20 KV TRANSMISSION LINE

20 KV CABLE CALCULATION

	DESIGN:		DATE:		REVISION DESCRIPTION:	CLIENT:
	CHECK:		DATE:			
	APPR1:		DATE:		ISSUED FOR APPROVAL	
	APPR2:		DATE:			
	CLIENT:					
	CONSULTANT:					

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A - 1 - INTRODUCTION

In order to selection of suitable 20 KVcable (from 20KVside of 132/20KV SUBSTATION to 20KV transmission line),necessary calculation has done as following :

A - 2 - REQUIRED NOMINAL CURRENT :

$$I_n = \frac{S_n \times 1000}{U_n \times \sqrt{3}}$$

S_n = Rated Power 6.5 MVA

U_n = Nominal Voltage = 20 KV

I_n = Nominal Current

→ I_n = 187.6 **A**

A - 3 - -CALCULATION METHODS :

A - 3 -1 CURRENT - CARRYING CAPACITY CRITERIA :

It is necessary to check that conductor cross - section , chosen whit respect to current carring capacity .The maximum values for the current capacity of cables laid in air can be found in ABB switchgear manual (10th Edition) . Different condition must be taken into account by application of conversion factors to the above current rating values . According to manufacturer(ALBORZ CO.)catalogue and ABB manual,two derating factors affects on rated current :

$$I_{Red} = I_n \;/\; (f_1 \,.\, f_2)$$

I_{Red} : Reduced Current Rating

f_1 : Conversion factor for defferent air temperatures

from table 13 - 51 , column 11 (ABB switchgear manua , page 655)

For XLPE cable → f_1 = 0.87

f_2 : Conversion factor for grouping

from table 13 - 52 , column 2 (ABB switchgear manua , page 657)

Number of racks = 2 , perforated cable troghs → f_2 = 0.93

$I_{Red} = I_n \;/\; (f_1 \,.\, f_2)$ = 231.91 **A**

Selection of suitable cable size:

According to Table1 rated current capacity of each (1 x 150) mm^2 cable is 320 A , thus selected Cable will be: (1x 300) mm^2 / Phase

A - 3 - 2 VOLTAGE DROP CRITERIA :

The following formula applies for the resistance R of conductor

$$R = (\rho \times L) / S$$

L = Total Length of conductor
S = Cross - section area of conductor
ρ = Specific resistance (at 20° c)

According to ***ABB*** switchgear manual the temperature coefficient is calculated from following formula :

$$a = 1 + 0.00392 (t - 20)$$

Where t is desired Temperature 90 ° C

The manufacture of Cable is ***ALBORZ*** (Or Similar) and the resistance & current rating of cables (Table 13 - 48 , column 5 ABB switchgear manua , Page 653) is :

Table 1 :

CABLE SIZE (mm2)	RESISTANCE AT 20° c (Ω/Km)	RESISTANCE (Ω/Km) AT 90 °C	INDUCTIVE REACTANCE (Ω/Km)	CURRENT RATING (A)
70	0.268	0.342	0.129	297
95	0.193	0.246	0.123	361
120	0.153	0.195	0.118	416
150	0.124	0.158	0.114	470
185	0.0991	0.126	0.110	538
240	0.0754	0.096	0.106	634
300	0.0601	0.077	0.102	724
400	0.047	0.060	0.098	829
500	0.0366	0.047	0.094	953

Formula for calculation of voltage drop in 3-phase AC system is:

$$V.D. = \frac{\sqrt{3} . L . I . (R_L . \cos\varphi + X_L . \sin\varphi) . 100}{1000 . n . U} \%$$

Where :

L = One-Way length of conductor **(m)** -------------------- **2000**
I = Current **(A)** ----------------------------------- **187.6**
R_L = Cable resistance per Km at 90 ° C **(Ω / Km)** ------ **0.158**
X_L = Cable reactance per Km **(Ω / Km)** ------------------- **0.114**
U = Phase to phase voltage **(V)** --------------------------- **20000**
$\cos\varphi$ = Load factor ------------------------------------ **0.8**
n = Number of cable per phase -------------------------- **1**

thus for this case whit (1*150) mm ^{2} cable per each phase we have :

V.D. = 0.6331 %

Whit considering permissible voltage drop equal to : **1.0** %

0.6331 < 1.0 condition is OK.

A - 3 - 3 SHORT CIRCUIT CRITERIA :

Short circuit current for three - phase fault is calculated by following equation :

$$I_{sc} = \frac{1.1 \times U_n}{\sqrt{3} \times Z}$$

Z is total Impedance and can be Find in :

$$Z = Z_{Tr} + Z_C$$

Where :

Z_{Tr} = Power Transformer Impedance

Z_C = Cable Impedance

And we have :

$$Z_{Tr} = \frac{U_n^2 \times U_k \%}{S_n}$$

S_n = Transformer Rated Power =	6.5	MVA
U_n =Transformer Nominal Voltage =	20	KV
U_k = Transformer Impedance Voltage =	12	%

→ $Z_{Tr} = X_{Tr} =$ j 7.385 Ω ($X_{Tr} >> R_{Tr}$)

Cable Impedanceas is calculated as below :

$$Z_C = (R_C + j X_C) = L \times (R_L + j X_L)$$

For Cable size (1*150) , L= 2000 m , t =20° C

$Z_C =$ 0.2480 + j 0.2280 Ω

And we have :

$Z =$ 0.2480 + j 7.6126 Ω

$|Z| = \sqrt{R^2 + X^2} =$ 7.6167 Ω

$I_{sc} =$ 1667.6 A

And in following SCF is calculated by :

$$SCF = \frac{I_{sc} \times \sqrt{t}}{n \, . \, S}$$

When the SCF < K the SCF criteria is satisfied

Where :

K = Current density of XLPE cable =	95	A / mm ^{2}
t = Short circuit duration in s =	1	s
S = Cross - section area of conductor	150	mm ^{2}

→ SCF = 11.12 A / mm 2 < 95 condition is OK.