The Use of Sheath Sectionalizers (Open Circuit Sheath) to Maintain the Ampacity of Cable Systems with Separated Phases

IEEE/ICC EDUCATION PROGRAM
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Frank Di Guglielmo, PE
Supervising Engineer

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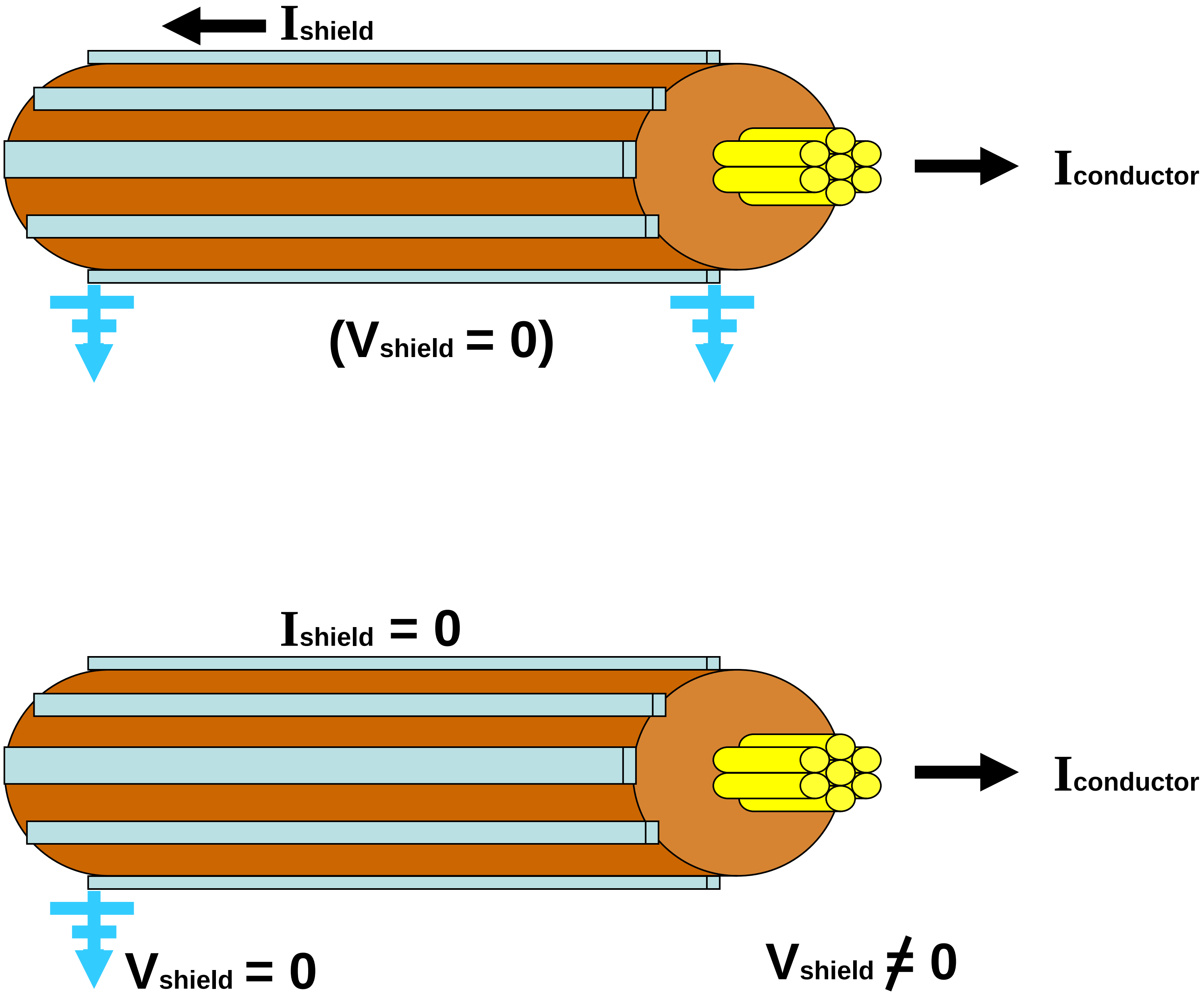
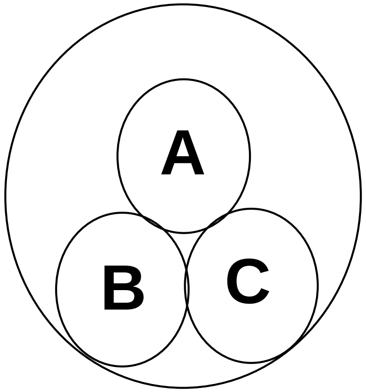
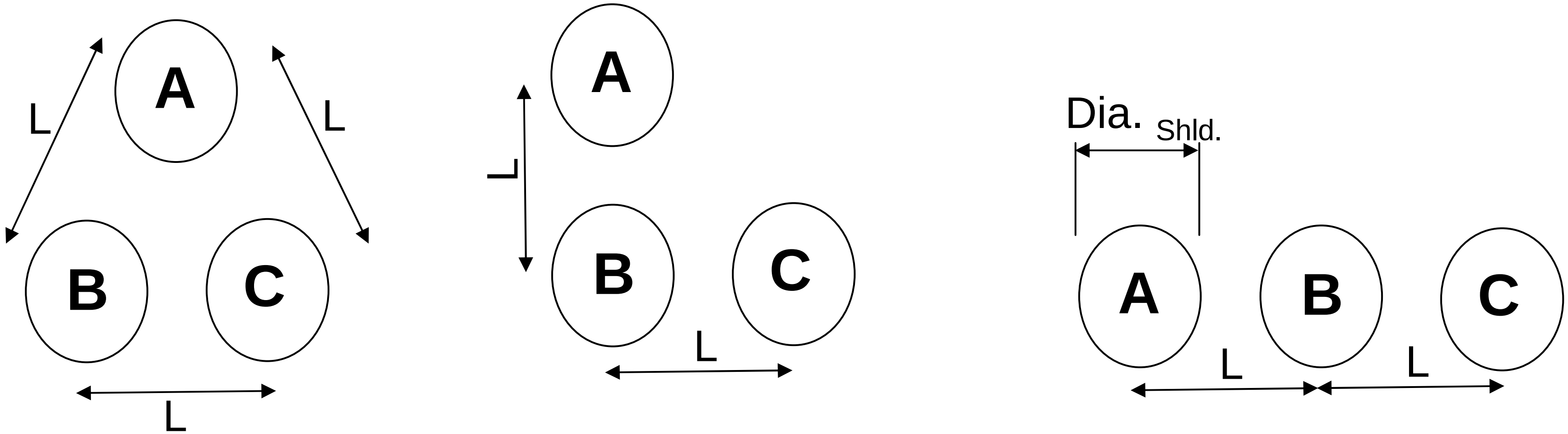


I_{shield}
$I_{conductor}$
$(V_{shield} = 0)$
$I_{shield} = 0$
$I_{conductor}$
$V_{shield} = 0$
$V_{shield} \neq 0$



With both ends grounded shield loss is approximately 5% (15 amps on a 300 amp design).



8“ or 9” spacing with both ends grounded shield loss is approximately 20% (60 amps on a 300 amp design).

V_{sheath} = 0.053 X log ((2 X Dm) / Ds) X I_{cond})

Where:

V sheath = Shield voltage / 1000 ft.

Dm = Geometric mean distance between cables

= L for separated equilateral triangular formation

= Cable OD for triplexed cables

= 1 1/8 X L for right triangular formation

= 1 ¼ X L for flat formation

Ds = Diameter of the cable metallic shield

I_{cond} = Cable phase current

Maximum Allowable Open

Circuited Sheath Voltages

V_O = 25 Volts (Old Paper & Lead Days)

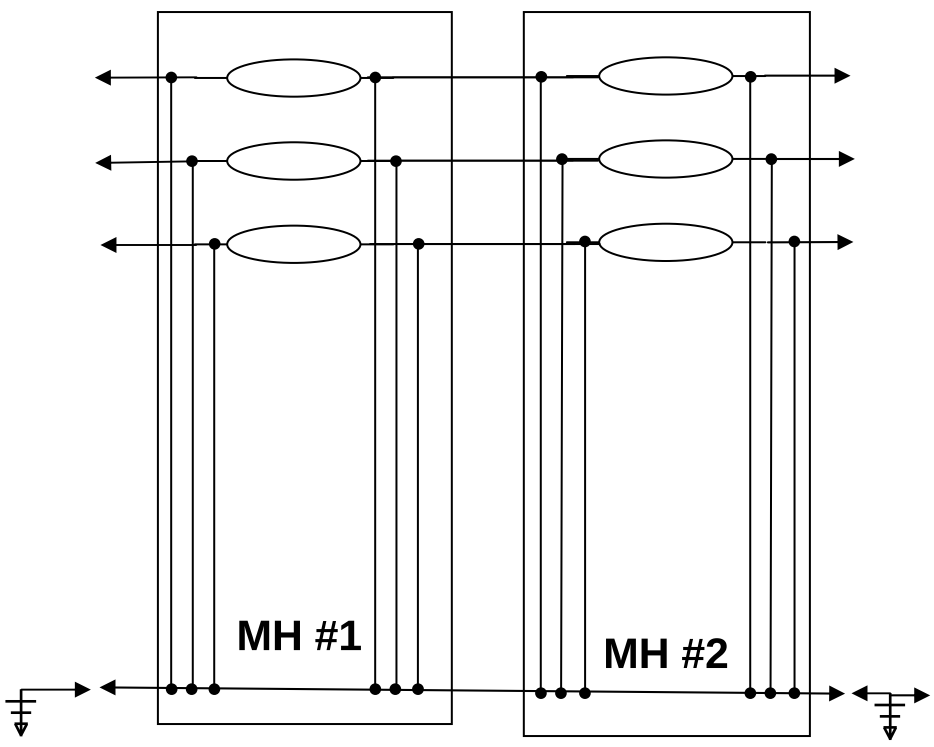
V_O = 50 Volts (Conservative Today)

V_O = 70/80 Volts (Perception Level)

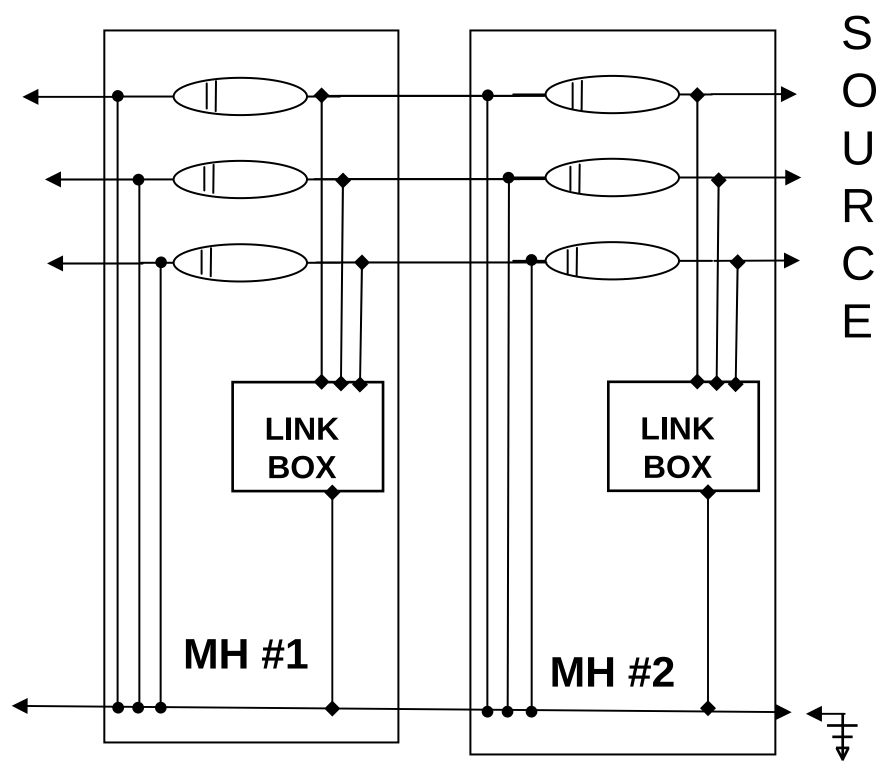
V_O = 125/400 Volts * (Some Cable Manufacturers Today)

* Requires safety analysis to eliminate bare metal exposure and properly insulated cables for the link box leads,
Because of through going fault currents.

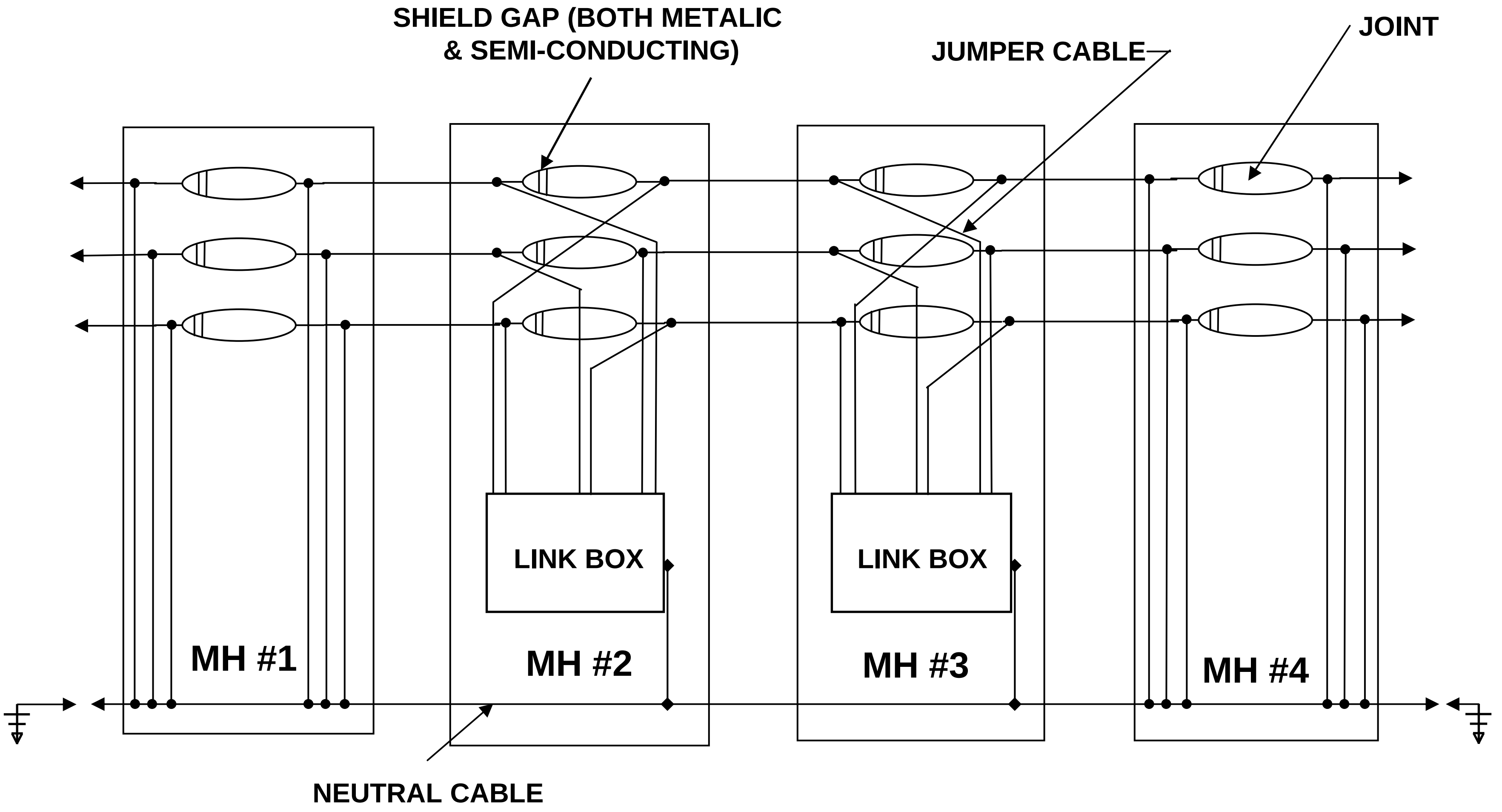
SHORT CIRCUITED SHEATH
(GROUNDED BOTH ENDS)

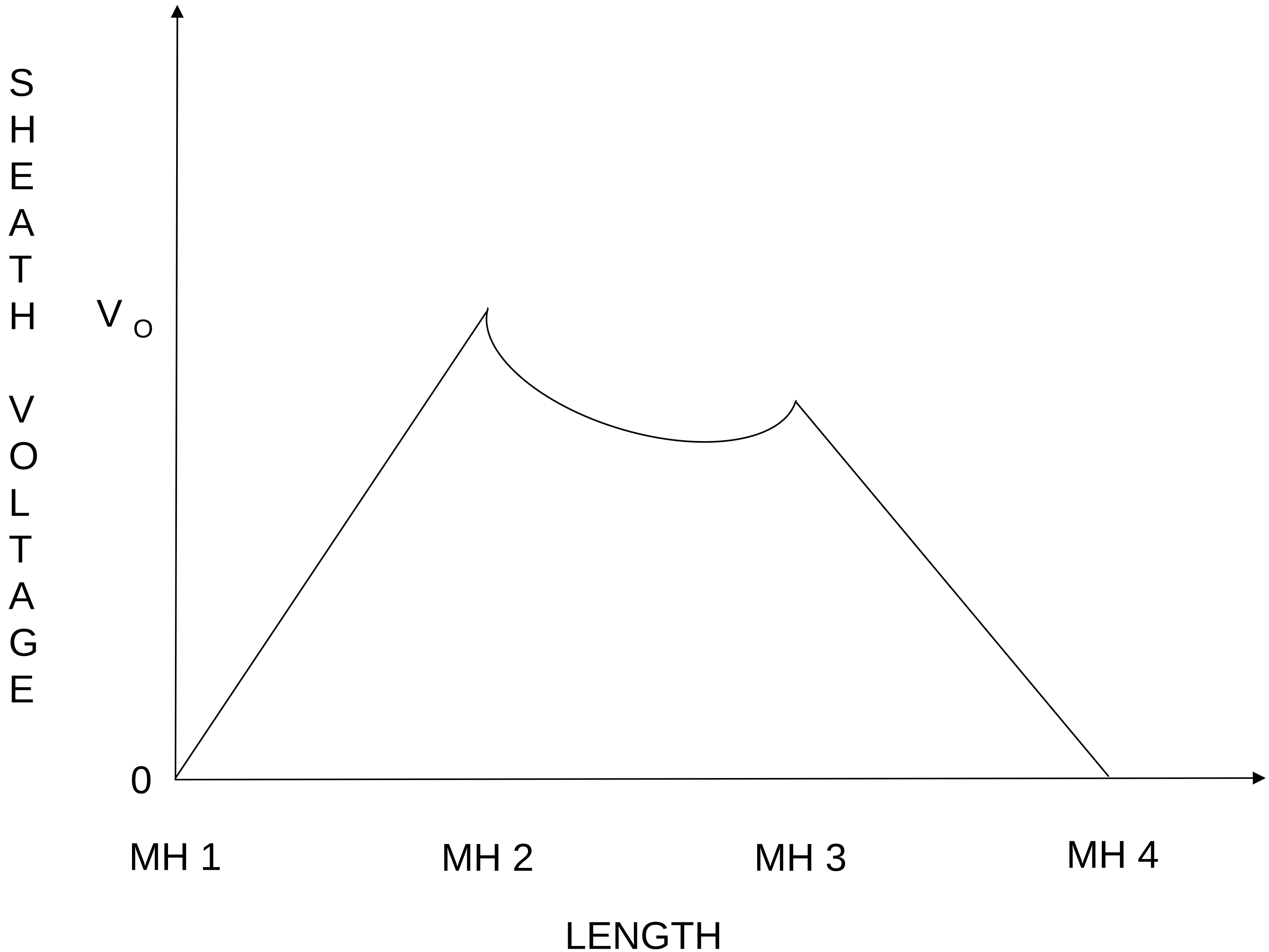


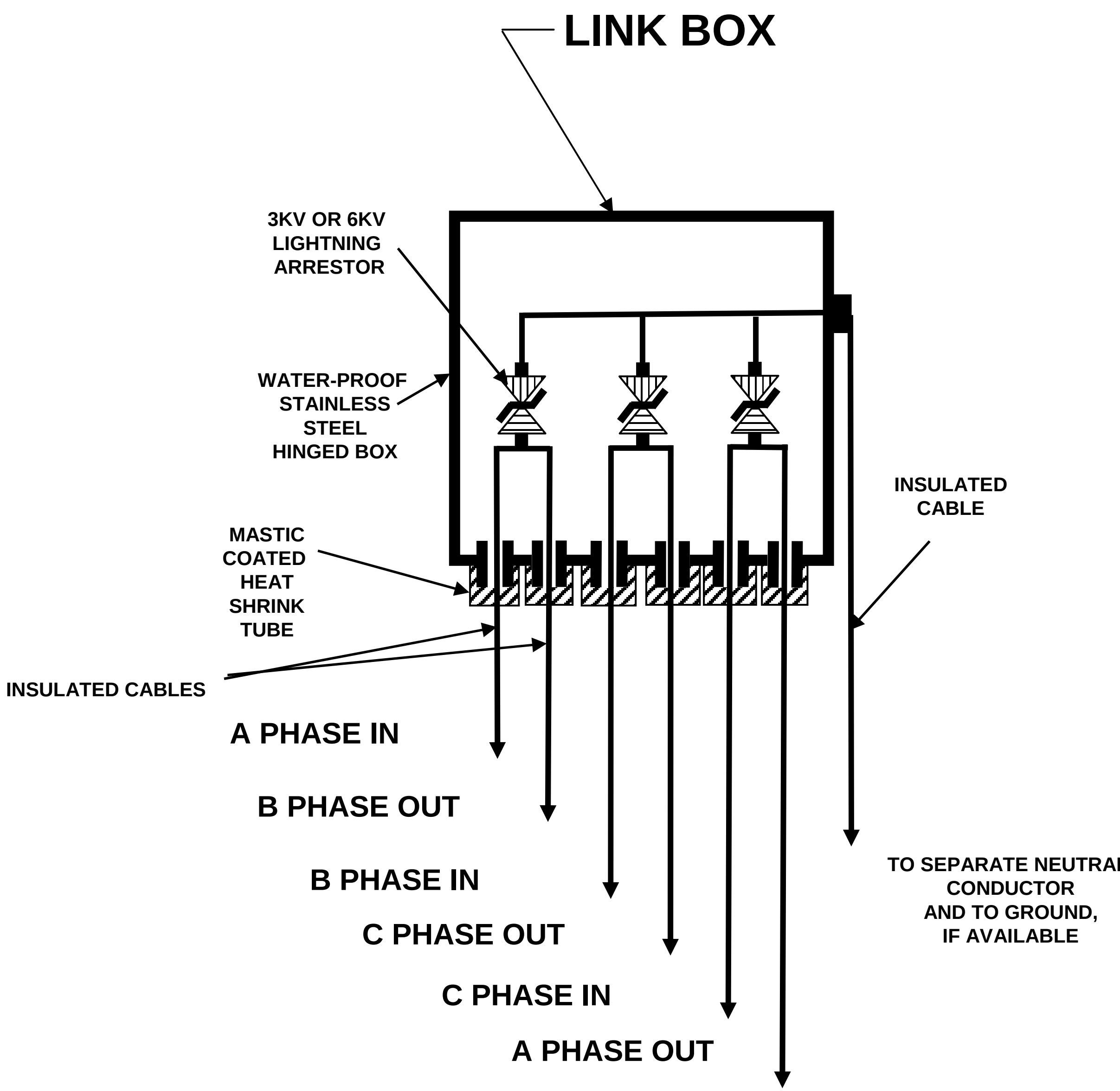
OPEN CIRCUITED SHEATH
(SOURCE END GROUNDED
LOAD END FLOATING)



ROTATED CROSS BONDED SHEATH JOINTS




SHEATH VOLTAGE
V O
0
MH 1
MH 2
MH 3
MH 4
LENGTH


LINK BOX
3KV OR 6KV LIGHTNING ARRESTOR
WATER-PROOF STAINLESS STEEL HINGED BOX
MASTIC COATED HEAT SHRINK TUBE
INSULATED CABLE
INSULATED CABLES
A PHASE IN
B PHASE OUT
B PHASE IN
C PHASE OUT
C PHASE IN
A PHASE OUT
TO SEPARATE NEUTRAL CONDUCTOR AND TO GROUND, IF AVAILABLE

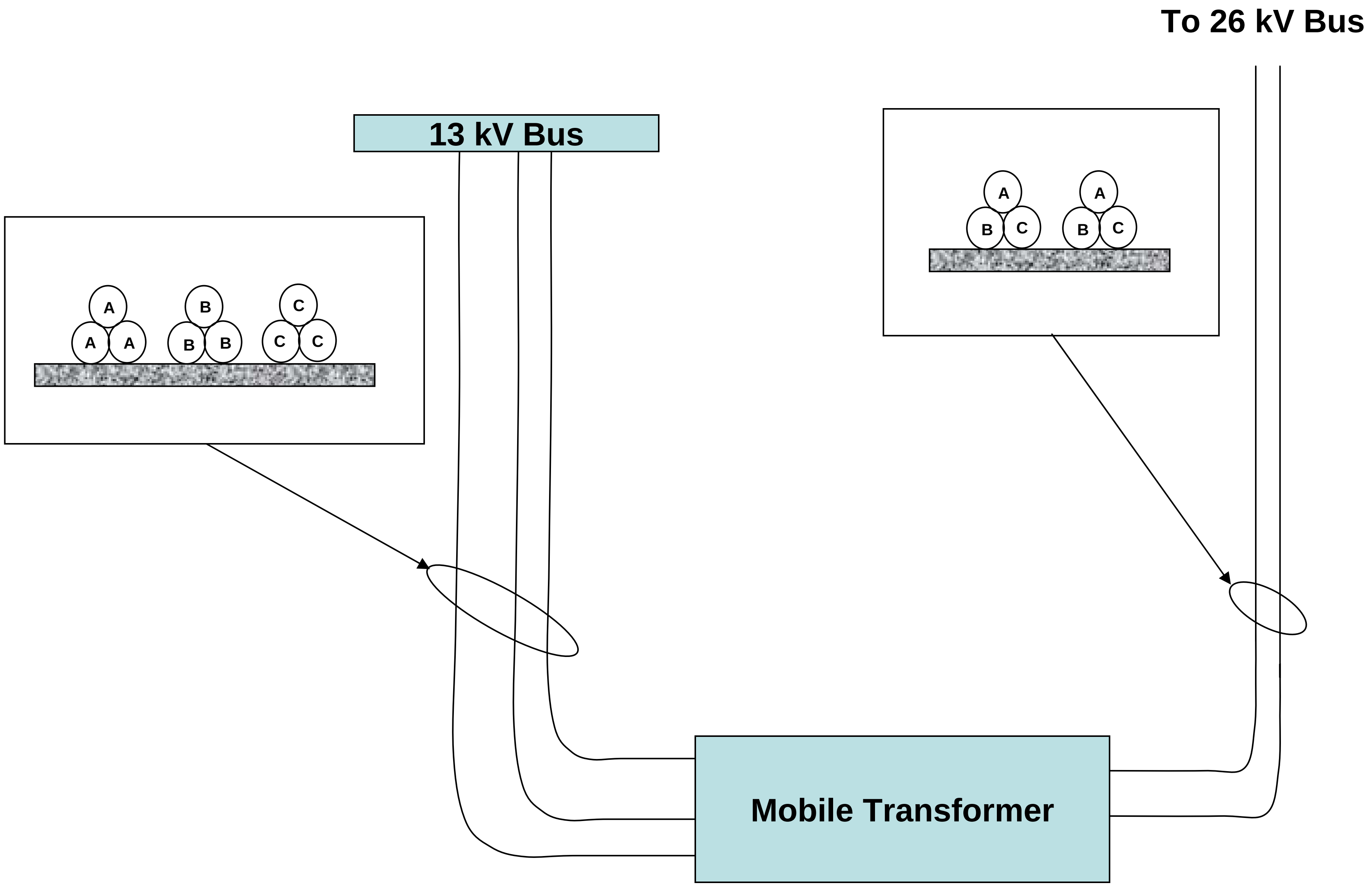
IEEE Guide for Bonding of High-Voltage Single-Conductor Power Cables - DRAFT 8

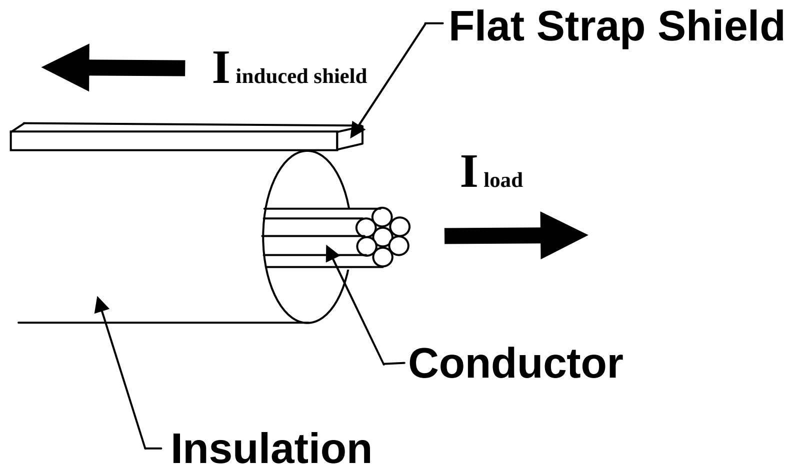
Sponsored by the
Insulated Conductors Committee of the IEEE Power Engineering Society

At the time this standard was completed,
the working group had the following membership:

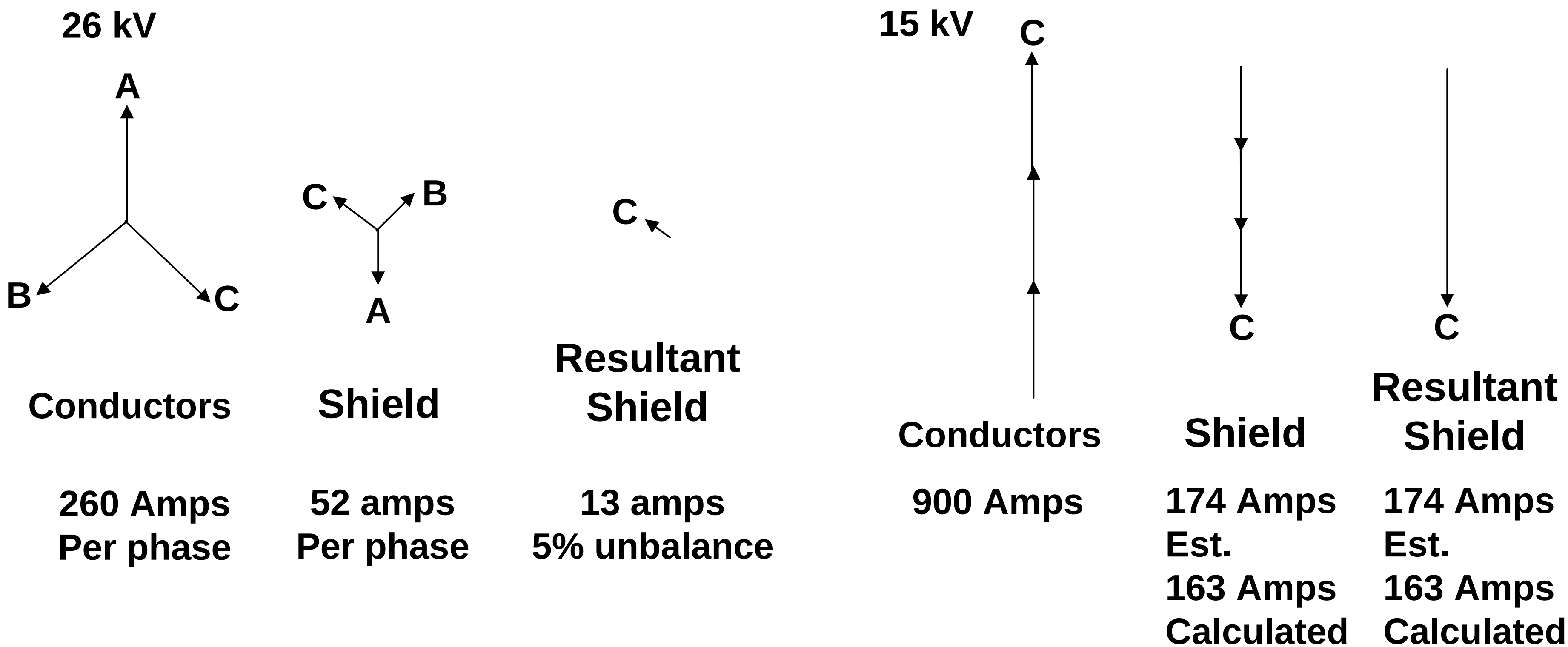
Michael D. Buckweitz, *Chair*
Thomas C. Champion, *Vice Chair*
Torben Aabo, Richard W. Allen, Jr. , Pierre Argaut, Ray Awad
Earle C. Bascom, III, Mohamed Chaaban, John H. Cooper,
Dennis F. DeCosta, Swapan K. Dey, Anthony Ernst,
William G. Hansen, Wolfgang B. Haverkamp,
Dennis E. Johnson, Arthur J. Kroese

Marion Drive Substation





Flat Strap Shield
I induced shield
I load
Conductor
Insulation



26 kV
A
B
C
C
B
A
C
Conductors
Shield
Resultant Shield
260 Amps Per phase
52 amps Per phase
13 amps 5% unbalance
15 kV
C
C
C
Conductors
Shield
Resultant Shield
900 Amps
174 Amps Est. 163 Amps Calculated
174 Amps Est. 163 Amps Calculated

Calculation of Induced Shield Currents on Mobile Transformer's 15 kV Cables

Assumed Current per Phase = 321 Amps. (22 MVA)

V_{ocs}, if bus end ungrounded = 0.5 V / 100 amps / 100 ft. = (.5) X (9.63) X (.75)

= 3.6 volts

Watts loss in conductor = (I)2 X (R ac cond)**

Watts loss reflected in shield = [(I)2 X (R ac shield)] + [(I)2 X (X mutual) X (number of additional phases)]**

R ac shield = R cu / (D X L)

R cu = .004

D = Mean Diameter of Shield = 1.385"

L = Thickness of Shield = .01

R ac shield = .004 / (1.385 X .01)

X mutual = [(53) X (log 10 (2S / D)] X (10)-3

S = Phase Spacing in Inches = 10"

D = Mean Diameter of Shield = 1.385"

X mutual = [(53) X (log 10 ({2 X 10} / 1.385)] X (10)-3

= 53 X 1.16 X 0.001 = 0.06

W shield = [(321 X 321) X .29] + [(321 X 321) X (.06) X (2)]

W shield = 42,247 Watts

Shield = 9 X .020" X .175" = 0.0315 in.2**

I2 = W / R = 42247 / 10 = 4225**

I = SQ RT (W / R) = 65.00 Amps

R ac shield = R cu / (D X L)

R cu = .004

D = Mean Diameter of Shield = 1.385" X 1.5

L = Thickness of Shield = .01

R ac shield = .004 / (1.385 X 1.5 X .01) = 0.19

X mutual = [(53) X (log 10 (2S / D)] X (10)-3

S = Phase Spacing in Inches = 10"

D = Mean Diameter of Shield = 1.385" X 1.5

X mutual = [(53) X (log 10 ({2 X 10} / 1.385 X 1.5)] X (10)-3 = 53 X 0.98 X 0.001
= 0.05

W shield = [(321 X 321) X .19] + [(321 X 321) X (.05) X (2)]

W shield = 29,882 Watts

Shield = 9 X .020" X .175" = 0.0315 in.2**
= 40,100 Circular Mils

R shield = Circular Mils / 4000 = 10 Ohms

I2 = W / R = 29882 / 10 = 2988**

I = SQ RT (W / R) = 55 Amps

I shield = I self + (2 X I adjecent) = 65 Amps + 2 X 55 Amps
= 175 Amps on each shield

Comparison (Amps):

	Rule of Thumb	Calculations	Delta
Self Inductance	**64**	**65**	**- 1**
Mutual Inductance (2X)	**61**	**55**	**+ 6**
Total	**186**	**175**	**+11**

References:

IEEE Guide for Bonding of High-Voltage Single-Conductor Power Cables, Oct. 31, 2006 – Draft 8 (ANSI / IEEE Std. 575 – 1988 Withdrawn)

EEI Underground Systems Reference Book, 1957 (Nat. Elec. Light Assoc. Underground Systems Reference Book, 1931)

USS Electrical Wire and Cable Handbook, 1956

USS Pipeliners' Handbook, 1965

Westinghouse T&D Handbook, 1964

AIEE Paper, "The Calculation of the Temperature Rise and Load Capability of Cable Systems", by J. Neher & M. Mc Grath, 1957

EPRI Underground Transmission Systems Reference Book, 2006 (1992)

Misc. Synaptic Activities' Rules of Thumb, 2007

FRANK’S RULES OF THUMB

1. Shield loss current = 5% of conductor current for triplexed cables.

2. Shield loss current = 20% of conductor current for cables separated by 8” or 9”.

3. Open circuited sheath voltage = 0.5 volt for each 100 amps of conductor current for each 100 feet of length.

Note:

These rules of thumb are approximations for a high level fly-by and not a substitute for running the numbers through IEEE 575 or discussions with the cable system suppliers.

Questions?