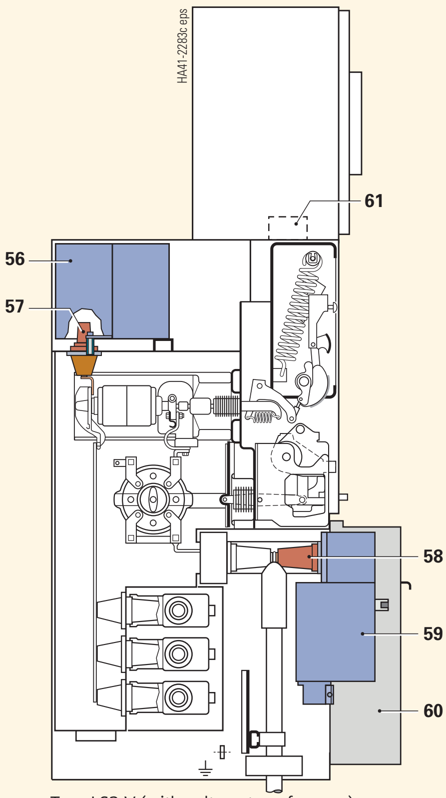
Panel design (examples)

Circuit-breaker panel

Section



Type LS1 (without voltage transformers)



Type LS2-V (with voltage transformers)

21 Partition for busbar
22 Earthing busbar with earthing connection
23 Three-position switch-disconnector
24 Spring-operated mechanism
25 Bushing for cable plug with bolted contact (M16)
26 Option: Cable T-plug
27 Cable compartment cover
28 Cable compartment
29 Cable bracket
30 Earthing connection for earthing accessories
31 HV HRC fuse assembly, cover removed
32 Handle for replacing HV HRC fuse links
33 Interlock for HV HRC fuse assembly
34 Cover of the HV HRC fuse compartment
35 Spring-operated / stored-energy mechanism
36 Bushing for cable plug with plug-in contact
37 Cable elbow plug with plug-in contact
38 Switch-position indicator for load-break function "CLOSED – OPEN" and, if applicable, "HV HRC fuse tripped" or "shunt release tripped"
39 Cover for access to the busbar connection and to the instrument transformers, screwed on
40 4MR voltage transformer
41 4MA7 current transformer
42 Cover to busbar connection compartment, screwed on
43 Option: SIPROTEC bay control unit
44 Low-voltage compartment (standard)

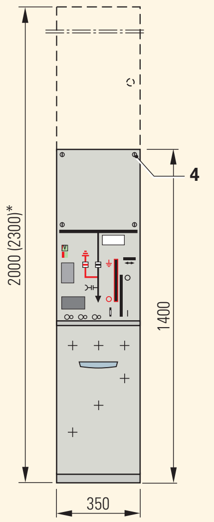
Vacuum circuit-breaker:

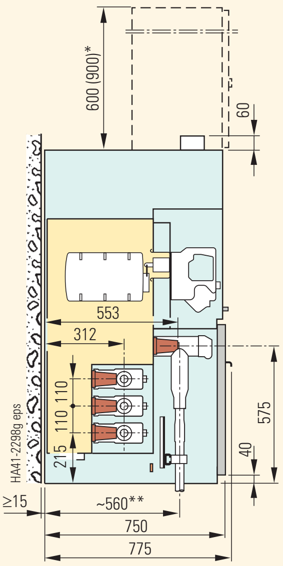
45 Opening for the hand crank
– for closing with manual operating mechanism
– for emergency operation with motor operating mechanism
46 Operating mechanism box
47 Mechanical "ON" pushbutton (not supplied with spring-operated mechanism)
48 Mechanical "OFF" pushbutton
49 Operating cycle counter
50 "Spring charged" indicator
51 Vacuum interrupter
52 Switch-position indicator

53 Option: Interlock between vacuum circuit-breaker and three-position switch-disconnector
54 Option: Three-phase current transformer (protection transformer)
55 Cable-type current transformer
56 4MT3 plug-in voltage transformer at the busbar
57 Bushing for connection of plug-in voltage transformers
58 Plug-in connection according to EN 50 181 / DIN EN 50 181 as interface type "A"
59 Option: 4MT8 plug-in voltage transformer at the connection
60 Deep cable compartment cover
61 Wiring duct, removable, for control cables and/or bus wires
62 Cover screwed on
63 Option: Interlock between three-position switch-disconnector and circuit-breaker

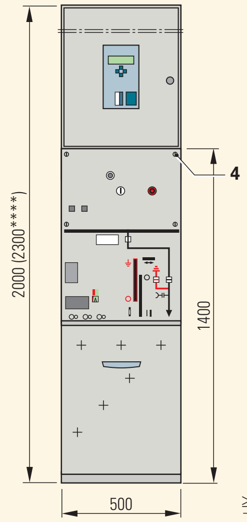
Dimensions

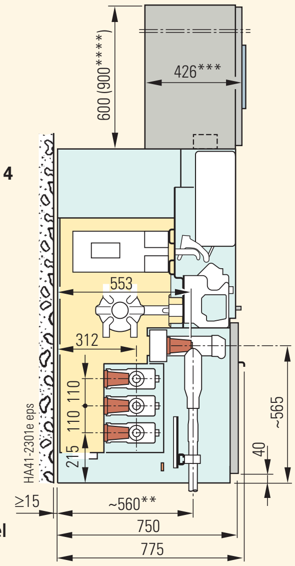
Ring-main, cable, transformer and circuit-breaker panels as individual panels



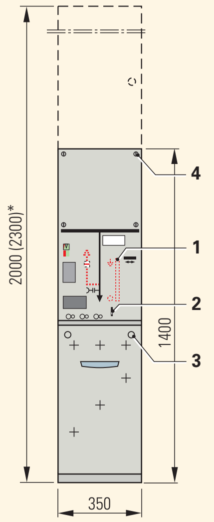


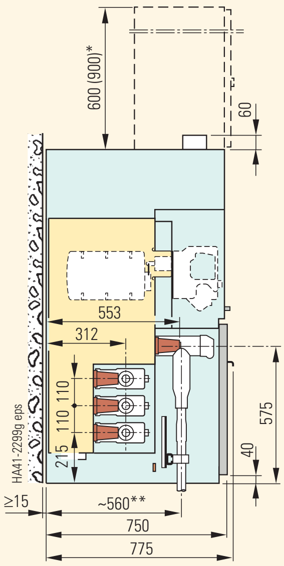
Ring-main panel type RK



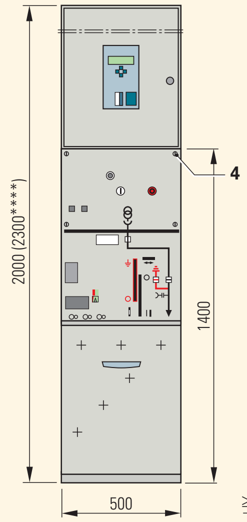


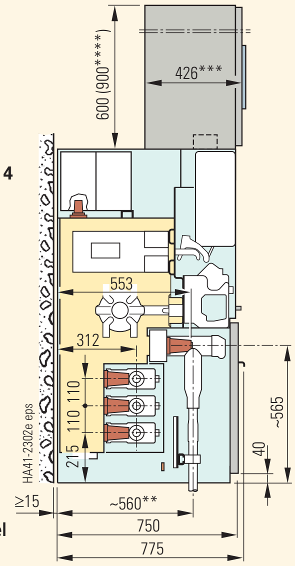
Circuit-breaker panel type LS1



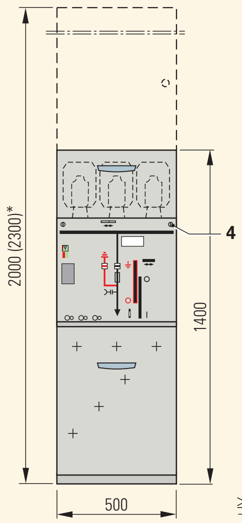


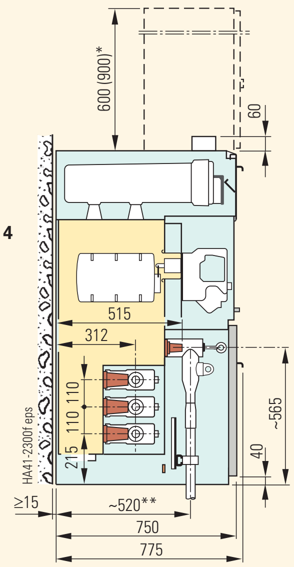
Cable panel type K





Circuit-breaker panel type LS1 V/LS2





Transformer panel type TR 1

Cable panel type K:

1 Option: Earthing function

2 Interlock of cable compartment cover if earthing function is available

3 Cable compartment cover screwed on (without earthing function)

4 Cover screwed on

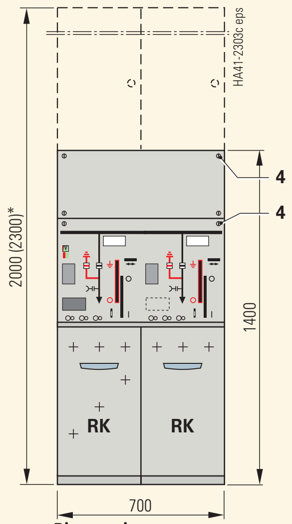
* Option: With low-voltage compartment

** Dependent on the type of cable plug

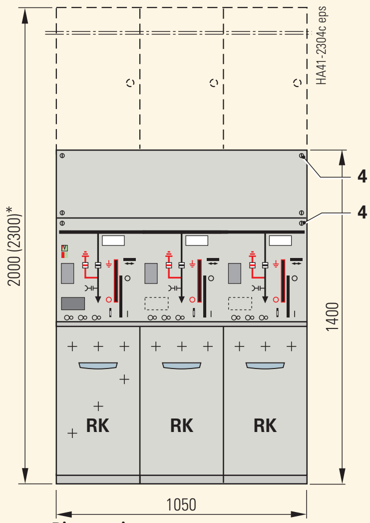
*** Available mounting depth for low-voltage equipment

**** Option: With high low-voltage compartment 900 mm

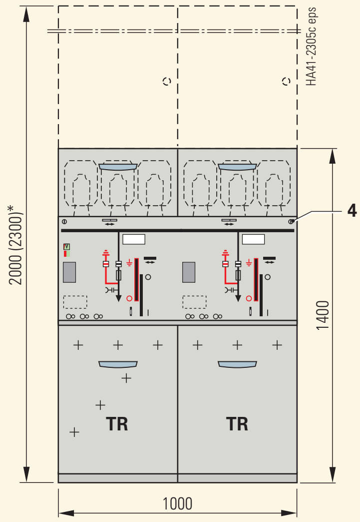
Ring-main, cable and transformer panels in panel blocks



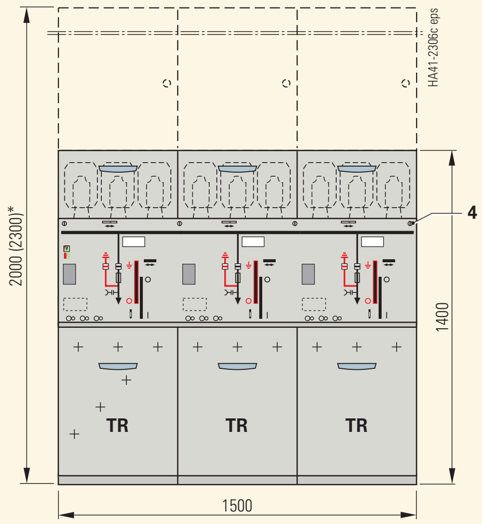
Ring-main
panel block type R-B2



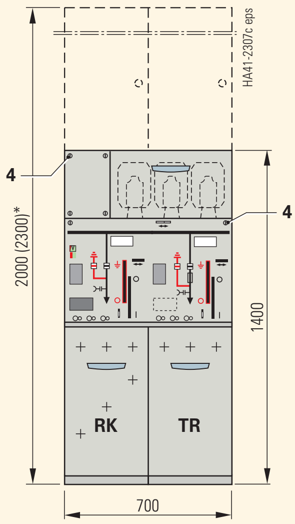
Ring-main
panel block type R-B3



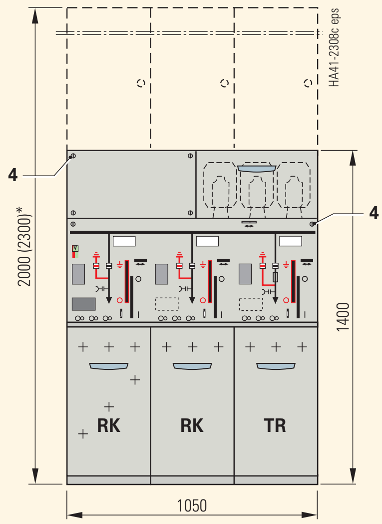
Transformer
panel block type T-B2



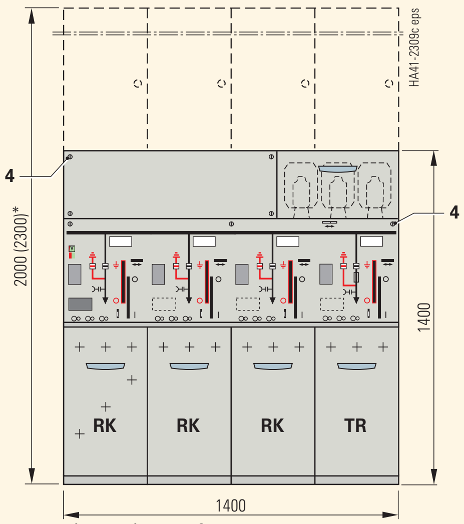
Transformer
panel block type T-B3



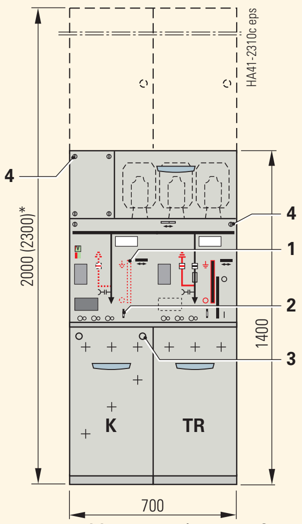
Ring-main/transformer
panel block type RT-B2



Ring-main/transformer
panel block type 2RT-B3



Ring-main/transformer
panel block type 3RT-B4



Cable connection/transformer
panel block type KT-B2

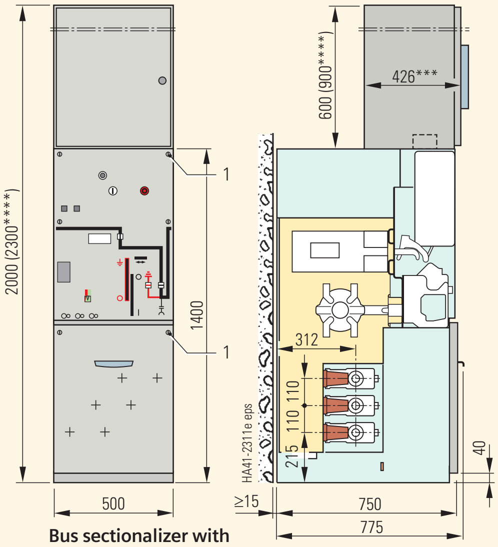
Cable panel type K:

1 Option: Earthing function
2 Interlock of cable compartment cover if earthing function is available
3 Cable compartment cover screwed on (without earthing function)
4 Cover screwed on

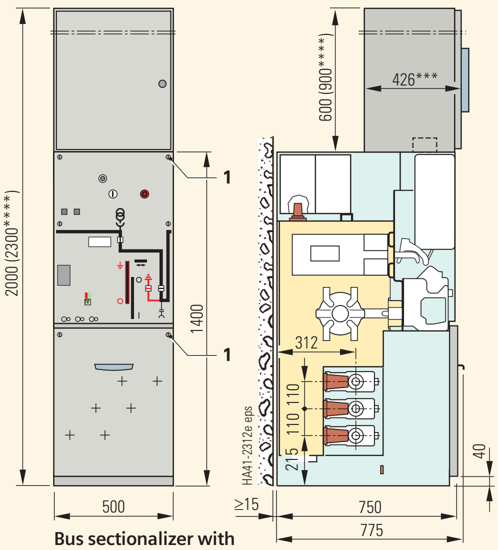
* Option:
With low-voltage compartment

Dimensions

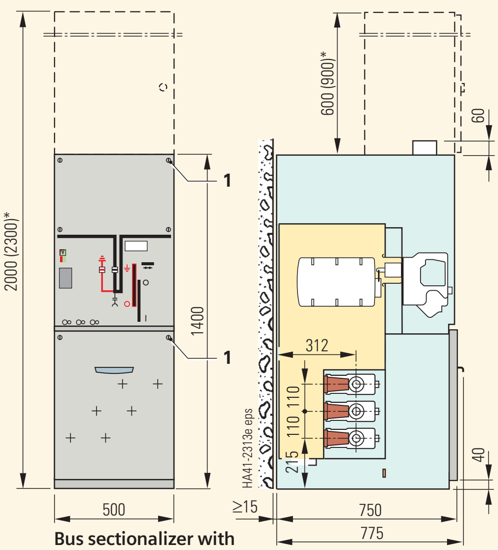
Bus sectionalizers with circuit-breakers, bus sectionalizers with switch-disconnectors and busbar voltage metering panel as individual panels



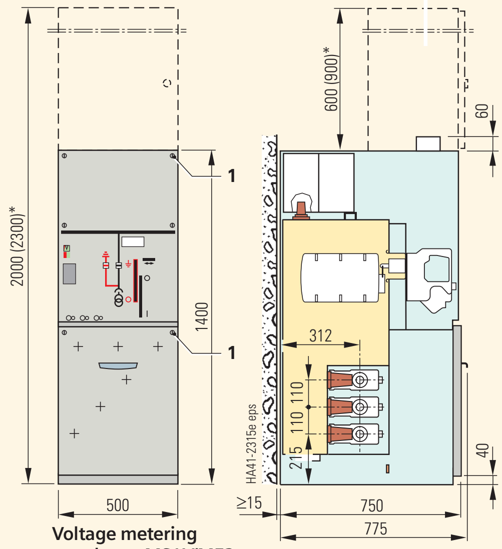
Bus sectionalizer with circuit-breaker type LK/LT1



Bus sectionalizer with circuit-breaker type LKV/LT1



Bus sectionalizer with switch-disconnector type LT2



Voltage metering panel type MS1V/ME3

1 Cover screwed on

* Option: With low-voltage compartment

*** Available mounting depth for low-voltage equipment

**** Option: With high low-voltage compartment 900 mm

1. INTERIOR Cuadro de BT CBTO ECOLAN

Aplicaciones

El cuadro de baja tensión optimizado CBTO ECOLAN, está diseñado para recibir la salida de baja tensión del transformador del centro de transformación y distribuirla en un máximo de ocho salidas protegidas con bases portafusibles (TRIVER).

Definición

El CBTO ECOLAN se ha diseñado para dar respuesta a las debilidades del CBT tipo UNESA primando la seguridad de los operarios, la fiabilidad, la calidad de servicio, la limitación de los daños en caso de fallo y el impacto medioambiental en su ciclo de vida.

El CBTO ECOLAN está compuesto de un seccionador vertical 3P+N con acometida superior y acometida auxiliar o socorro, un panel aislante, bases portafusibles (TRIVER) y el control. En el caso de fijación al suelo, dispone de un bastidor para su instalación.

La acometida está diseñada para un máximo de 4 cables de sección 240 mm² por fase y tres cables de sección 240 mm² para el neutro.

Características Técnicas

Tensión nominal	440 V
Intensidad nominal	1000 A / 1600 A, dependiendo del modelo
Intensidad nominal por salida	Según modelos de bases TRIVER
Nº de salidas	Según modelo
Tipo de salidas	*BTVC 160/250/400/630/800/1260 A
TENSIÓN A FRECUENCIA INDUSTRIAL	Fase-masa 10 kV
	Fase-masa 2,5 kV
RESISTENCIA A CORTOCIRCUITOS	25KV 1 sg. para modelo 1600A 15KV 1 sg. para modelo 1000A
Norma de Fabricación	UNE-EN 50300 / 60439-1 / 60947-1 / 60947-3
GRADO DE PROTECCIÓN	IP 2x
	IK 08

*El nº máximo de salidas varía según se combine la gama del catálogo de bases TRIVER: tamaño NH 00-1-2-3 o bases dobles.