Kursus Rekabentuk Elektrik Sistem Voltan Sederhana (Asas)
14.04.2021 - 15.04.2021

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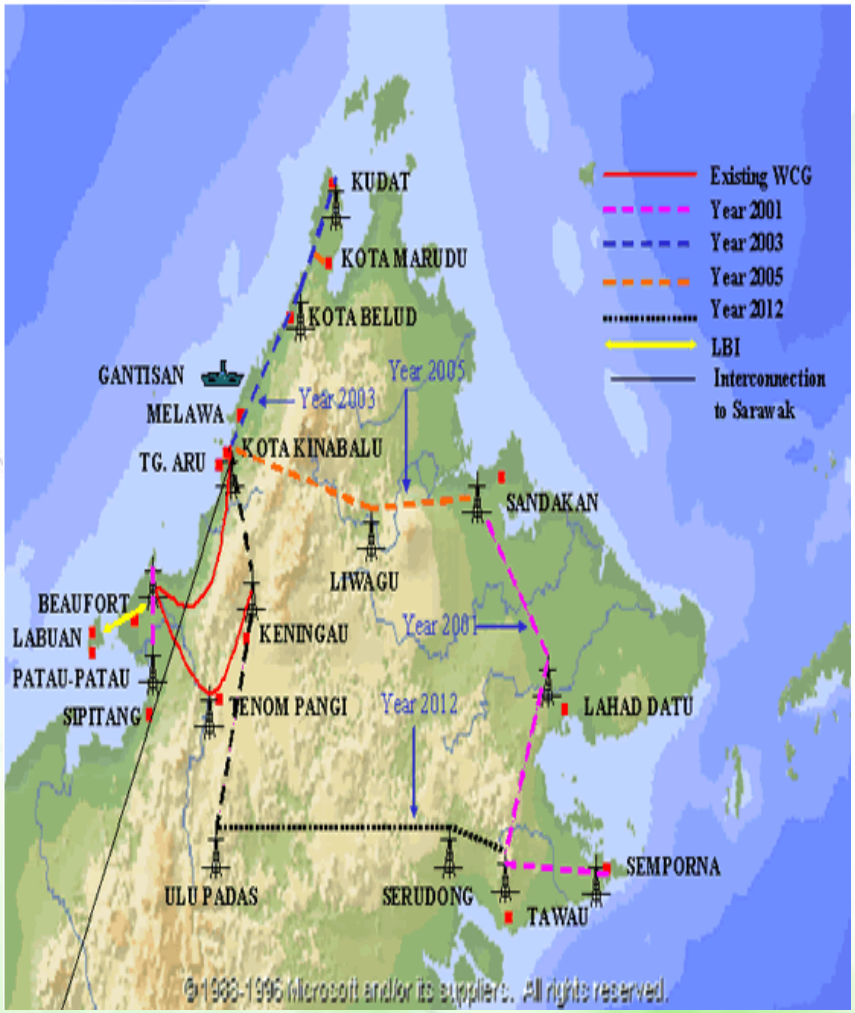
Pengenalan

- Voltages
  - Transmission voltage – 500kV, 275kV & 132kV
  - Distribution voltage – 33kV, 11kV & 400/230V (Certain part of Johor and Perak – 22kV & 6.6kV)
- Supply Frequency
  - 50Hz ± 1%

Pengenalan

- National grid system 132kV
- Stesen janakuasa elektrik
- Sistem penjanaan hidro

Pengenalan


KUDAT
KOTA MARUDU
KOTA BELUD
GANTISAN
MELAWA
TG. ARU
KOTA KINABALU
SANDAKAN
LIWAGU
BEAUFORT
LABUAN
PATAU-PATAU
SIPITANG
KENINGAU
TENOM PANGI
LAHAD DATU
ULU PADAS
SERUDONG
TAWAU
SEMPORNA
Year 2003
Year 2005
Year 2001
Year 2012
Existing WCG
Year 2001
Year 2003
Year 2005
Year 2012
LBI
Interconnection to Sarawak
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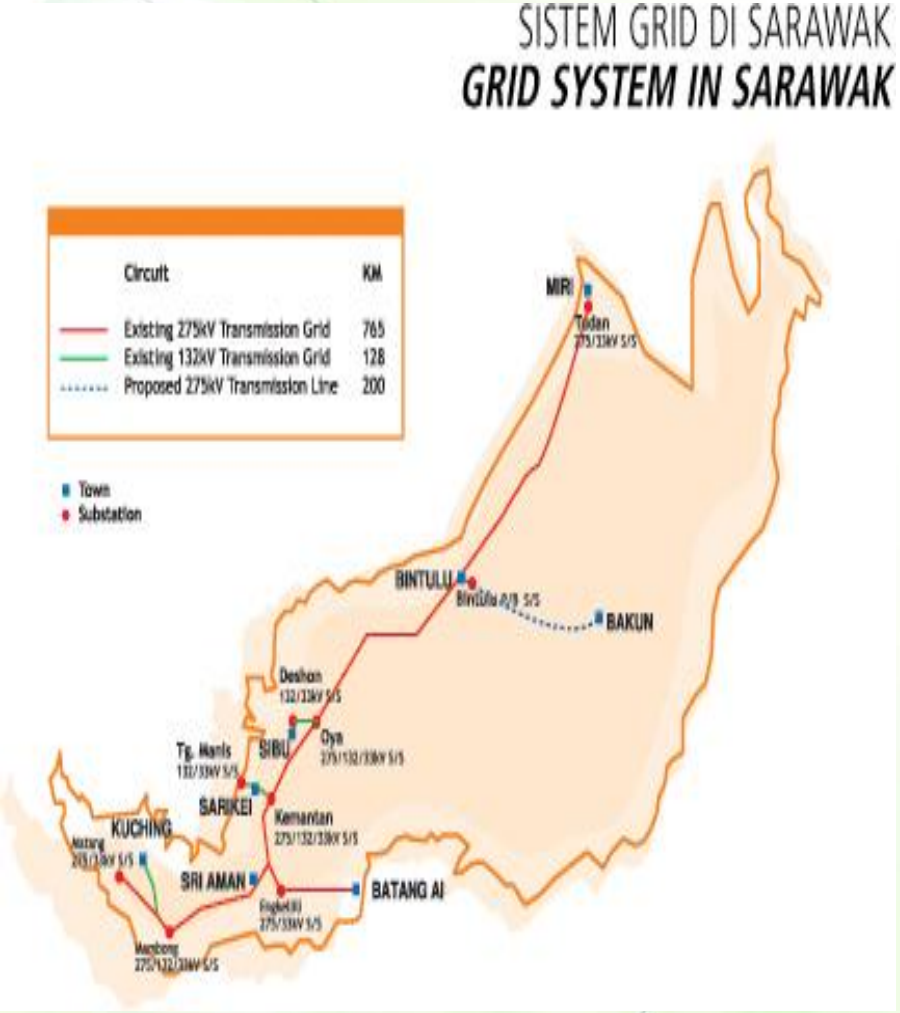
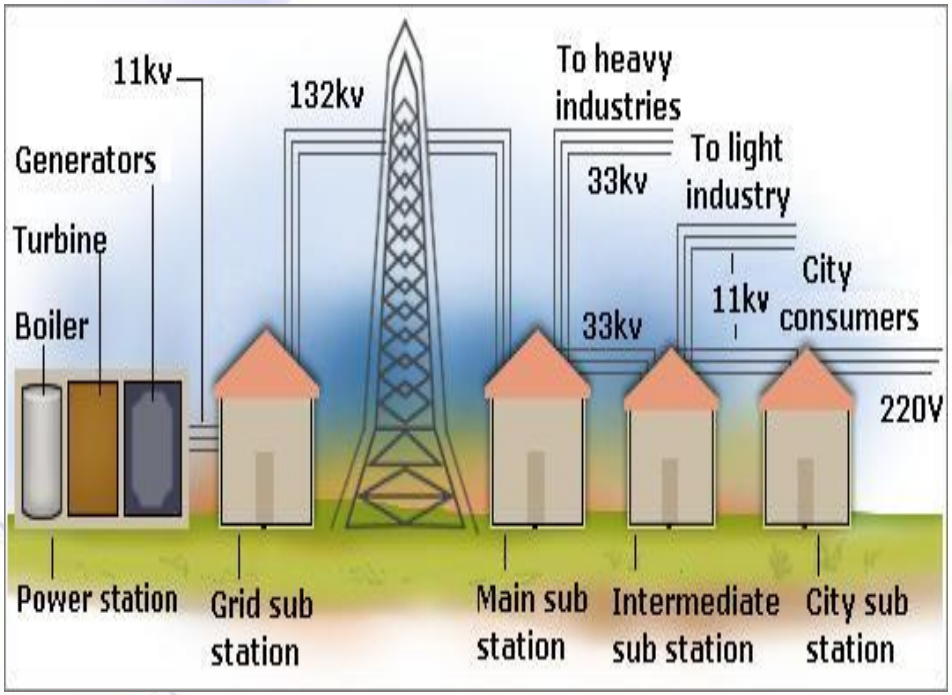

SISTEM GRID DI SARAWAK
GRID SYSTEM IN SARAWAK
Circuit
KM
Existing 275kV Transmission Grid 765
Existing 132kV Transmission Grid 128
Proposed 275kV Transmission Line 200
Town
Substation
MIRI
BINTULU
BAKUN
Desaon
SIBU
Tg. Manis
Oya
SARIKEI
Kemantan
KUCHING
SRI AMAN
BATANG AI

Pengenalan



- Core power utility company
- Konsep :- generation,transmission & distribution
  - Independent Power Producer (IPP)
  - Transmission
  - Distribution

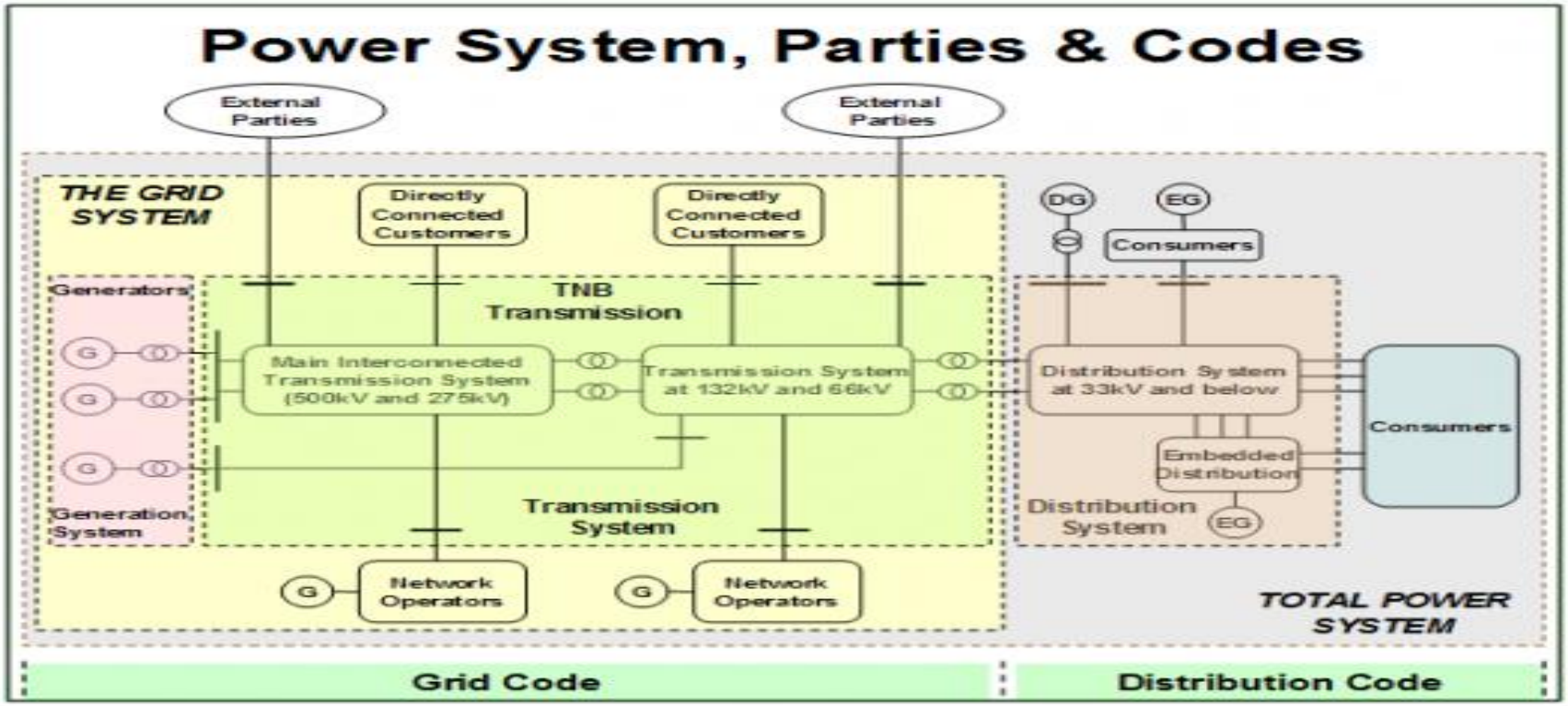
TENAGA NASIONAL

SESB

sarawak energy

Pengenalan

- PMU
- PPU
- PE



Low Voltage

M.D ranges of individual consumer	Supply voltage	Minimum supply scheme
Up to 12kVA	230V	Single phase overhead or underground services from existing LV network
>12kVA to 100kVA	400V	Three phase overhead or underground cable service from existing LV network subject to system capability study by TNB

Low Voltage

M.D ranges of individual consumer	Supply voltage	Minimum supply scheme
>100kVA to 350kVA	400V	Underground cable service from feeder pillar or a new/existing substation, subject to system capability study by TNB
>350 kVA to 1000kVA	400V	Direct underground cable service from new substation

High Voltage

M.D ranges of individual consumer	Supply voltage	Minimum supply scheme
1000kVA up to <5000kVA	11kV	Directly fed through TNB 11kV switching station. An additional PPU land may need to be allocated subject to system capability study by TNB.
5000kVA to 25000kVA	33kV	Directly fed through TNB 33kV switching station An additional PMU land may need to be allocated subject to system capability study by TNB

Contoh pemasangan JKR

M.D Ranges of Individual Consumer	Supply Voltage	Contoh Pemasangan Oleh JKR
>12 kVA to 1000kVA	400V	APMM Kuala Terengganu
1000kVA up to <5000kVA	11kV	KKR2, APMM Kuantan
1000kVA up to 10000kVA	22kV	Jarang digunakan, hanya dipasang di dua negeri sahaja iaitu Johor dan Perak
5000kVA to 25000kVA	33kV	Kem Tentera (TLDM Lumut), Universiti (UPSI, UTeM, UIAM & etc)

Keluasan Tanah (Keperluan TNB)

Substation Category	Type	Land Size (Average Dimensions – NOT inclusive of Land Setback Requirements)
Pencawang Pembahagian Utama (PPU)	Indoor	46m x 46m
Stesen Suis Utama (SSU) - 11kV (for LPC)	Conventional – Stand Alone	13.0m x 14.2m
Stesen Suis Utama (SSU) – 11kV (to support 11kV network connection to respective Pencawang Elektrik)	Conventional – Stand Alone	30m x 30m

Keluasan Tanah (Keperluan TNB)

Substation Category	Type	Land Size (Average Dimensions – NOT inclusive of Land Setback Requirements)
Pencawang Elektrik – 11/0.4 kV	Conventional – Stand Alone a) Single Chamber	13.6m x 14.8m
	b) Double Chamber	16.6m x 14.8m
	c) Compact Substation	9m x 11m

Luas Bangunan PE dengan Bilik Jangka (Keperluan TNB)

	Building Type	Overall (mm)	Switchgear Room (mm)	Tx Room (mm)	Meter Room (mm)	Depth (mm)
1	Stand Alone	7600 x 5700	4600	3000		5700
2	Attached	7600 x 5700	4600	3000		5700
3	Meter Room	3000 x 2000			3000	2000

- Drawing – Stand Alone
- Drawing - Attached

Luas Bangunan SSU (Keperluan TNB)

	Building Type	Overall (mm)	Switchgear Room (mm)	Tx Room (mm)	Depth (mm)
1	SSU	7000 x 5100	7000		5100
2	SSU + Tx	10500 x 5100	7500	3000	5100

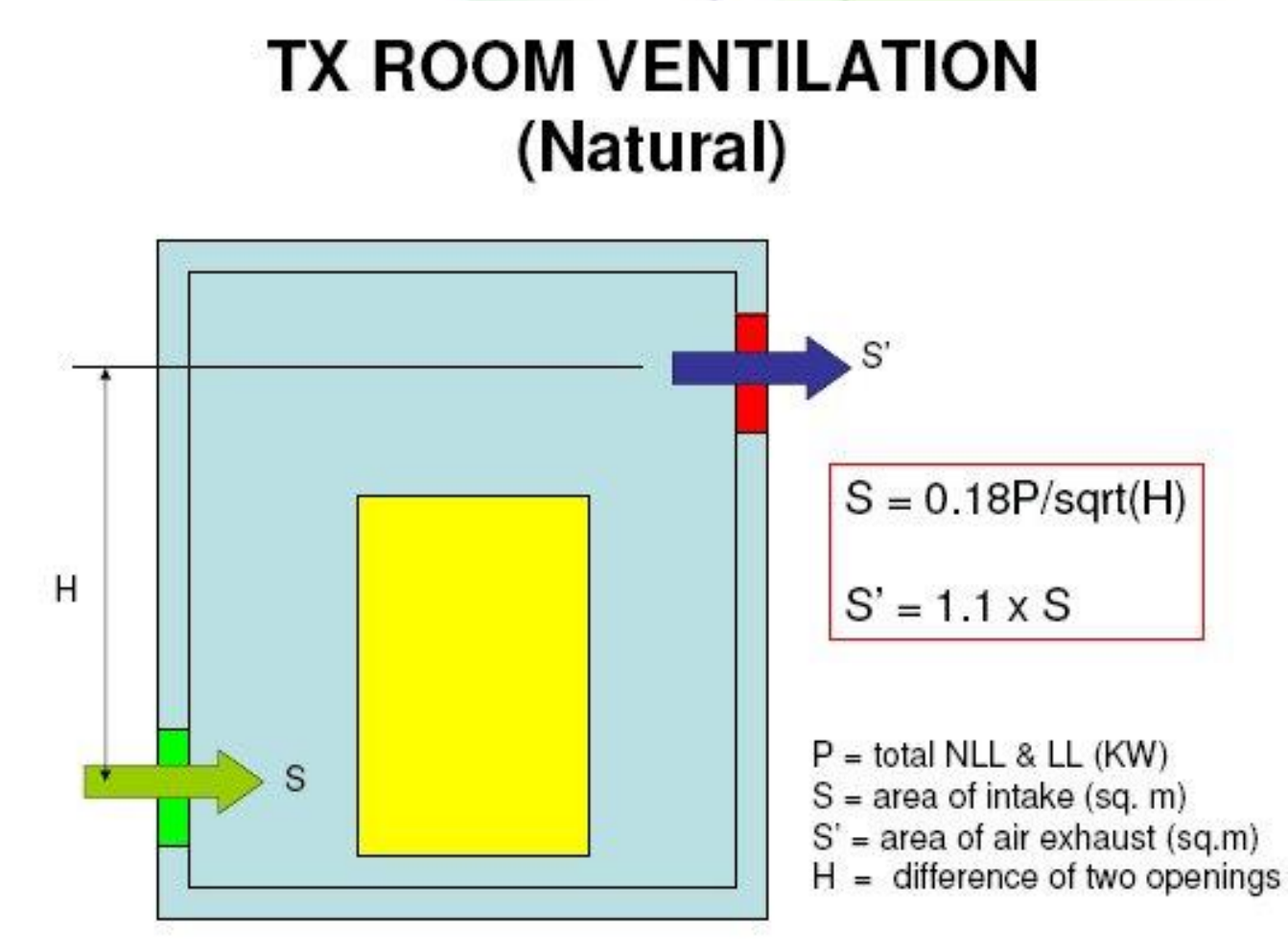
- Drawing – SSU
- Drawing – SSU + Tx

Sizing of Switchgear And Transformer Room

- Room for RMU & 1-Tx
- Room for RMU & 2-Tx
- Room for VCB & 1-Tx
- Room for VCB & 2-Tx
- Room for VCB & 2-Tx (staggered)

Transformer Room Ventilation

- Natural
- Forced

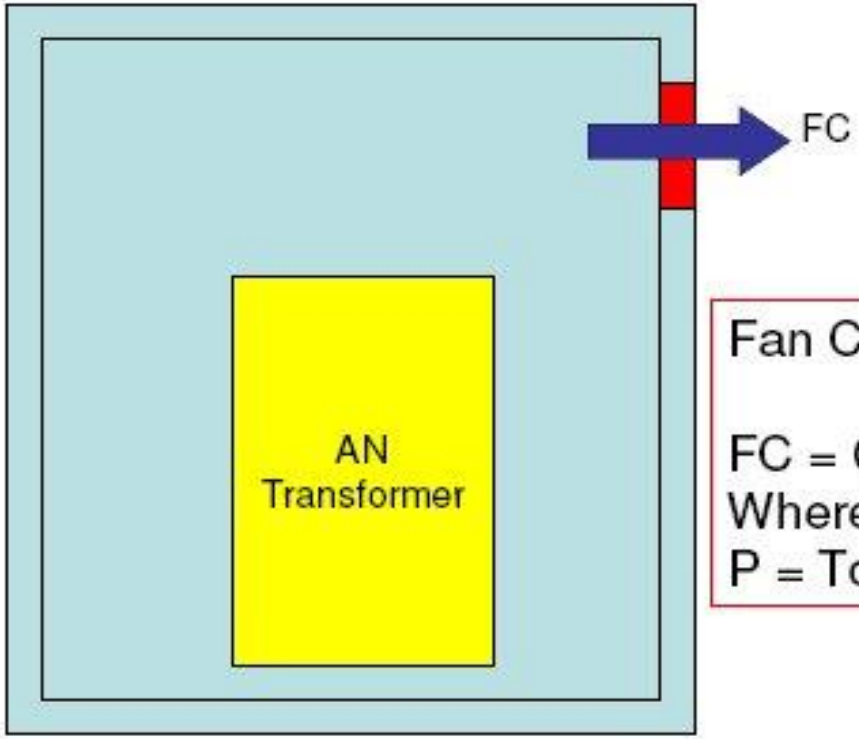


Contoh Pengiraan Bukaan Louvres

- Ada 2 buah Tx, 1250kVA dan 1000 kVA dalam 1 bilik
- Total Losses, P = 8200W + 10080W = 18280W
- $S = 0.18\ P / \sqrt{H}$
- $S' = 1.1 \times S$

Transformer Room Ventilation

TX ROOM VENTILATION (Forced)



Fan Capacity is given by

FC = 0.05 x P (cu m/sec)
Where
P = Total Tx Losses

Contoh Pengiraan Bilangan Kipas Pelawas

- Ada 2 buah Tx, 1250kVA dan 1000 kVA dalam 1 bilik
- Total Losses, P = 8200W + 10080W = 18280W
- S = 0.05 x P = 0.05 X 18280 = 914W
- CFM untuk 300mm dia. Ext fan = 727
- 914/727 = 1.26W
- Oleh itu perlu rb 2 nos of 300mm dia. Ext fan dalam bilik Tx

Perkara yang perlu diketahui apabila intake supply ialah Sistem MV

- Bangunan PPU/SSU (TNB) dan bangunan SSU/PE Pengguna
- Bilik Transformer, bilik Metal-Enclosed Switchgear dan bilik Remote Control Panel (RCP)
- Kos bangunan, pemasangan Sistem MV dan Sistem Pemadam Kebakaran Di PPU/SSU (TNB) dan SSU/PE Pengguna (HODT Mekanikal)
- Cas Sambungan Pengguna oleh TNB

Perkara yang perlu diketahui apabila intake supply ialah Sistem MV

- Tarif yang dikenakan oleh TNB
- Cas Sambungan Beban/Connected Load Charge (CLC) yang dikenakan oleh TNB
- Orang Kompeten Untuk Penyenggaraan Dan Operasi

Cas Sambungan Pengguna (CSP)

- RM45.00/kW Maximum Demand (MD)
- Contoh : MD = 2000kW, jadi CSP ialah 2000 x RM45.00 = RM 90,000.00
- Jika kabel TNB > 6km maka TNB akan memasukkan kos kabel ke atas Pengguna

Saiz mm^2 (aluminium)	Harga semeter
70	RM55
120	RM72
185	RM95
240	RM130
300	RM150

Cas Sambungan Pengguna (CSP)

- Kos tanam paip menggunakan kaedah Horizontal Directional Drilling (HDD) untuk kabel yang merentasi jalan
- Wang Cagaran yang dikehendaki oleh PBT/JKR untuk penanaman kabel pada ROW jalan

Tariff

- Tariff C1 – Medium Voltage General Commercial Tariff

Tariff Category	Unit	Rates
For each kilowatt of maximum demand per month	RM/kW	RM30.30/kW
For all kWh	Sen/kWh	36.5 sen/kWh
The minimum monthly charge is RM600.00		

- Note :
  a. Low Voltage : 400/230V
  b. Medium Voltage : 6.6kV up to 33kV
  c. High Voltage : 66kV and above

Connected Load Charge (CLC)

- Connected Load Charge is the penalty charge made to TNB when there is a significant load burden reduction from the original burden declared by a customer.
- The charge was introduced to avoid cases of underutilized load burden where customers initially requested for high maximum demand.
- Category 2: Supply voltage between 6.6 kV to 132 kV
- The CLC of the first year is waived
- Assumed declared MD to TNB is 1,000kW (A)
- The CLC is RM 8.50kW (F)
- The CLC is applicable for the first 6 years only

Connected Load Charge (CLC)

- Example :-

Year	Declared MD		Minimum 75% of MD/month to achieve, C= 75% x B	Estimated Actual Running MD (kW),D	Shortfall MD (kW), E=C-D	CLC/month (RM), G =E x F (F= RM 8.50/kW)	CLC/year (RM), G x 12 month
	%	kW, B=% x A					
1st	-	-	-	-	-	-	-
2nd	50	500	375	200	175	1,487.50	17,850.00
3rd	75	750	562.5	300	262.5	2,231.25	26,775.00
4th	100	1000	750	350	400	3,400.00	40,800.00
5th	100	1000	750	400	350	2,975.00	35,700.00
6th	100	1000	750	500	250	2,125.00	25,500.00
					Jumlah	12,218.75	146,625.00

Akta Bekalan Elektrik 1990

- Seksyen 21 – Pendaftaran Pepasangan
- Subseksyen 21(1) – Semua pepasangan hendaklah berdaftar dengan Suruhanjaya Tenaga
- Subseksyen 21 (2) – Tiada seorang pun boleh memiliki atau mengendalikan sesuatu pepasangan melainkan jika pepasangan itu didaftarkan pada suatu Perakuan Pendaftaran yang sah

Akta Bekalan Elektrik 1990

- Seksyen 23 – Orang-orang yang menjaga
- Subseksyen 23(1) – Semua pepasangan yang dikendalikan pada voltan lebih tinggi hendaklah dijaga dan dikawal pengendalian oleh Orang Kompeten

Orang Kompeten

No	Category	Classification
1	BO-2	High Voltage System (Without High Voltage Aerial Line and High Voltage Power Station; and Without Low Voltage Aerial Line and Low Voltage Synchronizing of Generators)
2	BO-1	High Voltage System (Without High Voltage Aerial Line and High Voltage Power Station; and Without Low Voltage Synchronizing of Generators)
3	BO	High Voltage System (Without High Voltage Aerial Line and High Voltage Power Station)
4	B1	High Voltage System (Without High Voltage Power Station)
5	B4	High Voltage System

Peraturan-Peraturan Elektrik 1994

- Peraturan 60 – Orang Kompeten
- Subperaturan 60(1)(b) – Orang kompeten untuk mengerjakan, mengendalikan atau mempunyai kawalan pepasangan pada voltan >600V dan <132kV :-
  - seorang Jurutera Perkhidmatan Elektrik
  - seorang Jurutera Elektrik Kompeten atau
  - seorang Jurutera Elektrik Kompeten Residen

Peraturan-Peraturan Elektrik 1994

- Peraturan 67 – Orang kompeten dan kekerapan lawatan dan pemeriksaan
- Subperaturan 67(1) – Orang kompeten yang dikehendaki untuk melawat dan memeriksa pepasangan adalah seperti berikut :-

  b) jika pepasangan itu dikendalikan pada voltan yang melebihi voltan rendah –

     i) Jurutera Perkhidmatan Elektrik atau

     ii) Jurutera Elektrik Kompeten

Peraturan-Peraturan Elektrik 1994

- Subperaturan 67(2) – Bilangan lawatan bagi maksud pemeriksaan oleh orang kompeten hendaklah seperti berikut :-
  b) Bagi pepasangan >600V tetapi ≤ 11kV, bilangan minimum lawatan bagi maksud pemeriksaan sebulan adalah 2 lawatan

Kelulusan MITI

- SPP bil. 7/2002 – Penggunaan Bahan/Barangan/Perkhidmatan Tempatan Dalam Perolehan Kerajaan
- AP 169.2 (a) – Bahan/Barangan/Perkhidmatan tempatan hendaklah digunakan sepenuhnya dalam perolehan masing-masing. Perolehan melalui import hanya akan dipertimbangkan setelah dipastikan ianya tidak boleh diperolehi secara tempatan

Spesifikasi JKR

No	Specification	Description	Version
1	L-S10	Specification For 11kV Distribution Transformers	May 1990
2	L-S11	Specification For 11kV High Voltage Oil Circuit Breaker	Dec 2018
3	L-S12	Specification For 11kV High Voltage Ring Main Unit Distribution Switchgear	July 1979
4	L-S13	Specification For 11kV High Voltage Underground Cable	May 1986

Spesifikasi JKR

No	Specification	Description	Version
5	L-S14	Specification For 11kV SF6 Ring Main Unit	Aug 2012
6	L-S15	Specification For 11kV Metal- Enclosed Switchgear	July 2011
7	L-S17	Specification For 11kV Dry-Type Distribution Transformers	Feb 2020

Voltages

- TNB
  - 230/400 V ⇨ Low Voltage
  - ≥ 6.6 kV to 33 kV ⇨ Medium Voltage
  - ≥ 66 kV ⇨ High Voltage
- Pemasangan oleh pihak JKR
  - 230V / 400V ⇨ Low Voltage (LV)
  - 11kV / 33kV ⇨ Medium Voltage (MV)

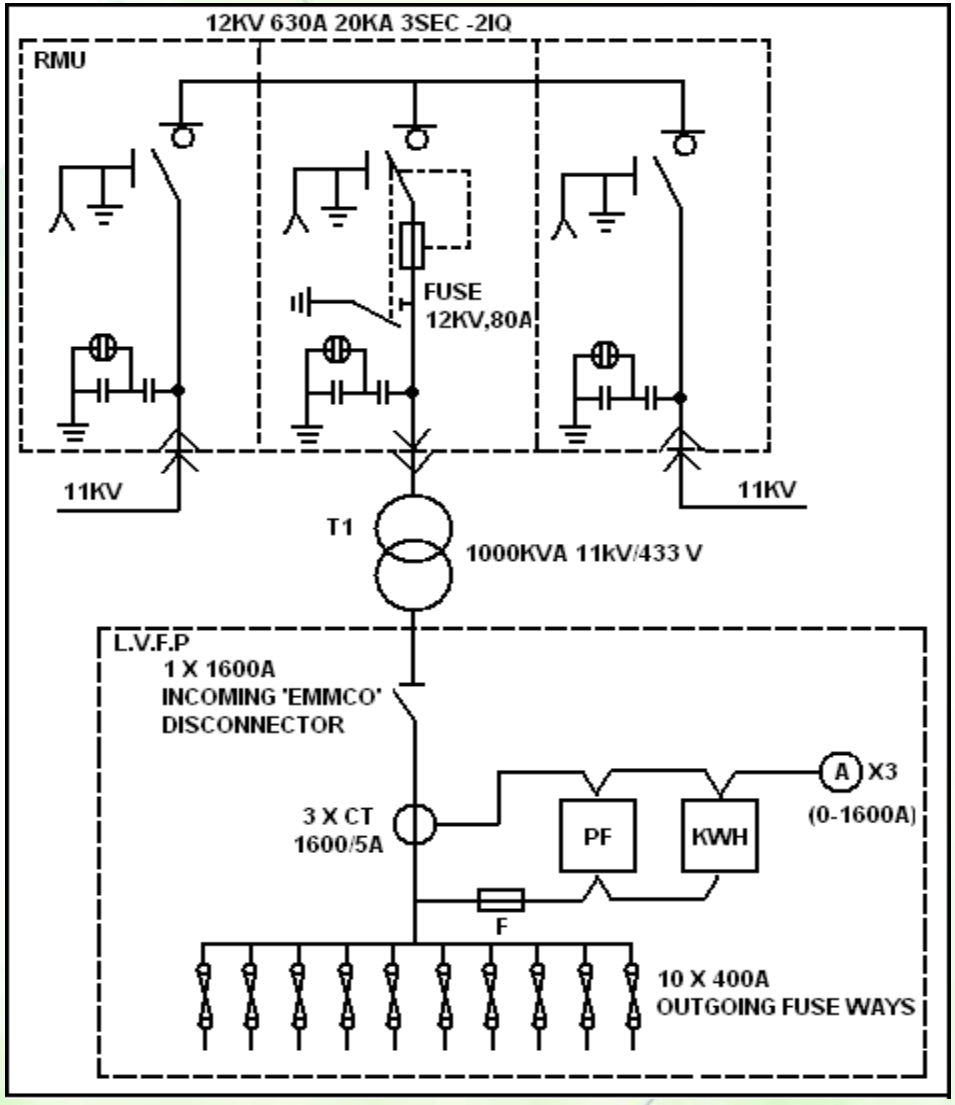
Komponen Sistem Voltan Tinggi

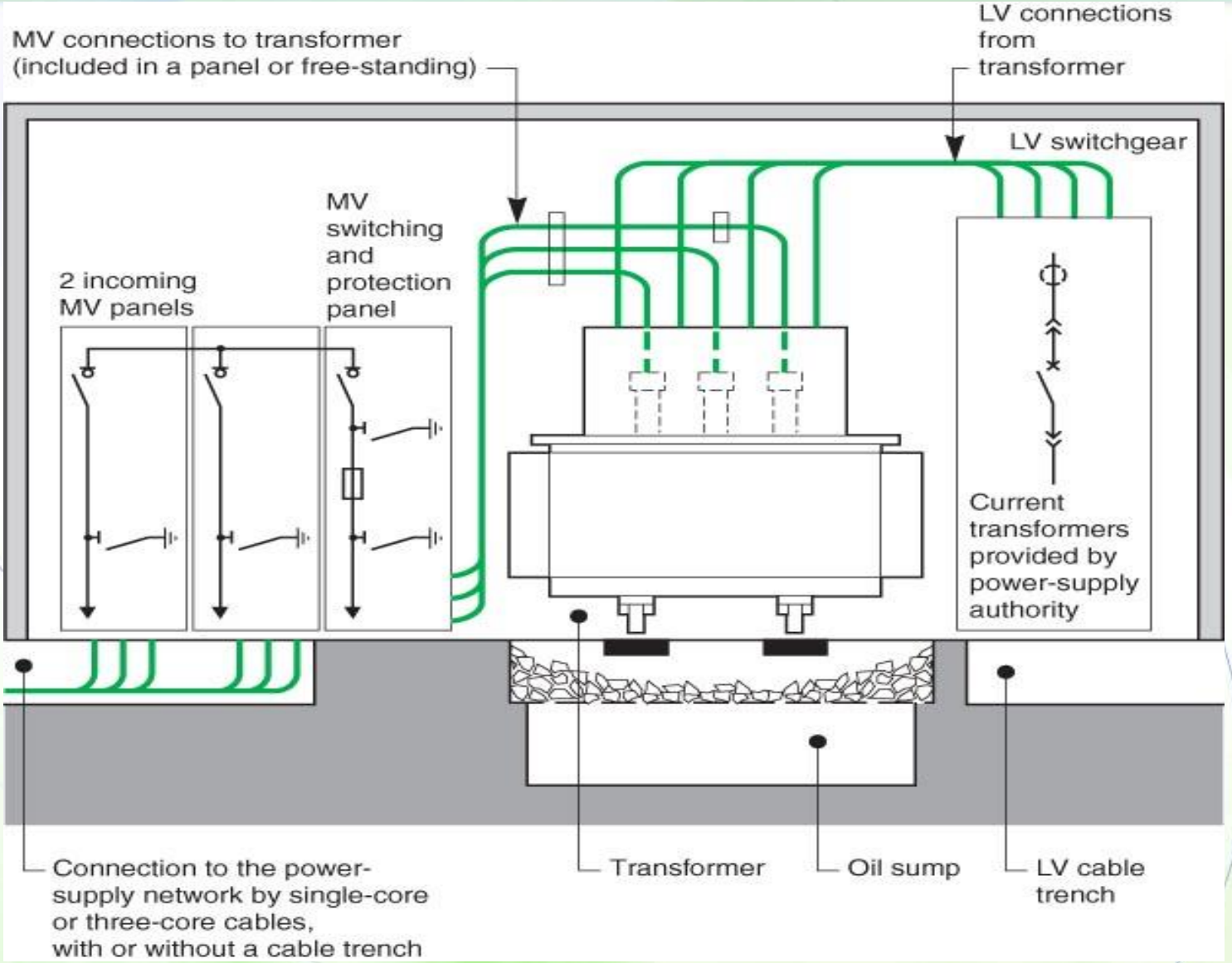
- Ring Main Unit (RMU) – SF6
- 11kV Metal-Enclosed Switchgear
  - VCB
  - SF6 (Sulfur Hexafluoride)
  - OCB (oil) - obsolete
- Transformer
  - Oil Immersed Type
  - Dry Type or Cast Resin Type
- MV Underground Cable

Komponen Sistem Voltan Sederhana

- Gambar RMU
- Compact SS TNB dan isi
- Gambar skematik RMU


R/R 06.09.05
TEAM 'A'
SEM PM
17-05-07
PWT TITI TERAS
TRANSFORMER
PWT TITI TERAS
TRANSFORMER
PWT TAMAN
MANGGIS
INDAH


12KV 630A 20KA 3SEC -2IQ
RMU
FUSE
12KV,80A
11KV
11KV
T1
1000KVA 11kV/433 V
L.V.F.P
1 X 1600A
INCOMING 'EMMCO'
DISCONNECTOR
A
X3
(0-1600A)
3 X CT
1600/5A
PF
KWH
F
10 X 400A
OUTGOING FUSE WAYS


MV connections to transformer
(included in a panel or free-standing)
LV connections
from
transformer
LV switchgear
MV
switching
and
protection
panel
2 incoming
MV panels
Current
transformers
provided by
power-supply
authority
Connection to the power-
supply network by single-core
or three-core cables,
with or without a cable trench
Transformer
Oil sump
LV cable
trench

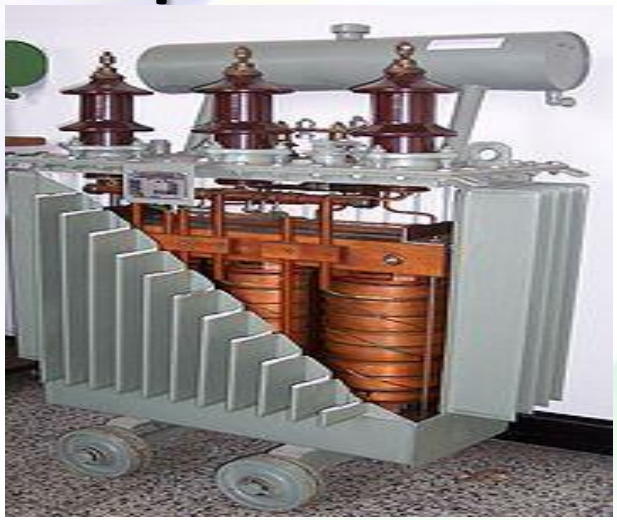
Komponen Sistem Voltan Sederhana

- Metal-Enclosed Switchgear
  - Truck mounted / Cassette type
  - VCB & SF6

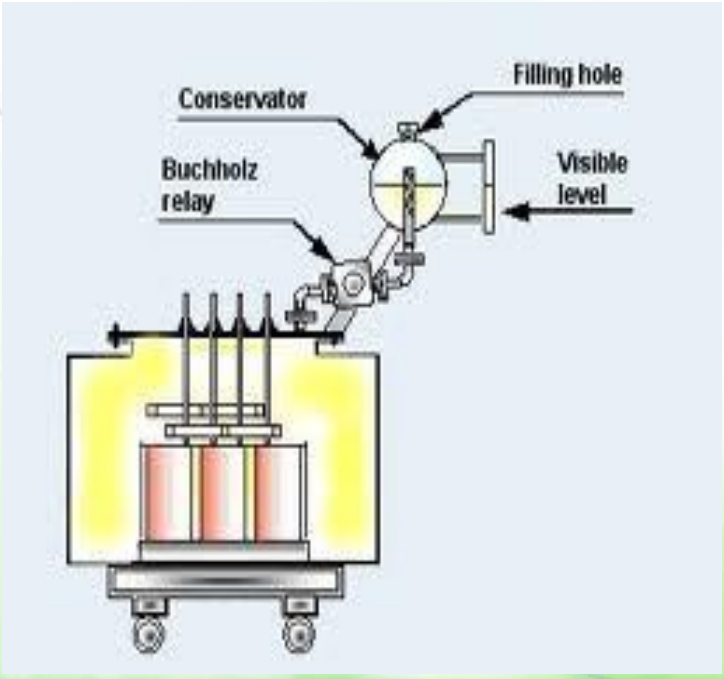
Komponen Sistem Voltan Sederhana

- Cast Resin Transformer
- Construction- LV winding :-vacuum cast, impregnated
- Protection – temp sensor PT100, AF

Komponen Sistem Voltan Sederhana



- Oil type
- Protection – temp and pressure sensor, buchholz relay



Komponen Sistem Voltan Sederhana

- Gambar MV cable
- 3 core
- CU/XLPE/CTS/PE/SWA/PE SHEATED - XLPE-Insulated, Copper Tape Screen, Steel Wire Armoured , PE-Sheathed Annealed Copper Conductor Cable (CCB)

Komponen Sistem Voltan Sederhana

- CU/SC/XLPE/CTS/PE/SWA/PE-XLPE Insulated, Copper Tape Screen, MDPE Sheathed, Steel Wire Armoured, Stranded Compacted Plain Annealed Copper Conductor Cable (Southern)
- CU/XLPE/CTS/PVC/SWA/PVC - XLPE Insulated, Copper Tape Screen, PVC Sheathed, Steel Wire Armoured, Stranded Copper Conductor Cable (Hi-Essence Cable)

Distribution Transformer

Distribution Transformer

- A static piece of apparatus with 2 or more windings
- Transforms a system of alternating V & I into another system of V & I at the same frequency at same kVA
- Purpose – transmitting electrical power
- 2 types :
  - Oil-Immersed Type
    - The magnetic circuit and windings are immersed in an insulating liquid
  - Dry-Type
    - The magnetic circuit and windings are not immersed in an insulating liquid

Parts of Transformer

- Magnetic Core
- Windings
- Insulation
- Tank
- Cooling System
- Bushings
- Tap-changers

Types of Transformer Losses

- No Load Losses

- Consists of the following components:-
  - Hysteresis losses in core lamination
  - Eddy current losses
  - I^2R losses due to no load losses
  - Stray losses
  - Dielectric losses

- Load Losses

- Consists of the following components:-
  - Losses in windings due to load current flow
  - Conductor eddy current losses
  - Losses at auxiliaries

Guidelines on Selection of Transformers

- The type of transformer
- Voltage transformation ratio
- The winding connection and vector group
- The impulse withstand voltage
- The impedance voltage
- Flux density
- The transformer losses and transformer efficiency
- The tapping range
- Limits of temperature rise
- Class of winding insulation
- Noise
- Design and construction

Guideline on Efficient Utilization of Transformer

- Sizing of capacity
- Balanced loading of transformers operating in parallel
- Load factor
- Transformer impedance
- Design and construction
- Effects of power quality and harmonics
- Choices of transformer core materials
- Techno-Economic Life Cycle Costs

Oil-Immersed Type Transformer

- Specification For 11kV Distribution Transformers L-S10 (May 1990)
- Maximum Phase Fault Level :-
  - 11kV – ~~350MVA~~ (20 kA for 3s)
- Voltage Ratios :-
  - 11000/433-250V
  - 33000/11000
  - 6600/433-250

Oil-Immersed Type Transformer

- Winding Connections :-
  - Higher voltage – Delta
  - Lower voltage : Star
- Vector Group – Dyn 11
- Impedance Voltage for transformer size ≤ 1000kVA is 4.75% at 75°C

Sizes of Transformers

- 100 kVA
- 300 kVA
- 500 kVA
- 750 kVA
- 1000 kVA

Oil-Immersed Type Transformer

- Losses

Rated Power (kVA)	No-Load Loss (W)	On-Load Loss (W)	Total Losses (W)
100	300	1500	1800
300	600	2800	3400
500	1000	4100	5100
750	1200	6000	7200
1000	1400	7000	8400

- On-Load Loss at 75°C
- Rujukan : EE Guidelines For CKE Design

Oil-Immersed Type Transformer

- Tapping Range :-
  - +5.0%, +2.5%,0%, -2.5% and -5.0%
- Method – tap changing shall be carried out with the transformers off circuit
- Class of Winding Insulation :-
  - Class A (105°C)
- Temperature Rise
  - for JKR 55 °C & 65°C for TNB

Type Tests

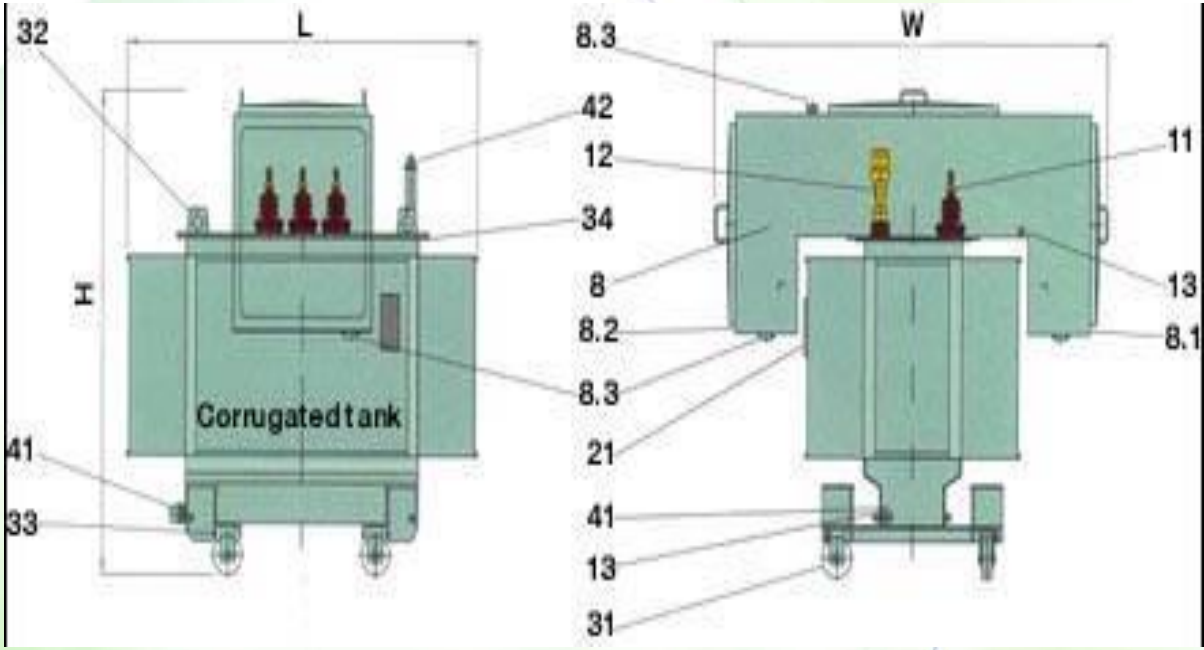
- Full wave impulse voltage withstand test
- Temperature rise test
- Short circuit test
- Measurement of zero sequence impedance
- Transformer tank vacuum test
- Transformer tank pressure test

Routine Tests

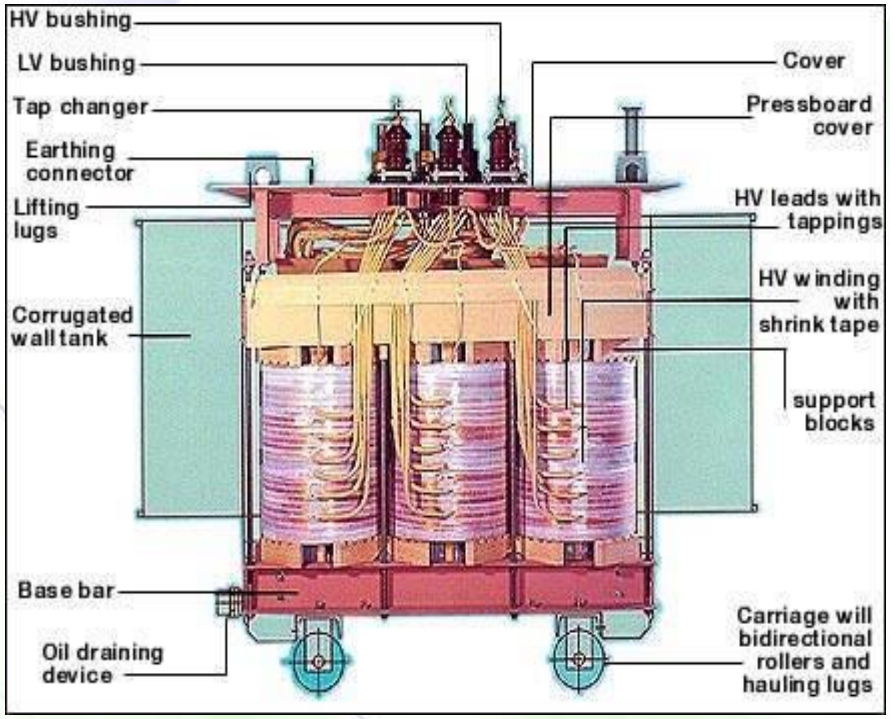
- Measurement of winding resistance
- Measurement of voltage ratio and check of voltage vector relationship
- Measurement of impedance voltage and short circuit impedance
- Measurement of load loss
- Measurement of no load loss
- Separate source power frequency voltage withstand test
- Transformer noise level measurement

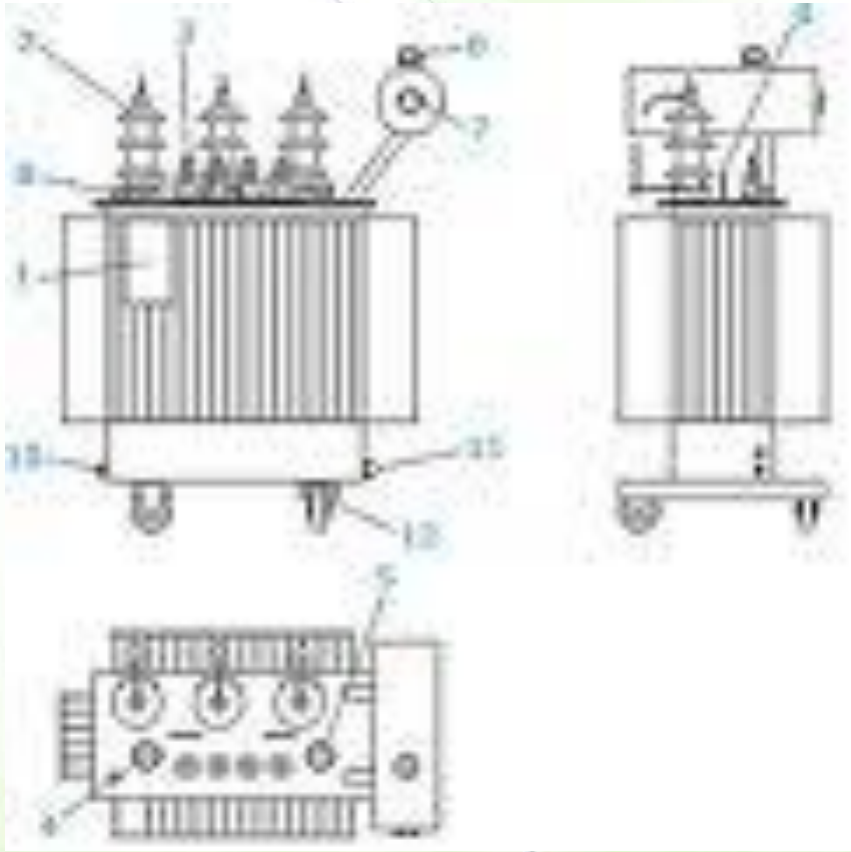
Photographs

Photographs



Photographs





Dry-Type Transformers

- Shall comply to the following standards:-
  1. MS 60076-1 – Power Transformer – Part 1 : General
  2. IEC 60076-2 - Power Transformer – Part 2 : Temperature Rise
  3. IEC 60076-3 – Power Transformer –Part 3 : Insulation Levels, dielectric tests and external clearances in air
  4. IEC 60076-5 – Power Transformer – Part 5 : Ability to withstand short circuit

Dry-Type Transformers

5. IEC 60076-10 – Power Transformer – Part 10 : Determination of sound levels
6. MS 60076-11 - Power Transformer – Part 11 : Dry-type transformers
7. IEC 60076-11 - Power Transformer – Part 11 : Dry-type transformers
8. MS IEC 60085 – Electrical Insulation – Thermal evaluation and designation
9. MS IEC 60529 – Degree of protection provided by enclosures (IP Code) (First Revision)

Dry-Type Transformers

10. MS IEC 60270 – High-voltage test techniques – Partial discharge measurements
11. MS ISO 9001– Quality Management Systems – Requirements (First Revision)
12. BS EN 13601 – Copper and copper alloys. Copper rod, bar and wire for general electrical purposes
13. IEC 60364-5-54 – Low-voltage electrical Installation – Part 5-54 – Selection and erection of electrical equipment - Earthing arrangements and protective conductors

Dry-Type Transformers

14. IEC 60364-4-44 – Low-voltage electrical Installation – Part 4-44 – Protection for safety – Protection against voltage disturbances and electromagnetic disturbances
15. BS 7430 – Code of practice for earthing
16. IEC 62561-5 – Lightning protection system components (LPSC) – Part 5 : Requirements of earth electrode inspection housings and earth electrode seals
17. ISO/IEC 17050-1 – Conformity assessment – Supplier's declaration of conformity – Part 1: General requirements

Service conditions

- The transformers shall be :-
  - Environmental Class E2 – Frequent condensation or heavy pollution or combination of both
  - Climatic Class C1 – The transformer is suitable for operation at ambient temperature not below -5°C but may be exposed during transport and storage to ambient temperature down to -25°C
  - Fire Behaviour Class F1 – No special fire hazard is envisaged. Except the characteristics inherent to the design of the transformer, no special measurement are taken to limit flammability.

Service conditions

- The altitude ≤ 1000m above sea level
- When the transformers are required to operate outside the normal service conditions, de-rating in accordance with MS 60076-11 or IEC 60076-11 shall be applied

Voltage Ratios

- 11000/433 V
- Load at the 400/230 V
- 3 phase
- 4 wire system
- Neutral solidly earthed

Winding Connections and Vector Group

- High-voltage (HV) winding – Delta-connected
- Low-voltage (LV) winding – Star-connected with neutral brought out
- Vector Group – Dyn 11

Sizes of Transformers

- 300 kVA
- 500 kVA
- 750 kVA
- 1000 kVA
- 1250 kVA
- 1600 kVA
- 2000 kVA

Dry-Type Transformer - Losses

Rated Power kVA	No-Load Loss W	Load Loss (at 120˚C) W	Total Losses W
300	400	2800	3200
500	800	4100	4900
750	1000	6000	7000
1000	1200	7000	8200
1250	1880	8200	10080
1600	2300	10300	12600
2000	2900	13000	15900

- Rujukan : Spesifikasi L-S17 (Feb 2020)

Tappings

- +5%, +2.5%, 0%, -2.5%, -5%
- The tapping selection shall be made off-circuit

Tap	HV	LV
1	11550	433
2	11275	433
3	11000	433
4	10705	433
5	10450	433


2
5
01.12.2008

Contoh pengiraan tappings

- Bekalan dari TNB 11450 V
- Julat 11 kV (± 5%)
- By default, tap 3 = (11450 x 433)/11000 = 450.7 V (too high)
- Calculate Tap 2 = (11450 x 433)/11275 = 439.7 V
- Change to Tap 1 = (11450 x 433)/11550 = 429 V

Short Circuit Impedance

Rated Power kVA	Short Circuit Impedance %
300	4
500	
750	
1000	6
1250	
1600	
2000	

Fault Condition

- Full short circuit current = 20kA
- Three (3) seconds
- TNB :-
  - 11kV - 20kA, 3s
  - 33kV – 25kA, 3s

Temperature Rise

- Temperature rise shall not exceed 100°C when transformer is loaded at its rated current and under steady load conditions when tested in accordance with MS 60076-11 or IEC 60076-11
- Ambient temperature = 40°C

Winding Insulation

- Winding Insulation Temperature is 155°C (Class F) as per standard MS IEC 60085

Rating Plate

- 2 nos rating plates shall be fixed. 1 no at Tx and another 1 no on the enclosure
- The rating plate shall indicate the following :-
  a) number and year standard;
  b) manufacturer's name;
  c) manufacturer's serial number;
  d) year of manufacture;
  e) insulation system temperature for each winding. The 1st letter shall refer to the HV winding, the 2nd letter shall refer to the LV winding;
  f) number of phases;
  g) rated power of each kind of cooling;

Rating Plate

h) rated frequency;
i) rated voltages, including tapping voltages;
j) rated currents for each kind of cooling;
k) connection symbol ;
l) short-circuit impedance at rated current and at 120°C (subjected to test result);
m) type of cooling;
n) total mass;
o) insulation levels;
p) degree of protection;
q) environmental class;
r) climatic class;
s) fire behaviour class

Rating Plate

Note (Environmental Classes):

Class E0 – No condensation occurs on the transformers and pollution is negligible. This is commonly achieved in a clean, dry indoor installation.

Class E1 – Occasional condensation can occur on the transformer (for example, when the transformer is de-energized). Limited pollution is possible.

Class E2 - Frequent condensation or heavy pollution or combination of both.

Rating Plate

Note (Climatic Classes):

Class C1 – The transformer is suitable for operation at ambient temperature not below -5°C but may be exposed during transport and storage to ambient temperature down to -25°C.

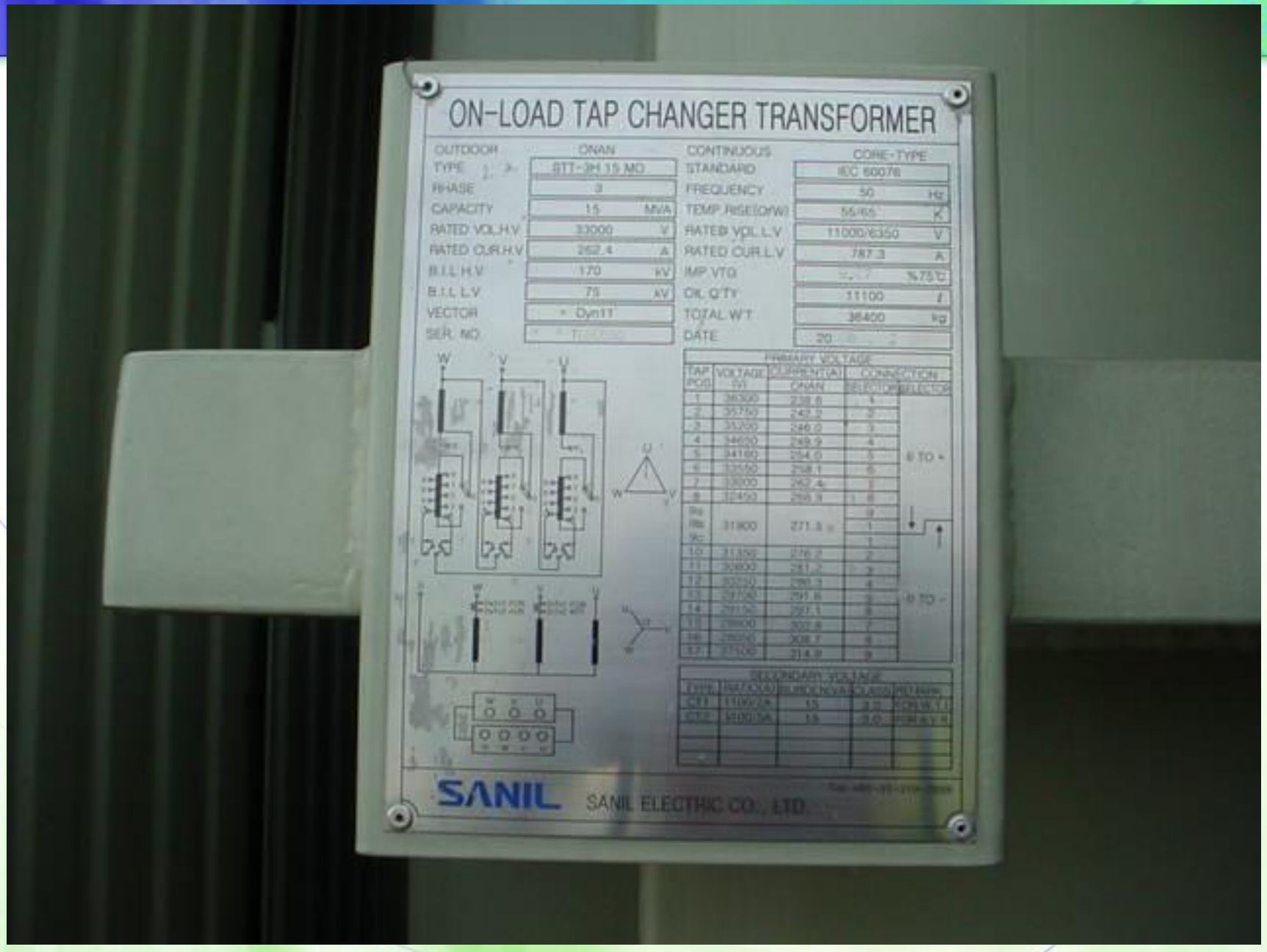
Class C2 – The transformer is suitable for operation, transport and storage at ambient temperature down to -25°C.

Rating Plate

Note (Fire behaviour class) :

F0 - There is no particular risk of fire. No special measures are taken to limit the flammability apart from typical characteristics in the design of the transformer. In any case, the emission of toxic substances and opaque fumes must be minimized

F1- No special fire hazard is envisaged. Except the characteristics inherent to the design of the transformer, no special measurement are taken to limit flammability.


ON-LOAD TAP CHANGER TRANSFORMER
OUTDOOR
ONAN
TYPE
STT-3M 15 MD
PHASE
3
CAPACITY
15
MVA
RATED VOL.H.V
33000
V
RATED CUR.H.V
262.4
A
B.I.L H.V
170
kV
B.I.L L.V
75
kV
VECTOR
Dyn11
SER. NO
CONTINUOUS
CORE-TYPE
STANDARD
IEC 60076
FREQUENCY
50
Hz
TEMP RISE(OIL/W)
55/65
K
RATED VOL L.V
11000/6350
V
RATED CUR L.V
787.3
A
IMP VTG
%75℃
OIL Q'TY
11100
l
TOTAL W'T
36400
kg
DATE
20
PRIMARY VOLTAGE
TAP POS
VOLTAGE
CURRENT(A)
ONAN
CONNECTION
SELECTOR
1
36300
238.8
2
35750
242.2
3
35200
246.0
4
34650
249.9
5
34100
254.0
6
33550
258.1
7
33000
262.4
8
32450
266.9
9
31900
271.3
10
31350
276.2
11
30800
281.2
12
30250
286.3
13
29700
291.6
14
29150
297.1
15
28600
302.8
16
28050
308.7
17
27500
314.9
0 TO +
0 TO -
SECONDARY VOLTAGE
TYPE
RATIO(A)
BURDEN
CLASS
W
CT1
1000/5A
15
0.2
CT2
1000/5A
15
0.2
SANIL
SANIL ELECTRIC CO., LTD.

Overload Protection

- The temperature of each winding – alarm,trip and fan
- Overload protection sensors - Platinum Thermal Resistance Sensor (PT 100)
- Digital Temperature Controller
- It shall be fixed on the wall nearest to the Tx unit

Digital Temperature Controller

- Highest temperature of 3 phases LV coils
- It shall provide :-
  - Max temperature memory
  - Alarm relay (normally set @ 90°C)
  - Remote alarm connection
  - Trip relay (normally set @ 120°C)
  - Manual or automatic fan controls
- Shall be provided with remote monitoring on alarm, trip and fan status


PYROGEN
090
23.07.2009


TECSYSTEM
T154
SCAN
AUTO
MAN
T.MAX
087
°C
TRIP
ALARM
FAN
FAULT
CH 1 2 3 4
PRG ON
TEST ON
TEST
MODE
PRG SET
ENT RESET
Tx 2
RINATEK SDN. BHD.
WORK RECORD
Tx-2
90138
MEGGER 1kV
29.9.2007
23.07.2009

Enclosures

- As a safeguard against any electrical part of the transformer
- Shall be supplied by the transformer manufacturer or the approved fabricator
- Electrogalvanised sheet steel and finished with epoxy oven baked
- Naturally ventilated
- Minimum IP 20
- 16 sq. mm protective conductors shall be provided

Enclosures

- Removable panels for:-
  - Easy reconnection of HV tappings
  - Assembling of cables
- Bottom or top entering shall be clearly stated
- 2 nos inspection windows of 300mm (l) x 300mm (w) x 3mm thickness transparent polycarbonate material on every sides

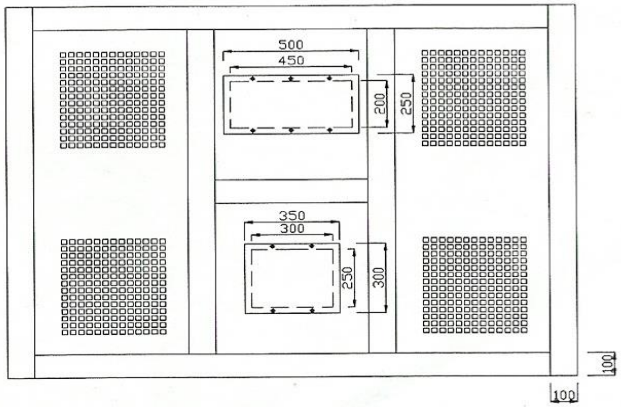
Enclosure

- The complete assembly shall be securely mounted on transformer base frame
- If IP 23 or higher IP specified, de-rating shall be applied
- Minimum clearance between live parts and enclosure of 200mm to prevent flashover

Enclosure

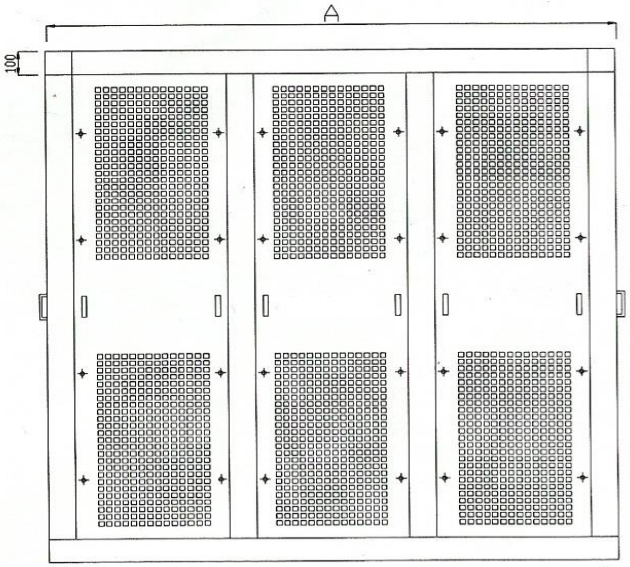
- Cut-outs for HV/LV cables and flanges (bus duct) on the LV side shall be provided
- The size, type cables/bus ducts and also whether bottom or top entering shall be stated
- If the enclosure is IP23 or more, de-rating shall be applied

Illustrations

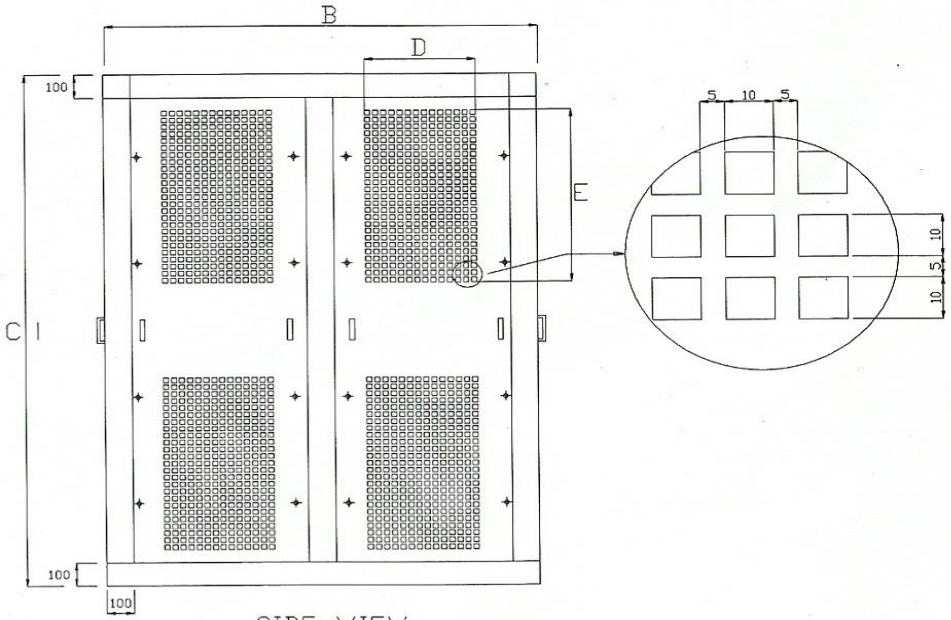


TOP VIEW

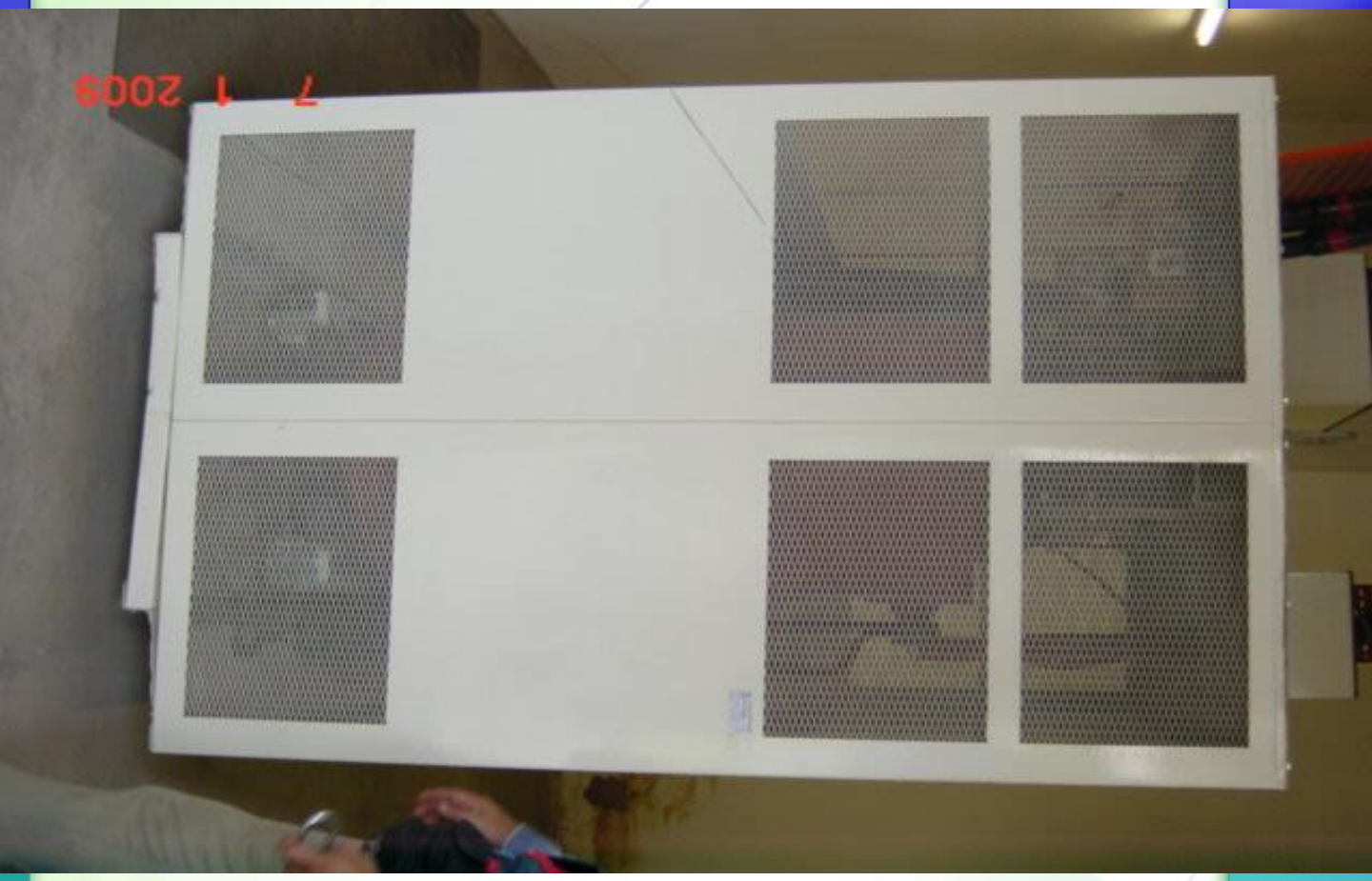
TYPE	S – small	M – medium		
CAPACITY	1000/1250KVA	1500/1600kVA	2000 KVA	2500 KVA
HV/LV	11/0.433 KV	11/0.433 KV	11/0.433 KV	11/0.433 KV
WIDTH (B)	1600	1800	1800	2000
LENGTH (A)	2100	2400	2550	2400
HEIGHT (C)	2200	2440	2430	2900



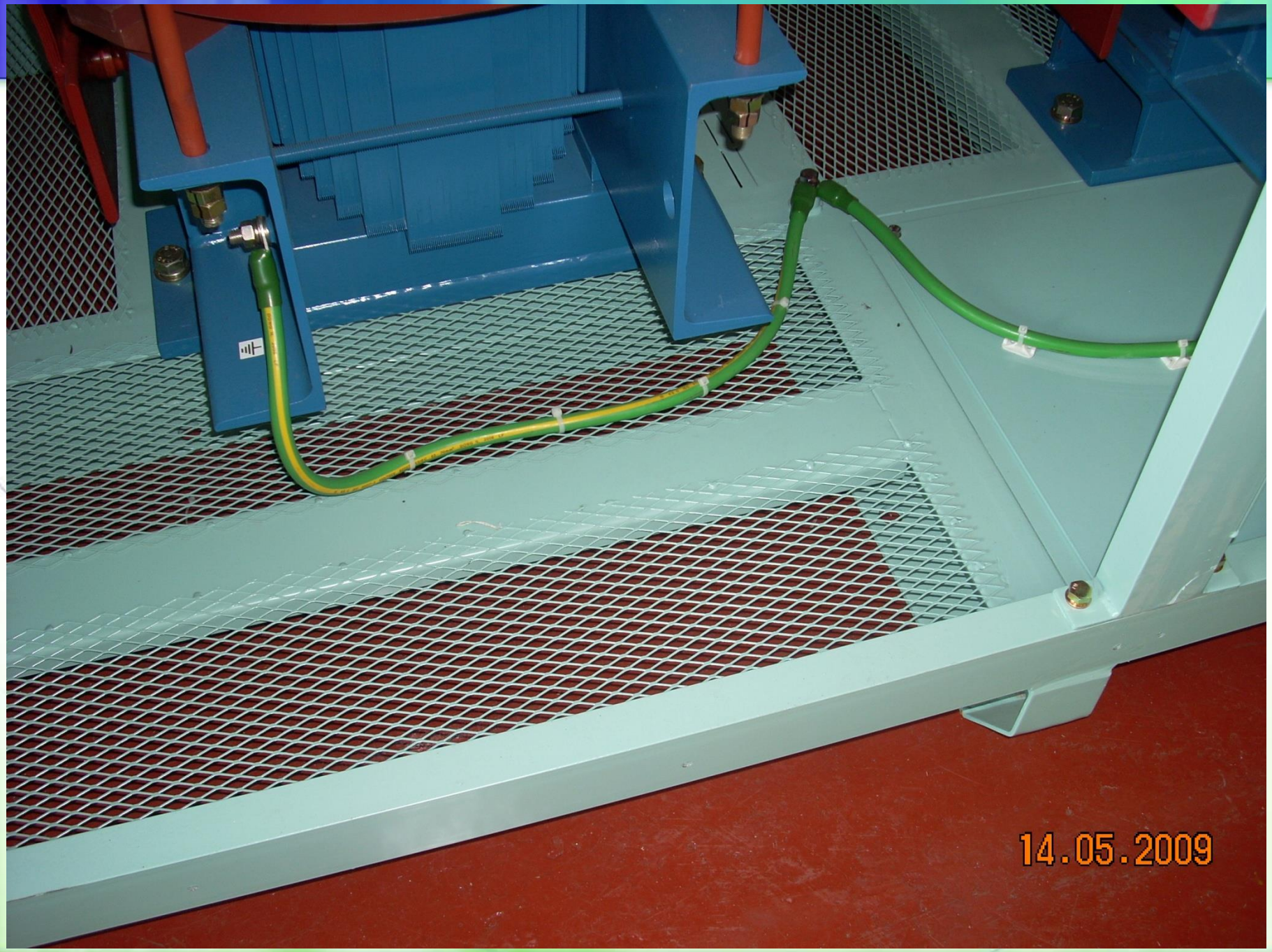
FRONT VIEW/BACK VIEW



SIDE VIEW

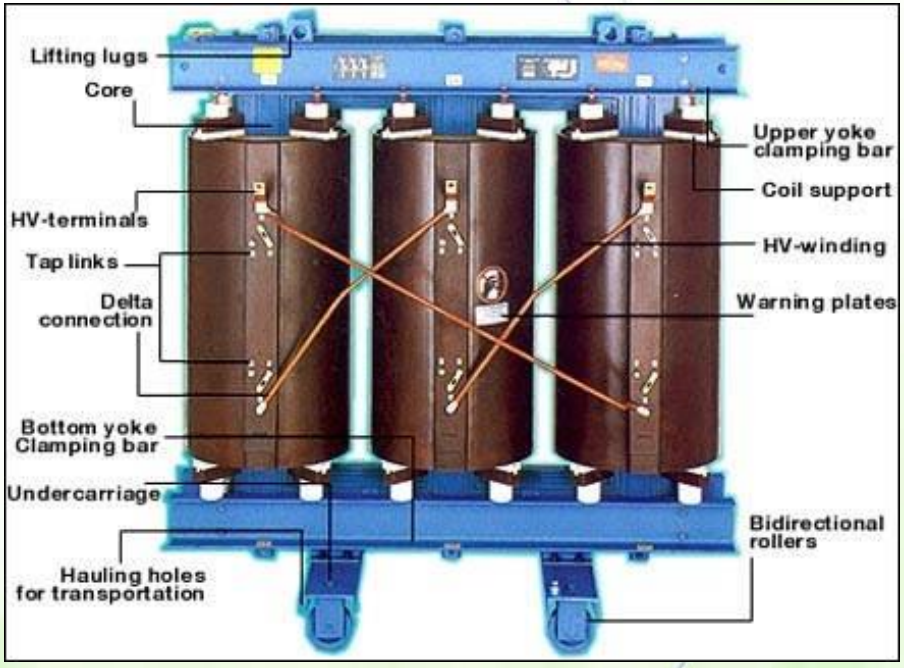

7 1 2009


7 1 2009

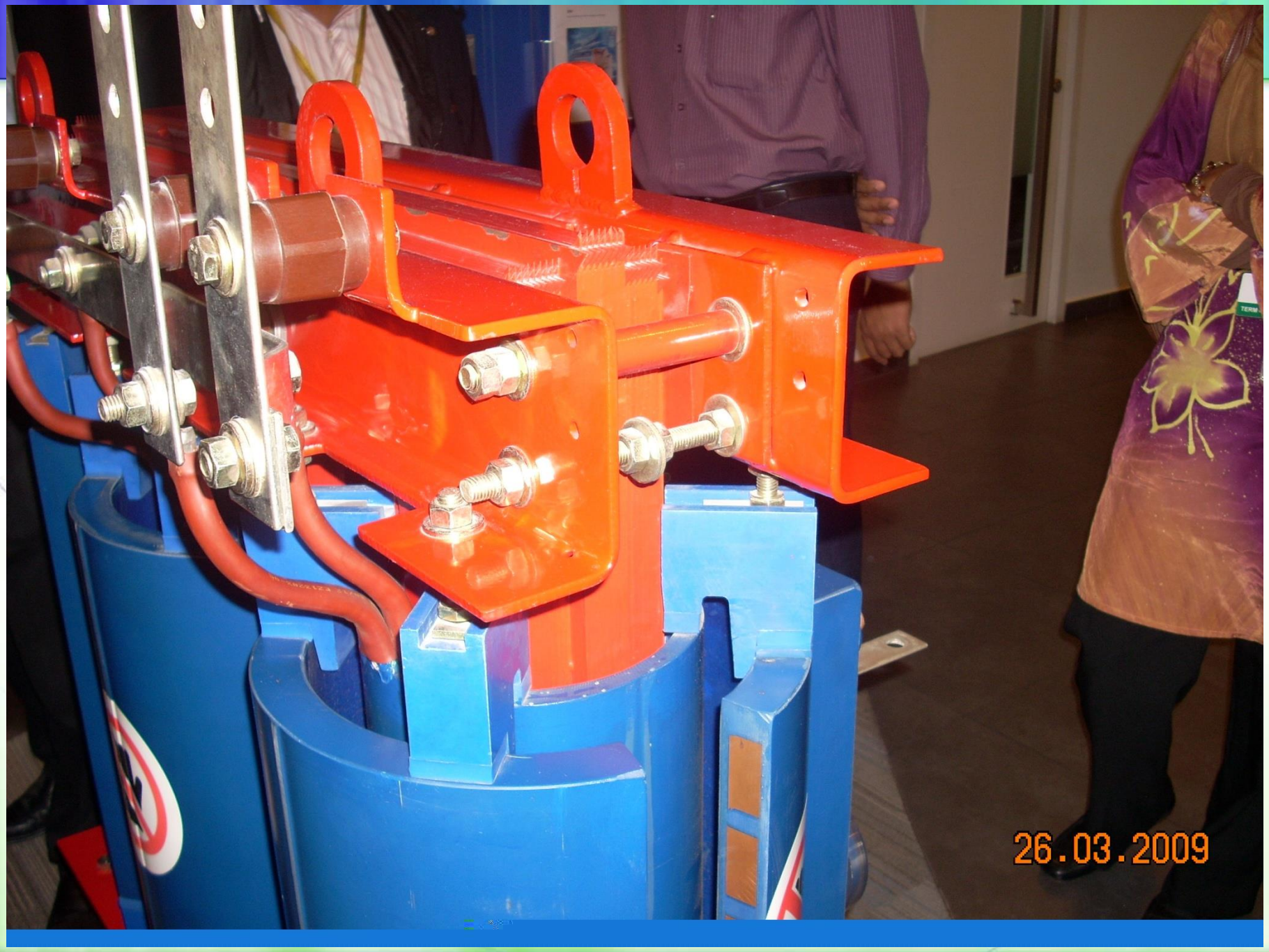

14.05.2009

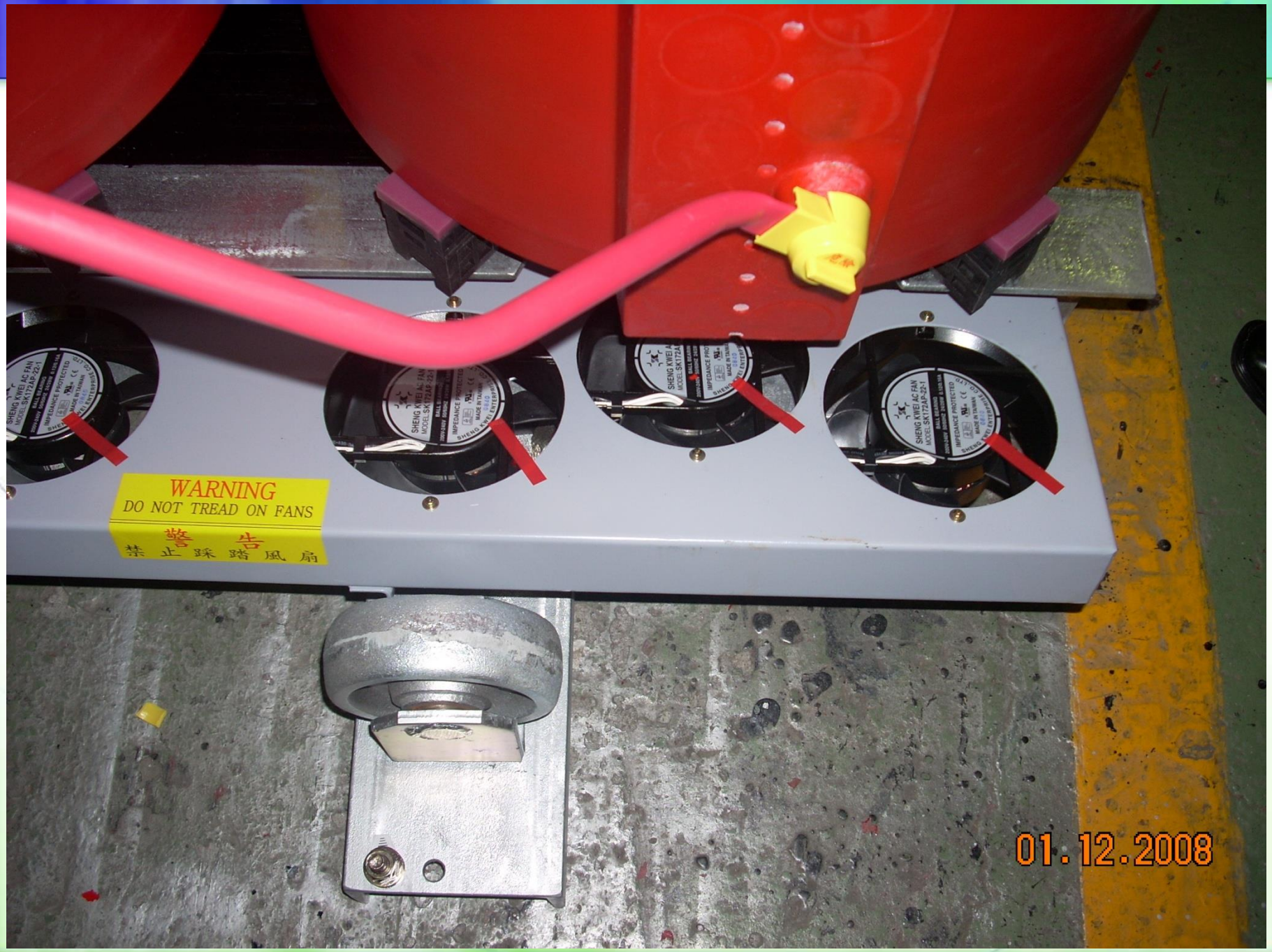
Photographs

Photographs




26.03.2009


26.03.2009


WARNING
DO NOT TREAD ON FANS
警 告
禁 止 踩 踏 風 扇
01.12.2008

Testing of Transformers

- Routine Tests
- Type Tests
- Special Tests

Routine Tests

1. Measurement of Winding Resistance
2. Measurement of Voltage Ratio and Check of Phase Displacement
3. Measurement of Short-circuit Impedance and Load Loss
4. Measurement of No-load Loss and No-Load Current
5. Separate-source AC Withstand Voltage Test
6. Induced AC Withstand Voltage Test
7. Partial Discharge Measurement

Type Tests

1. Lightning Impulse Test
2. Temperature Rise Test

Special Tests

1. Sound Level Measurement

Rated Power kVA	SPL dB(A)
300	<65
500	
750	
1000	<68
1250	
1600	
2000	<70

Special Tests

3. Short-circuit Test
4. Environment Test – Environmental Class E2
5. Climatic Test – Climatic Class C1
6. Fire Behaviour Test – Fire Behaviour Class F1

Earthing Systems

- Frame to Earth
  - $R<3\Omega$
- Neutral to Earth
  - $R<3\Omega$
  - $S=(\sqrt{i^2t})/k$

- Perimeter earthing untuk bilik Tx dan bilik Metal- Enclosed Switchgear
- Lukisan neutral to earth (N – E)
- Lukisan frame to earth (F – E)

Transformer Room

- Electrical Contractor to inform the weight of the transformer to Structural Engineer
- Min. 6mm thickness and 1000 mm width rubber mate shall be provided around the transformer
- Sign :-
  - ‘BAHAYA’
  - ‘DI LARANG MASUK’
  - ‘SUBSTATION NO:’
  - ‘DI LARANG MEROKOK’
- Electric Shock Treatment Chart

Transformer Room

- Trenches shall be filled up with washed river sand to a level above cable ducts
- As installed schematic wiring diagram shall be framed up layout plans
- One unit of 9 kg portable dry powder fire extinguisher for A,B,C class of fire in every transformer room and certified by JBPM for a period of 12 months

Brand and country of origin (JMAL)

1. JSHP, China
2. SGB, Malaysia
3. SEA, Italy
4. Sunten, China
5. Tesar, Italy
6. Sanil, Korea

Routine Tests

- Knowledge on FAT
- How to read the test results?
- Whether to accept or not the test results?

By Ir. Hamzah Bin Ismail

Perbandingan oil immersed & cast resin Tx

- Oil Immersed Vs Cast Resin
  - Life span
  - Maintenance
  - Initial Cost
  - O&M cost
  - Safety of surveillance

Metal-Enclosed Switchgear

General

- Shall be accommodated for instruments, metering and protection relays at the front of the cubicle
- In the cubicle :-
  - Busbar
  - Circuit Breaker (CB)
  - Plugging contacts
  - Instrument transformers
  - Main and auxiliary cable connection
  - Small wiring

General

- Circuit breaker control selector switches
- Earthing switches
- Indicating devices for CB

Standard

1. IEC 60129 – Alternating current disconnectors and earthing switches
2. MS IEC 62271-102 – High voltage switchgear and control gear – Part 102- Alternating current disconnectors and earthing switch
3. IEC 62271-1 – High-voltage switchgear and control gear – Part 1 – common specifications
4. IEC 60056 – High-voltage alternating-current circuit-breakers

Standard

5. MS IEC 62271-100 – High voltage switchgear and control gear – Part 100- Alternating-current circuit-breaker
6. IEC 60298 – A.C. Metal-Enclosed Switchgear and control gear for rated voltages above 1kV and up to and including 52kV
7. MS IEC 62271-200 – High voltage switchgear and control gear – Part A.C. Metal-Enclosed Switchgear and control gear for rated voltages above 1kV and up to and including 52kV

Standard

8. IEC 60044-1 – Instrument transformer – part 1- Current transformer
9. IEC 60044-2 – Instrument transformer part 2 : Inductive voltage
10. IEC 60255-5 – Electrical relays – Part 5 : Insulation coordination for measuring relays and protection equipment- requirements and tests
11. MS 136 – Specification for PVC Insulated cables (non-armoured) for electric power and lighting

Standard

12. MS 274 – Specification for PVC insulated cables for electricity supply
13. BS EN 13601-Copper and copper alloys, copper rod, bar and wire for general electric purposes
14. BS 7430- Code of practice for earthing
15. BS 7671 – Requirement for electrical installation
16. BS 159 – Specification for high-voltage busbars and busbar connection

Standard

17. IEC 60359 – Electrical and electronic measurement equipment – expression off performance
18. IEC 60688 – Electrical measuring transducers for converting a.c. electrical quantities to analog or digital signals
19. MS 925 – Specification for direct acting indicating electrical measuring instruments and their accessories

Metal-Enclosed Switchgear

- 11kV, 3 phase, 50Hz
- Single busbar
- Metalclad
- Floor mounting
- Indoor type with horizontal isolation and horizontal draw out features having air insulated busbar
- Current and voltage transformer chambers

Metal-Enclosed Switchgear

- Extensible left and right – to couple individual units
- Feeder Circuit
- Transformer Circuit
- Bus Section
- Ambient temperature 40°C
- RH up to 100%
- Altitude ≤ 1000m above sea level

Metal-Enclosed Switchgear

- Busbars - copper bars shrouded with epoxy resin or heat shrinkable material
- Safety shutters – label ‘BUSBAR’ and ‘CABLE’
- Heater with thermostat control and faulty lamp indicator
- Circuit Breaker (CB) – close door operation (plug in type remotely operated)
  - CB Truck Type
  - CB Cassette Type
- Earthing switch – open or closed

Metal-Enclosed Switchgear

- CT – 15VA, 5P10 (protection), Class 0.5 (metering) and Class 0.2 (TNB Metering)
- CT Ratio – primary : 50A,75A,100A,150A, 200A & 300A.secondary 5A
- Voltage/Potential Transformer- 3-phase, 3 limb, star star, ratio 11000/110V, Burden 100VA and Class 0.5
- Indication instrument and meters – digital

Metal-Enclosed Switchgear

- Protection Relays – Microprocessor based relay, IDMT type, rated at 30Vdc
- Preventive Internal Arc Fault Protection – simultaneous occurrence of arc and over-current incidences will trip the protection relay
- Small wiring – 2.5 mm^2 black pvc cable and ≥ 4mm^2 green pvc to the nearest earth bar
- Battery and Battery Charger– One 30Vdc Ni-Cad battery tripping unit (5 hour rate) to trip min 3 nos CB, self contained, floor standing steel cabinet, supply from 13A 3 pin SSO

Metal-Enclosed Switchgear

- Labelling – min size 50mm x 150mm, black background and white lettering, mimic diagram at the facial

Metal-Enclosed Switchgear

Metal-Enclosed Switchgear

Circuit Breaker

- Vacuum Circuit Breaker (VCB)
- Fault level : 20kA, 3s
- Rated current : 630A (800A,1250A,2000A)
- Rated voltage : 12kV

Circuit Breaker

Installation

- Min clearance of 600mm (back/side)
- Min clearance of 1500mm (front)

Switchgear Room

- Min 6mm thickness and width 1000mm in front of metal-enclosed switchgear and full length
- Sign :-
  - ‘BAHAYA’
  - ‘DILARANG MASUK’
  - ‘SUBSTATION NO:’
  - ‘DILARANG MEROKOK’
  - 2 sets of ‘BAHAYA-KERJA-KERJA SEDANG DIJALANKAN’ c/w 200mm x 300mm hanging string (background red and white lettering)
- Shock treatment chart

Switchgear Room (2)

- Trenches – filled up with clean sand to a level above cable duct
- As installed layout plans, schematic wiring diagrams, plans showing cable routes and positions of earthing points shall be framed
- One 9kg dry powder fire extinguisher for A/B/C class of fire shall be installed in every metal-enclosed switchgear room

Brand (JMAL)

1. EPE
2. Schneider
3. SRS
4. ESTA
5. Toshiba
6. Pestech

11kV SF6 Ring Main Unit

Standards

1. MS IEC 60265-1 – High-voltage switches-Part 1: Switches for rated voltages above 1kV and less than 52kV
2. IEC 62271-1 – High voltage switchgear and controlgear – Part 1 : Common specifications
3. IEC 62271-100 – High-voltage switchgear and controlgear – Part 100 : Alternating current circuit-breakers
4. MS IEC 62271-102 - High-voltage switchgear and controlgear – Part 105 : Alternating current disconnectors and earthing switch

Standards

5. MS IEC 62271-105 – High-voltage switchgear and controlgear – Part 105 : Alternating current switch-fuse combinations
6. MS IEC 62271-200 – High-voltage switchgear and controlgear – Part 200 : A.C Metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV
7. IEC 60376 – Specification of technical grade sulfur hexafluoride (SF6) for use in electrical equipment

Standards

8. MS IEC 60502 – Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um=1.2kV) up to 30kV (Um=36kV)
9. MS IEC 60529 – Degree of protection provided by enclosure (IP Code)(First Revision)
10. IEC 61243-5 – Live working-Voltage Detectors-Part 5 : Voltage Detecting system (VDS)
11. BS EN 13601 – Copper and copper alloys. Copper rod, bar and wire for general electrical purpose

Standards

12. BS 7430 – Code of practice for earthing
13. MS IEC 60364-5-54 – Electrical installation of buildings – Part 5-54 : Selection and erection of electrical equipment : earthing arrangements, protective conductors and protective bonding conductors
14. MS 26 : Part 2 – Methods of testing concrete Part 2 : Methods of testing hardened concrete
15. MS ISO 9001 – Quality management systems – requirements (First Revision)

General

- 11 kV, 3 phase, 50 Hz
- Single busbar
- Metalclad
- Floor mounting type
- Provided with integral earthing and testing terminals
- Ambient temperature 40°C
- RH up to 100%
- Altitude up to 1000m above sea level

Construction of RMU

- Two SF6 gas-insulated 630A Load Break Switch (LBS) with one 630A VCB
- Earthing Switches
- 630A copper busbar fully encapsulated within the SF6 gas tank
- Provision for adding one VCB in future
- LBS and VCB shall be within SF6 tank
- Rated short circuit current, 20 kA for 3s
- Inner enclosure – IP67
- Complete RMU – IP 54

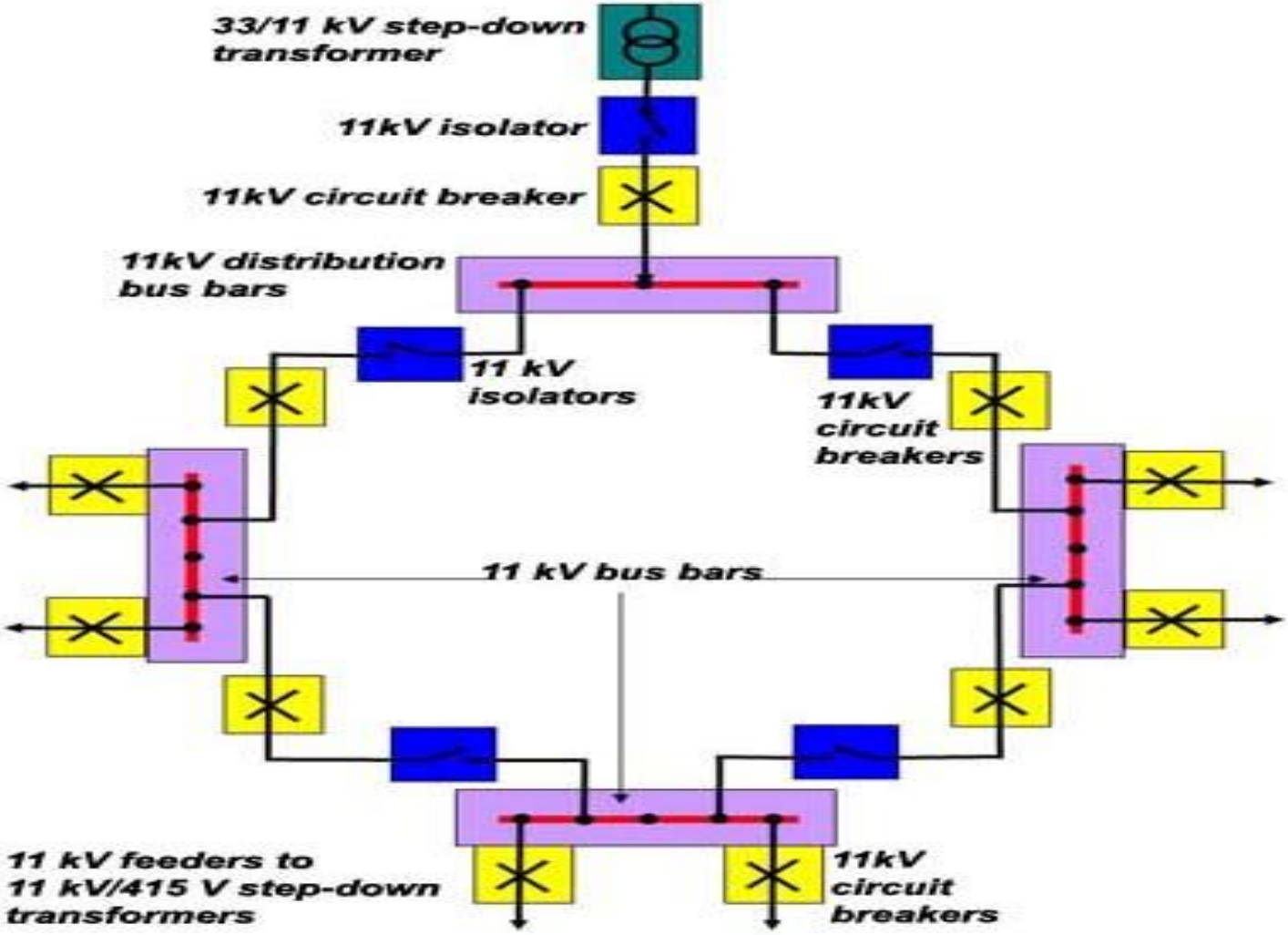
Ring Main Unit (RMU)

- As an equipment for electrical distribution in the building complex and depends on number of sub-station
- Cheaper than circuit breaker
- Simple
- Medium - SF6
- Solely switching and VCB tripping mechanism for transformer feeder

RMU Vs VCB Metal-Enclosed Switchgear

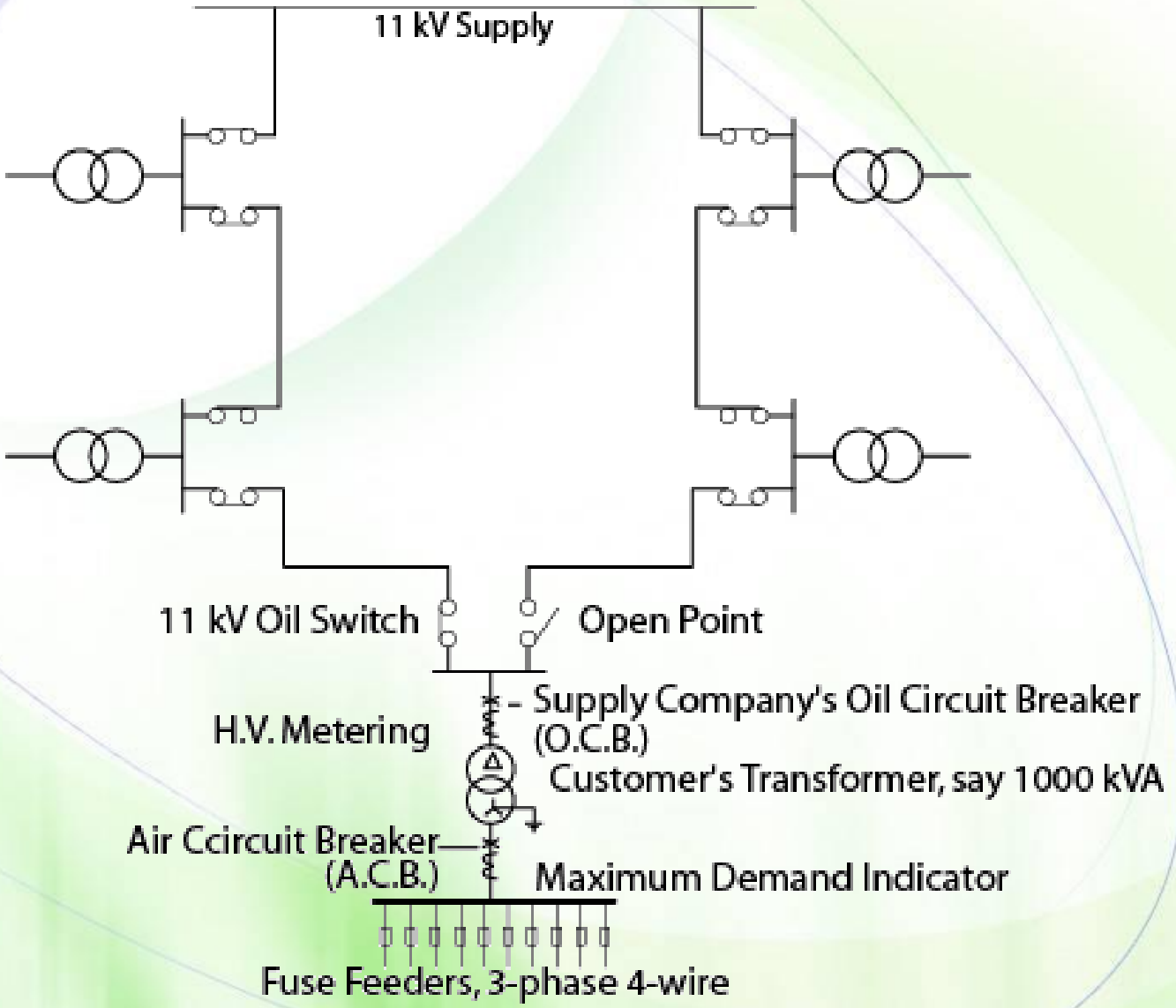
- Not for SSU Pengguna
- Only for Pencawang Elektrik Pengguna
- Existing installation
- Not for SCADA
- Cheaper
- Setting protection relays only at SSU Pengguna

Ring Circuit

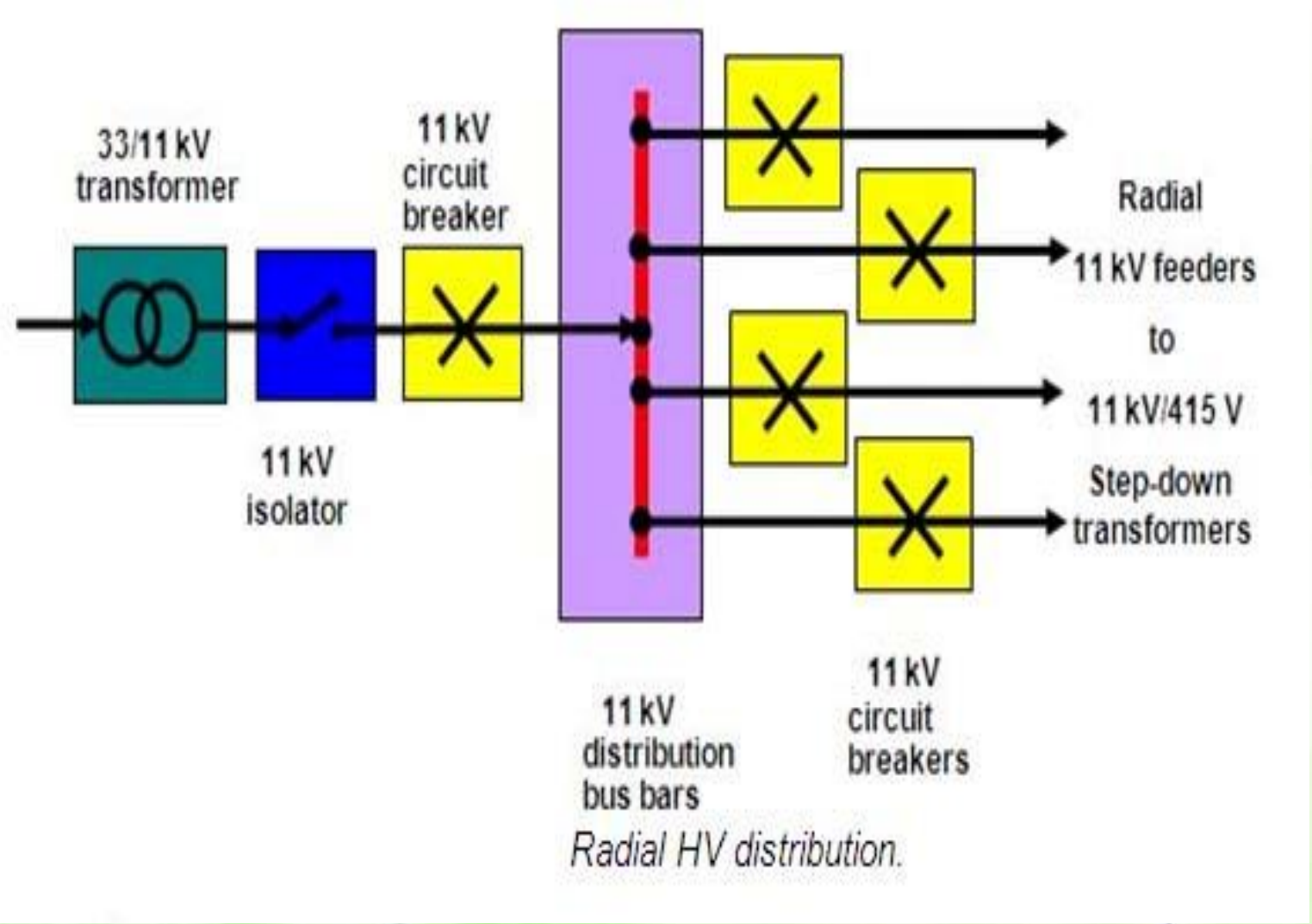


Ring HV distribution.

Normal Open Point (NOP)



Radial Circuit



Radial HV distribution.

RMU

- Rated current - 200A, 630A @ 20kA for 3 sec
- Personal safety – metal-enclosed
- Operational safety – 3 position switch disconnector /interlock ON, OFF, Earth
- Indoor IP 20 and Outdoor IP 54
- Economical in price and space
- Ease of maintenance (mostly maintenance free)

Medium Voltage Underground Cable

Standards

- IEC 60502-2
- Power cables with extruded insulation and their accessories for rated voltages from 1kV (Um=1.2kV) up to 30kV (Um=36kV)
- Part 2: Cables for rated voltages from 6kV (Um=7.2kV) up to 30kV (Um=36kV)

Type of cable

- 3C XLPE/SWA/PVC
  - CU/XLPE/CTS/PE/SWA/PE SHEATED - XLPE-Insulated, Copper Tape Screen, Steel Wire Armoured , PE-Sheathed Annealed Copper Conductor Cable (CCB)
  - CU/SC/XLPE/CTS/PE/SWA/PE-XLPE Insulated, Copper Tape Screen, MDPE Sheathed, Steel Wire Armoured, Stranded Compacted Plain Annealed Copper Conductor Cable (Southern)

- CU/XLPE/CTS/PVC/SWA/PVC - XLPE Insulated, Copper Tape Screen, PVC Sheathed, Steel Wire Armoured, Stranded Copper Conductor Cable (Hi-Essence Cable)
- 3 x 1C XLPE/AWA/PVC (jarang guna)
- Voltage 6350/11000V
- Copper conductor

Routine Tests

- Measurement of the electrical resistance of conductors
- Partial discharge test on cables having cores with conductor screens and insulation screens
- Voltage Test

MV Underground Cable

- Cable trenches
  - 750mm depth
  - ≥450mm width
- Cable duct
  - 150mm dia. Pipe
  - Any crossing – concrete block at a depth of 750mm
  - Space factor 40%
- Complete length
- If cable is cut, the ends shall be immediately sealed if the cable termination is to be done later

MV Underground Cable

- Cable laid direct in ground (to comply with L-S3)
  - Using 250mm (w) x 1000mm (L) uPVC cable cover slab
  - Orange colour
  - new
  - 25mm overhang on each side of the cable
- Cable installed in pre-cast concrete trenches
  - Laid on bottom or
  - On perforated hdg cable tray
  - 25mm from the trench wall at 600mm intervals
  - Trench in the building shall be filled with clean sand up to a level above the cable ducts

MV Underground Cable

- Cable run on the walls and under floor slabs (as describe in Cable installed in pre-cast concrete trenches)
- Cable termination and jointing
  - Witness by Wakil SO
- Cable termination
  - Using heat shrinkable method
  - Tests to carry out on each length of cable before termination:-
    - Phasing
    - Insulation resistance

MV Underground Cable

- Cable jointing
  - Undertaken by competent and experienced jointer
  - Approve cable boxes, compound and jointing materials
  - To be carried out on the same day
  - Tests to carry out on each length of cable before jointing is commenced :-
    - Phasing
    - Insulation resistance
- Cable markers
  - Same as Spec. L-S3, only different is word ‘H.V’

Selection of MV Underground Cable

- 3 criteria to determine size:-
  - Short circuit current ratings (≥20kA) –refer graph
  - Duration of short circuit (3s)-refer graph
  - Current rating in air @ ambient air temperature, 30°C) [trench] or

    Current rating in the ground @ ground temperature, 20°C) [buried direct in the ground]
  - max load the cable can carry (MW)

    $= \sqrt{3} \times V \times Iz \times \cos \phi$

Sizes MV Underground Cables

Copper Cables :-

- 240 mm^2
- 300 mm^2

Correction Factors

- Correction factors for ambient air temperature other than 30°C
  - 40°C = 0.91
- Correction factors for ambient ground temperature other than 20°C
  - 25°C = 0.96
- Correction factors for depth of laying other than 0.8m for direct buried cables
- Correction factors for depth of laying other than 0.8m for cables in ducts

Correction Factors

- Correction factors for soil thermal resistivity other than 1.5km/w for direct buried single-core cables
- Correction factors for soil thermal resistivity other than 1.5km/w single-core cables in buried ducts
- Correction factors for soil thermal resistivity other than 1.5km/w for direct buried three-core cables

Correction Factors

- Correction factors for soil thermal resistivities other than 1.5km/w for three-core cables in ducts
- Correction factors for groups of three-cables in horizontal formation laid direct in the ground
- Correction factors for groups of three-phase circuits of single-core cables laid direct in the ground
- Correction factors for groups of three-core cables in single way ducts in horizontal formation

Correction Factors

- Correction factors for groups of three-phase circuits of single-core cables in single-way ducts

Current rating

- Multicore cables -3C 11kV XLPE/SWA/PVC

Size mm^2	Current Rating		
	Buried direct in ground @ 20°C (A)	In a buried duct (A)	In air @ 30°C (A)
240	431	387	529
300	482	435	599

- Rujukan IEC 60502-2 Table B.6 page 119

Current rating

- Single core cables -1C 11kV XLPE/AWA/PVC

Size mm^2	Current Rating		
	In air @ 30°C (A)	In the ground @ 20°C (A)	In single-way ducts (A)
240	431	387	529
300	482	435	599

- Rujukan IEC 60502-2 Table B.6 page 119

Brand (JMAL)

Copper

1. CCB
2. Southern Cable
3. Hi-Essence Cable

Aluminium

1. CCB

SCADA

- SCADA – Supervisory Control And Data Acquisition
- Tujuan :-
  - Status operasi perkakasan voltan sederhana
  - Data analysis
  - Remote control operation

Case Studies

- Perpustakaan Negeri Kuantan
- KKR2
- UTeM
- TUDM Subang

Guidelines to MV System Design

List of drawings

- MV & LV System in one tender
- List of drawings :-
  - Site Plan + Pelan Lokasi + Pelan Kunci (TNB cable)
  - Site Plan (MV System)
  - Trenches details (MV)- PPU/SSU TNB & SSU/PE Pengguna
  - Perimeter Earthing (MV) – PPU/SSU TNB & SSU/PE Pengguna + Neutral to Earth + Frame to Earth
  - Lighting & socket layout dan DB Schematic Wiring Diagram untuk PPU/SSU TNB & SSU/PE Pengguna
  - Lightning Protection System for PPU/SSU TNB (if required)
  - MV System Schematic Wiring Diagram
  - Site Plan (LV) and etc…

Location of Distribution Transformer

- Location of distribution transformer shall comply with table below

Load fed by Transformers	Distance of transformer from load centres
> 600A	≤20 m
300A to 600A	≤100 m

Distribution Transformer Design Criteria

- Loadings shall be ≤ 70% of rated capacity under normal conditions
- The transformer sizes shall consider harmonics
- Air forced transformer capacity and automatic fan cooling of the transformer shall be considered for certain type of buildings and certain conditions of project

Air Forced Cooling Requirement

- Oil-Immersed
  - ONAN
  - ONAF
- Dry-Type Transformer
  - AN
  - AF

Design Tutorial

- Tutorial #1
- Tutorial #2
- Tutorial #3

You are asked to calculate, size up and draw wiring schematic diagram of MV System including earthing system

Group presentation is compulsory before we end the course

THANK YOU