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REQUEST REPORT

In this project aim build the transformer center Sancaktepe Fitness Center and it is located at 8.layout, 13.plot and 14.block Paşaköy district of Istanbul. This transformer center will build by Company of Bayar Construction to supplying electricity demand of Sancaktepe Fitness Center with dated on 06/22/1990 and numbered of 1938. Energy Permitting Certificate.

Demand of Energy is destined via HDPE pipe in empty cell of third transformer center by type of 34.5 kV cross sectional area is $3*(1*240)$ mm² from these cell with approximately 250 meters along XLPE cable type of 34.5 kV and cross sectional area is $3*(3*120)$ mm².

For this purpose, CBC will build three-cell concrete kiosk transformer center and the company will transferred transformer center to TEDAS. Power of this transformer center is 1600 kVA.

Medium voltage cells will build according to 36 kV and input load breaker consist of the modular cell with metal enclosure, in output and transformer output protection cell will using seconder modular cell with metal enclosure. Load and circuit breakers will working with 24 V dc motors. Fault location indicator will found in output cell.

Suppling 34.5 kV in Sancaktepe Fitness Center transformer center of low voltage panel will sharing with NY_Y cables.

We notice that low voltage TC switch startup current of dc motor. In order to neutralize the electrostatic charges that may occur at the transformer center, all metal parts in the substation middle voltage and low voltage section shall be grounded and grounding resistor will less than 5 ohm.

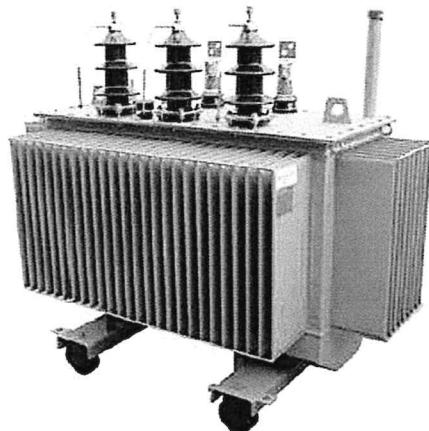
Electricity project of 1600 kVA transformer substation has been prepared and its inspection and approval are presented.

ELECTRICAL POWER PANEL SELECTION

In this project, we will build transformer center in specified location and we going to use transformer of Schneider Company. This transformer power is 1600 kVA and cooler type is oil. (ONAN) Dyn11. We showed that transformer features in the figures 1, 2, and price in figure 3.

Minera

Yağlı tip dağıtım transformatörleri,
2,5 MVA - 36 kV'ye kadar



Müşteri avantajları

- Ürün çeşitliliği
- Yüksek kalite ve güvenilirlik
- Ekonomik olarak optimize edilmesi
- Kayıpların sınırlanılması
- Kanıtlanmış ve kalıcı olarak optimize edilmiş teknoloji
- Azaltılmış boyutlar
- Dayanıklı yapı
- Geri dönüşümlü malzemeler

Ülkemiz standart ve metodlarına bağlı kalarak kullanacağınız transformatör, şebekenize en iyi şekilde ve ekonomik koşullara adapte edilmelidir. Dünya çapındaki endüstri platformumuz ile ürün çeşitliliği, esneklik ve müşterileri beklentilerini tam olarak karşılayacak yağlı dağıtım transformatörleri sunmaktadır.

Uzun yıllara dayalı kalite tecrübesi 80 yılın üzerindeki tecrübesi ve iki milyonu aşkın dünya üzerindeki transformatör kapasitesi ile kalitesi kanıtlanmış bir ürünü almaktasınız. Bu ürün, ürün geliştirme merkezi tarafından sürekli olarak geliştirilmektedir.

Minera'daki Ürün yelpazemiz Standart Minera transformatör seçim aralığımız aşağıdaki gibidir:

- Üç fazlı (tek fazlı isteğe göre)
- 2,5 MVA ve 36 kV'ye kadar - 50 / 60 Hz
- Genleşme depolu veya hermetik tam kapalı
- Direk veya zemin tipi
- Doğal soğutmalı (ONAN) veya fanlı soğutmalı (ONAF) isteğe göre

80 MVA, 170 kV'ye kadar yüksek güç ve gerilimlerde ve özel uygulama alanları içinde (Akım doğrultucu, Petrol & Gaz Zone II Platformları, topraklama, reaktör, şalterli vs. transformatör ihtiyaçlarınıza karşılamaktayız).

Figure 1

SYMBOLS AND MEANING

- ***ONAN***: ‘O’ means burn point is ≤ 300 °C have mineral oil or synthetic insulation , ‘N’ means cooling natural thermosiphon circulation through cooling equipment and windings, ‘A’ means air.
- **S_{Tr}** : Transformer Power (kVA)
- **P_k** : Total installed power in Watt
- **k_f** : Loss factor
- **T_f** : Demand factor
- **$\cos \varphi$** : Angle between real power axis
- **P_T** : Demand power in Watt
- **V_{LL}** : Line to Line voltage in Volt
- **l** : Distance in meter
- **k** : 56 cm/mm²
- **m** : DC heat component
- **n** : AC heat component
- **f** : Frequency (50 Hz or 60 Hz)
- **I_b** : Symmetric short circuit
- **E''** : The initial transient voltage of the synchronous machine
- **I_b** : Symmetrical short circuit current
- **I_k** : Steady state symmetrical short circuit current
- **I_{kp}** : Steady state short –
circuit current at the terminals of the combined exciter generator
- **I_k''** : Initial short circuit current
- **I_{LR}** : Symmetrically blocked rotor current of asynchronous motor
- **I_r** : Electrical equipment rated current
- **I_{th}** : Thermal equivalent short circuit current
- **$I_{d.c}$** : Short circuit d.c component
- **I_p** : Peak short circuit current
- **K** : Impedance correction factor
- **p** : Pair of asynchronous motor poles

- q_n : Nominal section
- R_G : Resistive resistance of synchronous machine
- S_k'' : Initial symmetrical short circuit power
- S_r : Declared power of electrical equipment
- T_k : Short – circuit duration
- U_m : Highest voltage for equipment (phase to phase)
- c : Rated voltage of the system (phase to phase)
- U_n : Declared voltage (phase to phase)
- U_r : Short – circuit impedance of three – phase a system
- Z_1 : Positive component short – circuit impedance
- Z_2 : Negatif component short – circuit impedance
- Z_0 : Zero component short – circuit impedance
- η : Asynchronous motor supply
- κ : Factors related to the calculation of peak short – circuit current
- μ : Factor related to the calculation of the steady – state short – circuit current
- μ_0 : Absolute permeability of vacancy
- ρ : Resistivity

CALCULATIONS

I. TRANSFORMER POWER TYPE AND SELECTION

Firstly, I have to find my total installed power of my system, so I chose that

$$k_f = 1.1 \text{ (For a loss of \%10)}, T_f = 1, \cos \varphi = 0.99 \text{ and } S_{Tr} = 1600 \text{ kVA}$$

$$S_{Tr} = \frac{P_k * k_f * T_f}{\cos \varphi}$$

So, I get total installed power from the above this equation $P_k = 1440 \text{ kW}$.

In my project, I have 8 panels and I will separate the P_k to 10 panels. I divided $\frac{1440 \text{ kW}}{10}$. Its equal the 144 kW to each one panel.

NO	OUTPUT PANEL NAME	POWER
1	G PANEL	144 kW
2	O PANEL	144 kW
3	K PANEL	144 kW
4	H PANEL	144 kW
5	A PANEL	144 kW
6	N PANEL	144 kW
7	B PANEL	144 kW
8	Y PANEL	144 kW
9	R PANEL	144 kW
10	1907 PANEL	144 kW

2. COMPENSATION PANEL CALCULATION

To compensation,

Find demand power $P_T = P_K * T_f$ then $P_T = 1440 \text{ kW}$, $T_f = 1$ $\cos \varphi_1 = 0.8$

$$P_T * \cos \varphi_1 = 1152 \text{ kW} \quad \cos \varphi_2 = 0.98$$

$$Q = P * (\tan \theta_1 - \tan \theta_2) = 1152 * 0.55$$

$Q = 633.6 \text{ kVAr}$ (0.55 is called k factor and Table -2h shows that.)

$$\frac{Q}{P} = \frac{20}{100} = \frac{1}{5} \quad (\text{To direction EPDK}) \cos \varphi_2 = \frac{P}{S} = \frac{5}{\sqrt{26}} \quad \varphi_2 = 0.98$$

Tablo-2h. Kompenzasyon için k katsayısi çetveli

$\cos \varphi_1$	0.95	0.96	0.97	0.98	0.99	k
0.44	1.71	1.75	1.79	1.84	1.9	
0.45	1.65	1.69	1.73	1.78	1.84	
0.46	1.6	1.64	1.68	1.73	1.79	
0.47	1.55	1.58	1.63	1.65	1.74	
0.48	1.5	1.54	1.58	1.63	1.65	
0.49	1.45	1.49	1.53	1.58	1.64	
0.5	1.4	1.44	1.48	1.53	1.59	
0.51	1.36	1.4	1.44	1.49	1.55	
0.52	1.31	1.35	1.39	1.44	1.5	
0.53	1.27	1.31	1.35	1.4	1.45	
0.54	1.23	1.27	1.31	1.35	1.42	
0.55	1.19	1.23	1.27	1.32	1.38	
0.56	1.15	1.19	1.23	1.28	1.34	
0.57	1.11	1.15	1.19	1.24	1.3	
0.58	1.07	1.11	1.15	1.2	1.26	
0.59	1.04	1.08	1.12	1.17	1.23	
0.6	1	1.04	1.08	1.13	1.19	
0.61	0.97	1.01	1.05	1.1	1.15	
0.62	0.94	0.98	1.02	1.07	1.13	
0.63	0.9	0.94	0.98	1.03	1.09	
0.64	0.87	0.91	0.95	1.0	1.06	
0.65	0.84	0.88	0.92	0.97	1.03	
0.66	0.81	0.85	0.89	0.94	1.00	
0.67	0.78	0.82	0.86	0.91	0.97	
0.68	0.75	0.79	0.83	0.88	0.94	
0.69	0.72	0.76	0.8	0.85	0.91	
0.7	0.69	0.73	0.77	0.82	0.88	
0.71	0.66	0.7	0.74	0.79	0.85	
0.72	0.63	0.67	0.71	0.76	0.82	
0.73	0.61	0.65	0.69	0.74	0.8	
0.74	0.58	0.62	0.66	0.71	0.77	
0.75	0.55	0.59	0.63	0.68	0.74	
0.76	0.53	0.57	0.61	0.66	0.72	
0.77	0.5	0.54	0.58	0.63	0.69	
0.78	0.47	0.51	0.55	0.6	0.65	
0.79	0.45	0.49	0.53	0.59	0.64	
0.8	0.42	0.46	0.5	0.55	0.61	
0.81	0.39	0.43	0.47	0.52	0.58	
0.82	0.37	0.41	0.45	0.5	0.56	
0.83	0.34	0.38	0.42	0.47	0.53	
0.84	0.32	0.36	0.4	0.45	0.51	
0.85	0.29	0.33	0.37	0.42	0.48	
0.86	0.26	0.3	0.34	0.39	0.45	
0.87	0.24	0.28	0.32	0.37	0.43	
0.88	0.21	0.25	0.29	0.34	0.4	
0.89	0.18	0.22	0.26	0.31	0.37	
0.9	0.15	0.19	0.23	0.26	0.34	

$$S_{Tr} * \%3 < Q_c(\text{stable}) < S_{Tr} * \%5$$

$$1600 \text{ kVA} * \%3 < Q_c(\text{stable}) < 1600 * \%5$$

$$48 \text{ kVAr} < Q_c(\text{stable}) < 80 \text{ kVAr}$$

No	Level	Power
1	Stable	50 kVAr
2	1.level	40 kVAr
3	2.level	50 kVAr
4	3.level	50 kVAr
5	4.level	50 kVAr
6	5.level	50 kVAr
7	6.level	50 kVAr
8	7.level	60 kVAr
9	8.level	60 kVAr
10	9.level	60 kVAr
11	10.level	60 kVAr
12	11.level	60 kVAr

$$\text{Total} = 635 \text{ kVAr} > 633.6 \text{ kVAr}$$

Figure 2

3. CABLE AND LINE SELECTION CALCULATION

First of all, I have to find main distribution panel current using this equation.

$$I_{ADP} = \frac{P_k}{\sqrt{3} * V_{LL} * \cos \varphi} = \frac{1440}{\sqrt{3} * 380 * 0.99} = 2209.5 \approx 2210 A$$

In using table 5h-a, we can find the selected cable for main distribution panel

$1 * 240 \text{ mm}^2$ cable is carrying 561 A current in air, so if I use this cable for three phase can enough for 2210 A current.

Tablo-5h. a) Tek damarlı NYY kablo (0,6/1 kV) teknik bilgileri

Normal Kest mm ²	Dış Çap (yaklaşık) mm	Net Ağırlık (yaklaşık) kg/km	SU	ELEKTRİKSEL ÖZELLİKLER									
				DC Direnci 20°C de max	AC Direnci 70°C max	Endüktans 0°C	Endüktif Direnç (X ₀) 0°C	Endüktif Direnç (X ₁) 0°C	Akım Taşıma Kapasitesi	Toprakta 20°C	Havada 30°C		
mm ²	mm	kg/km	m	ohm/km	ohm/km	mH/km	mH/km	ohm/km	ohm/km	0°C	0°C	0°C	0°C
1x1,5	5,8	50	1000	12,1	14,478	0,505	0,459	0,159	0,144	-	-	25	29
1x2,5	8,2	60	1000	7,41	8,862	0,47	0,423	0,148	0,133	-	-	34	37
1x4	7	85	1000	4,61	5,516	0,45	0,404	0,141	0,127	-	-	45	37
1x6	7,5	105	1000	3,08	3,685	0,426	0,38	0,134	0,119	-	-	57	48
1x10	9	160	1000	1,83	2,19	0,395	0,35	0,124	0,110	-	-	78	66
1x16	10	215	1000	1,15	1,376	0,374	0,327	0,117	0,103	127	107	103	89
1x25	11,5	320	1000	0,727	0,87	0,358	0,312	0,112	0,098	163	137	137	113
1x35	12,5	420	1000	0,524	0,627	0,345	0,299	0,108	0,094	195	165	169	145
1x50	14	570	1000	0,387	0,464	0,336	0,29	0,105	0,091	230	195	208	176
1x70	15,5	780	1000	0,268	0,321	0,326	0,28	0,102	0,088	282	239	261	224
1x95	18	1050	1000	0,193	0,232	0,321	0,274	0,101	0,085	338	287	321	271
1x120	19,5	1300	1000	0,153	0,184	0,315	0,269	0,099	0,085	382	329	374	314
1x150	21	1600	1000	0,124	0,15	0,313	0,265	0,098	0,084	429	366	428	361
1x185	23,5	1950	1000	0,0991	0,121	0,31	0,264	0,097	0,083	453	414	454	412
1x240	27	2550	1000	0,0754	0,093	0,307	0,261	0,096	0,082	561	481	590	484
1x300	30,5	3150	1000	0,0601	0,075	0,305	0,258	0,096	0,081	632	542	678	549
1x400	34	4200	1000	0,047	0,051	0,302	0,256	0,095	0,080	730	542	817	657
1x500	39	5200	1000	0,0365	0,049	0,299	0,252	0,094	0,079	823	542	940	749
1x650	42	6450	500	0,0283	0,041	0,293	0,247	0,092	0,078	866	775	1108	920

SU: Sekir Uzunluğu
soc: Bu şekil, düz terlip veya yan yana şeklinde adlandırılır.
örn: Bu şekil üçgen terlip veya dömet şeklinde adlandırılır.

$$3[(5 * 240 \text{ mm}^2)] + 3(1 * 240 \text{ mm}^2) \text{ NYY cable}$$

For 3 phases

$$5 * 561 * 0.88 = 2468.4 A > 2210 A$$

Correction factor

Each output panel have 144 kW power and if I use the formula again, I will find,

$$I_G = I_O = I_K = I_H = I_A = I_N = I_B = I_Y = I_R = I_{1907}$$

$$= \frac{P}{\sqrt{3} * V_{LL} * \cos \varphi} = \frac{144 * 10^3}{\sqrt{3} * 380 * 0.8} = 273.481 A$$

Figure 3

We can find the cable measure using with table 5h – c,

The correction factor is '1' because there is no other cable in the cable tray or on the route where the cable is laid.

$$(3 * 120 \text{ mm}^2) * 1$$

$$282 * 1 \text{ A} = 282 \text{ A} > 273.481 \text{ A}$$

Correction factor

PANEL NO	PULLED		SYSTEM	LAYING	CORRECTION	SELECTED CABLE	CABLE DRAWER	THIS SLAP SHAPE DRAWER	CABLE DRAWER -NYY
	Power (kW)	Current (A)							
MAIN DISTURI BITON PANEL	1440	2209.5	5	AIR	0.88	$3[(5 * 240 \text{ mm}^2)] + 3(1 * 240 \text{ mm}^2)$ NYY cable	$5 * 561 * 0.88 = 2468.4 \text{ A}$	$2468.4 \text{ A} > 2210 \text{ A}$	240
G PANEL	144	273.481	2	AIR	1	(3 * 120 mm ²)	273.481 A	$282 \text{ A} > 273.481 \text{ A}$	120
O PANEL	144	273.481	1	AIR	1	(3 * 120 mm ²)	273.481 A	$282 \text{ A} > 273.481 \text{ A}$	120
K PANEL	144	273.481	2	AIR	1	(3 * 120 mm ²)	273.481 A	$282 \text{ A} > 273.481 \text{ A}$	120
H PANEL	144	273.481	2	AIR	1	(3 * 120 mm ²)	273.481 A	$282 \text{ A} > 273.481 \text{ A}$	120
A PANEL	144	273.481	2	AIR	1	(3 * 120 mm ²)	273.481 A	$282 \text{ A} > 273.481 \text{ A}$	120

N PANEL	144	273.481	2	AIR	1	(3 * 120 mm ²)	273.481 A	282 A > 273.481 A	120
B PANEL	144	273.481	2	AIR	1	(3 * 120 mm ²)	273.481 A	282 A > 273.481 A	120
Y PANEL	144	273.481	2	AIR	1	(3 * 120 mm ²)	273.481 A	282 A > 273.481 A	120
R PANEL	144	273.481	2	AIR	1	(3 * 120 mm ²)	273.481 A	282 A > 273.481 A	120
1907 PANEL	144	273.481	1	AIR	1	(3 * 120 mm ²)	273.481 A	282 A > 273.481 A	120

O&G Trafo Merkezlerinin Projelendirilmesi

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Tablo-5h. c) Üç damarlı NYY kablo (0,6/1 kV) teknik bilgileri

Normal Kest	Dış Çap (yaklaşık)	Net Ağırlık (yaklaşık)	Sekm Uzunluğu	ELEKTRİKSEL ÖZELLİKLER			
				DC Direnç 20°C max	AC Direnç 70°C max	Endüktans Direnç (X)	Akım Taşıma Kapasitesi
mm ²	mm	kg/km	m	ohm/km	ohm/km	ohm/km	Toprakta 20°C (A) 30°C (A)
3x1,5	12	200	1000	12,1	14,478	0,328	0,103 26 165
3x2,5	13	250	1000	7,41	8,866	0,304	0,096 34 25
3x4	14,5	340	1000	4,61	5,516	0,303	0,095 44 34
3x6	16,5	420	1000	3,05	3,685	0,288	0,090 56 43
3x10	19,5	620	1000	1,83	2,19	0,269	0,083 75 60
3x16	20,5	835	1000	1,15	1,376	0,255	0,080 98 80
3x25/16	24	1250	1000	0,727	0,87	0,255	0,060 98 80
3x35/16	26	1600	1000	0,574	0,627	0,265	0,050 129 106
3x50/25	29,5	2100	1000	0,367	0,464	0,246	0,077 157 131
3x70/35	33,5	2900	1000	0,268	0,321	0,247	0,078 185 159
3x95/50	38	3900	1000	0,193	0,232	0,258	0,076 225 202
3x120/70	42	4900	1000	0,153	0,194	0,231	0,075 275 244
3x150/95	48	5900	500	0,124	0,15	0,233	0,073 313 282
3x185/115	51	7200	500	0,0991	0,121	0,233	0,073 353 324
3x240/150	58	9450	500	0,0754	0,093	0,232	0,073 371 435
3x300/175	65	11800	250	0,0601	0,075	0,231	0,073 454 481
3x400/185	71	15500	250	0,047	0,06	0,229	0,072 524 560

Figure 4

BOYUT VE AĞIRLIKLAR				ELEKTRİKSEL ÖZELLİKLER				
Normal Kest	Dış Çap (yaklaşık)	Net Ağırlık (yaklaşık)	Sekm Uzunluğu	DC Direnç 20°C max	AC Direnç 70°C max	Endüktans Direnç (X)	Akım Taşıma Kapasitesi	Toprakta 20°C (A) 30°C (A)
mm ²	mm	kg/km	m	ohm/km	ohm/km	ohm/km	Toprakta 20°C (A) 30°C (A)	
3x1,5	12	200	1000	12,1	14,478	0,328	0,103	26 165
3x2,5	13	250	1000	7,41	8,866	0,304	0,096	34 25
3x4	14,5	340	1000	4,61	5,516	0,303	0,095	44 34
3x6	16,5	420	1000	3,05	3,685	0,288	0,090	56 43
3x10	19,5	620	1000	1,83	2,19	0,269	0,085	75 60
3x16	20,5	835	1000	1,15	1,376	0,255	0,080	98 80
3x25/16	24	1250	1000	0,727	0,87	0,255	0,060	128 106
3x35/16	26	1600	1000	0,574	0,627	0,265	0,077	157 131
3x50/25	29,5	2100	1000	0,367	0,464	0,246	0,078	185 159
3x70/35	33,5	2900	1000	0,268	0,321	0,247	0,078	225 202
3x95/50	38	3900	1000	0,193	0,232	0,258	0,075	275 244
3x120/70	42	4900	1000	0,153	0,194	0,231	0,073	313 282
3x150/95	46	5900	500	0,124	0,15	0,233	0,073	353 324
3x185/115	51	7200	500	0,0991	0,121	0,233	0,073	371 341
3x240/150	58	9450	500	0,0754	0,093	0,232	0,073	454 481
3x300/175	65	11800	250	0,0601	0,075	0,231	0,073	524 560

Figure 5

4. BUS-BAR CROSS SECTION CALCULATION

$$P_k = 1440 \text{ kW} \quad I_{ADP} = \frac{P_k}{\sqrt{3} * V_{LL} * \cos \varphi} = \frac{1440}{\sqrt{3} * 380 * 0.99} = 2209.5 \approx 2210 \text{ A}$$

$$R_{bara} = \frac{l}{ks}$$

$$X_{Lbara} = 2\pi f * 2 \left[\ln \left(2 * \frac{a\pi + h}{b\pi + 2h} + 0.03 \right) \right] * 10^{-7}$$

I decided cable measure using in table 7h-a.

		SÜREKLİ YÜKLEME AKIMI (A) - 50 Hz A.C																
Beyütler mm	Kesit mm ²	Ağırlık kg/m	Boyalı Bara Adedi				Çiplak Bara Adedi				I	II	III	IV	V	VI	VII	VIII
			I	II	III	IV	V	VI	VII	VIII								
12x2	24	0.21	125	250	—	—	110	220	—	—	—	—	—	—	—	—	—	
15x2	30	0.27	155	270	—	—	140	240	—	—	—	—	—	—	—	—	—	
15x3	45	0.40	185	330	—	—	170	300	—	—	—	—	—	—	—	—	—	
20x2	40	0.36	205	350	—	—	185	315	—	—	—	—	—	—	—	—	—	
20x3	60	0.54	245	425	—	—	220	380	—	—	—	—	—	—	—	—	—	
20x5	100	0.89	325	550	—	—	290	495	—	—	—	—	—	—	—	—	—	
25x3	75	0.67	300	510	—	—	270	460	—	—	—	—	—	—	—	—	—	
25x5	125	1.12	385	670	—	—	350	600	—	—	—	—	—	—	—	—	—	
30x3	90	0.80	350	600	—	—	315	540	—	—	—	—	—	—	—	—	—	
30x5	150	1.34	450	780	—	—	400	700	—	—	—	—	—	—	—	—	—	
40x3	120	1.07	480	780	—	—	420	710	—	—	—	—	—	—	—	—	—	
40x5	200	1.78	600	1000	—	—	520	900	—	—	—	—	—	—	—	—	—	
40x10	400	3.56	835	1500	2060	2800	750	1350	1850	2500	—	—	—	—	—	—	—	
50x5	250	2.23	720	1200	1750	2300	630	1100	1500	2100	—	—	—	—	—	—	—	
50x10	500	4.45	1025	1800	2450	3330	920	1620	2200	3000	—	—	—	—	—	—	—	
60x5	300	2.67	825	1400	1980	2650	750	1300	2800	2400	—	—	—	—	—	—	—	
60x10	600	5.34	1200	2100	2800	3800	1100	1860	2500	3400	—	—	—	—	—	—	—	
80x5	400	3.56	1085	1800	2450	3300	950	1650	2200	2900	—	—	—	—	—	—	—	
80x10	800	7.12	1540	2600	3300	4600	1400	2300	3100	4200	—	—	—	—	—	—	—	
100x5	500	4.45	1310	2200	3400	4600	1400	2000	2600	3400	—	—	—	—	—	—	—	
100x10	1000	8.90	1880	3100	2950	3800	1100	1700	2700	3800	4800	—	—	—	—	—	—	
120x10	1200	10.68	2200	3500	4800	6100	2000	3200	4200	5500	—	—	—	—	—	—	—	
160x10	1600	14.24	2880	4400	5800	7800	2500	3900	5200	7000	—	—	—	—	—	—	—	

Figure 6

I chose that in the table $2 * (80 * 10)$ mm painted Bara

$2600 > 2210 \text{ A}$ Suitable ✓

$$h = 80 \text{ mm} = 8 \text{ cm}, b = 10 \text{ mm} = 1 \text{ cm}$$

$$a_{ave} = \sqrt{a_1 * a_2 * a_3} = 12.59 \cong 12.6 \text{ cm}$$

$$l = 2 \text{ m}, a_1 = 10 \text{ cm} a_2 = 20 \text{ cm} a_3 =$$

$$10 \text{ cm} (\text{random chose}), \text{ so I get } R_{bara} = \frac{2}{56 * 80 * 10} = 0.045 \text{ m}\Omega$$

$$X_{Lbara} = 2 * \pi * 50 * 2 \left[\ln \left(2 \frac{12.6\pi + 8}{\pi + 2 * 8} + 0.03 \right) \right] * 10^{-7}$$

$$= 0.101 \text{ m}\Omega$$

$$0.101 \text{ m}\Omega * 2 \text{ meter} = 0.202 \text{ m}\Omega$$

$$Z_{bara} = \sqrt{R_{bara}^2 + jX_{bara}^2} = 0.20 \text{ m}\Omega$$

$$\text{To compensation BUS BAR } I_{ADP} = \frac{633.6*10^3}{\sqrt{3}*380} = 962.6 A$$

I have to choose %20 more to this value.

$$962.6 + 192.5 = 1155.1 A$$

If I chose (60 * 10) mm 1200 > 1155.1 A Suitable ✓

$$h = 60 \text{ mm} = 6 \text{ cm}, b = 10 \text{ mm} = 1 \text{ cm}$$

$$a_{ave} = \sqrt{a_1 * a_2 * a_3} = 12.59 \cong 12.6 \text{ cm}$$

$$l = 2 \text{ m}, a_1 = 10 \text{ cm} a_2 = 10 \text{ cm} a_3 = 20 \text{ cm} (\text{random chose}), \text{ so I get } R_{bara} = \frac{2}{56*80*10} = 0.045 \text{ m}\Omega$$

$$X_{Lbara} = 2 * \pi * 50 * 2 \left[\ln \left(2 \frac{12.6\pi + 6}{\pi + 2 * 6} + 0.03 \right) \right] * 10^{-7} = 0.131 \text{ m}\Omega$$

$$0.131 \text{ m}\Omega * 2 \text{ meter} = 0.262 \text{ m}\Omega$$

$$Z_{bara} = \sqrt{R_{bara}^2 + jX_{bara}^2} = 0.264 \text{ m}\Omega$$

5. VOLTAGE REGULATION CALCULATION

L=125 m (random chose)

$$\text{For mono phase } \%e = \frac{2*100*P*L}{K*S*U_{LN}^2}$$

$$\text{To three phases } \%e = \frac{100*P*L}{K*S*U_{LN}^2}$$

Each output panel has 144 kW power I used and

$$\cos \varphi = 0.8 \quad L = 150m \quad 0.6/1 \text{ kV PVC isolated NYY cable}$$

$$I = \frac{P}{\sqrt{3}*U_n*\cos(\varphi)} = \frac{144*10^3}{\sqrt{3}*380*0.8} = 274 A$$

(In Table 5h-c) 3*120 mm² NYY cable

$$\%e = \frac{100*P*L}{K*S*U_{LN}^2} = \frac{100*144*10^3*125}{56*380^2*120} = 1.854 < 3 \text{ (suitable)}$$

To real value of voltage drop

$$R = 0.184 \Omega, X_L = 0.073 \frac{\Omega}{km}, L = 125$$

$$\%e = \frac{\sqrt{3}*I_b*L*(R_{cable}*\cos(\varphi)+X_{cable}*\sin(\varphi))}{U_{LL}} * 100$$

$$\%e = \frac{\sqrt{3}*274*0.125*(0.184*0.8+0.073*0.6)}{380} * 100$$

$$\%e = 2.98 < 3 \quad (\text{Suitable}) \quad \checkmark$$

$$\%e = L * P * k_3 + L * P * m_3 * \tan(\varphi) \quad \text{To (NYY 3*120 mm}^2)$$

$$\cos(\varphi) = 0.8, \tan(\varphi) = 0.75$$

$$k_3 = \frac{100}{56*120*380^2} = 1.03 * 10^{-7} \Omega/m*V^2$$

$$X_L = 0.073 \frac{\Omega}{km} \quad m_3 = \frac{100*0.073*10^3}{380^2} = 5.055*10^{-8} \Omega/m*V^2$$

To (NYY 3*120 mm²)

50 m

$$L * P(k_3 + m_3 * \tan(\varphi)) = 50 * 144 * 10^3 (1.03 * 10^{-7} + 5.055 * 10^{-8} * 0.75) = 1.01 < 3 \quad (\text{Suitable}) \quad \checkmark$$

100 m

$$L * P(k_3 + m_3 * \tan(\varphi)) = 100 * 144 * 10^3 (1.03 * 10^{-7} + 5.055 * 10^{-8} * 0.75) = 2.03 < 3 \quad (\text{Suitable}) \quad \checkmark$$

150 m

$$L * P(k_3 + m_3 * \tan(\varphi)) = 150 * 180 * 10^3 (1.03 * 10^{-7} + 5.055 * 10^{-8} * 0.75) = 3.04 < 3 \quad (\text{Not Suitable}) \quad X$$

To Bara system, $l = 2 m$ painted Bara

(80*10 mm)

$$\%e = \frac{100*1440*10^3*2}{56*380^2*80*10} = 0.44 < 5 \quad (\text{Suitable}) \quad \checkmark$$

$$\%e = \frac{\sqrt{3}*I_b*L*(\frac{1}{k*s}*\cos(\varphi)+X_{bara}*\sin(\varphi))}{U_{LL}}*100$$

$$\%e = \frac{\sqrt{3}*2210*2*(\frac{1}{56*80*10} * 0.8 + 10^{-3} * 0.6)}{380} * 100$$

$$\%e = 1.245 < 3 \quad (\text{Suitable}) \quad \checkmark$$

To (k) approaches

$$R = \frac{L}{K*S} \quad e = \frac{\Delta U}{U} \quad \%e = \frac{\Delta U}{U} * 100$$

$$\Delta_U = \frac{P * L}{U * \cos(\varphi)} * (R * \cos(\varphi) + X_k * \sin(\varphi))$$

$$\Delta_U = \frac{P * L^2}{U * K * S} \left(1 + \frac{X_k}{R} * \tan(\varphi) \right)$$

$$\%e = \frac{\Delta_U}{U} = \frac{P * L * k}{U^2 * K * S} * 100$$