2012 IEEE Rural Electric Power Conference
Milwaukee, WI

Bonding Requirements for Conductive Poles

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HIRING


CARRINGTON SQUARE
Custom Offices
Now Pre-Selling / Leasing
COLONY
DEVELOPMENT
PARTNERS
704·362·5000
SPEED LIMIT
45
NORTH
16

System Characteristics

	Transmission	Distribution
Load Connection:	Three-Phase	Phase-to-Ground
Pole Location:	Sometimes Remote	Always in Public
Available Isc:	2000 → 7000A	5000 → 15,000A
Clearing Time:	~ 0.3 sec	> 2.0 sec
I_G:	~ 1800A @ 115 kV	~ 200A @ 7.2 kV

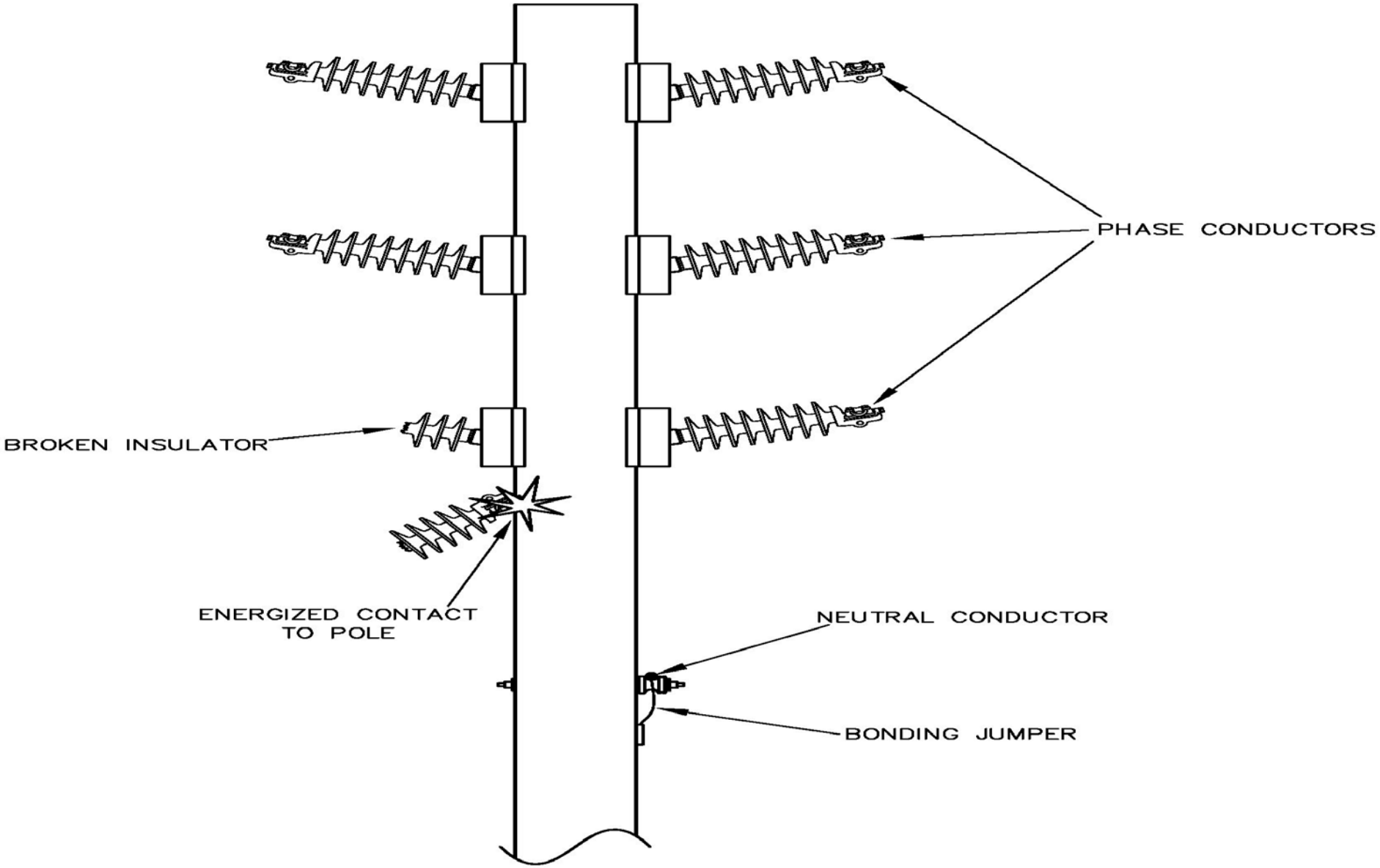
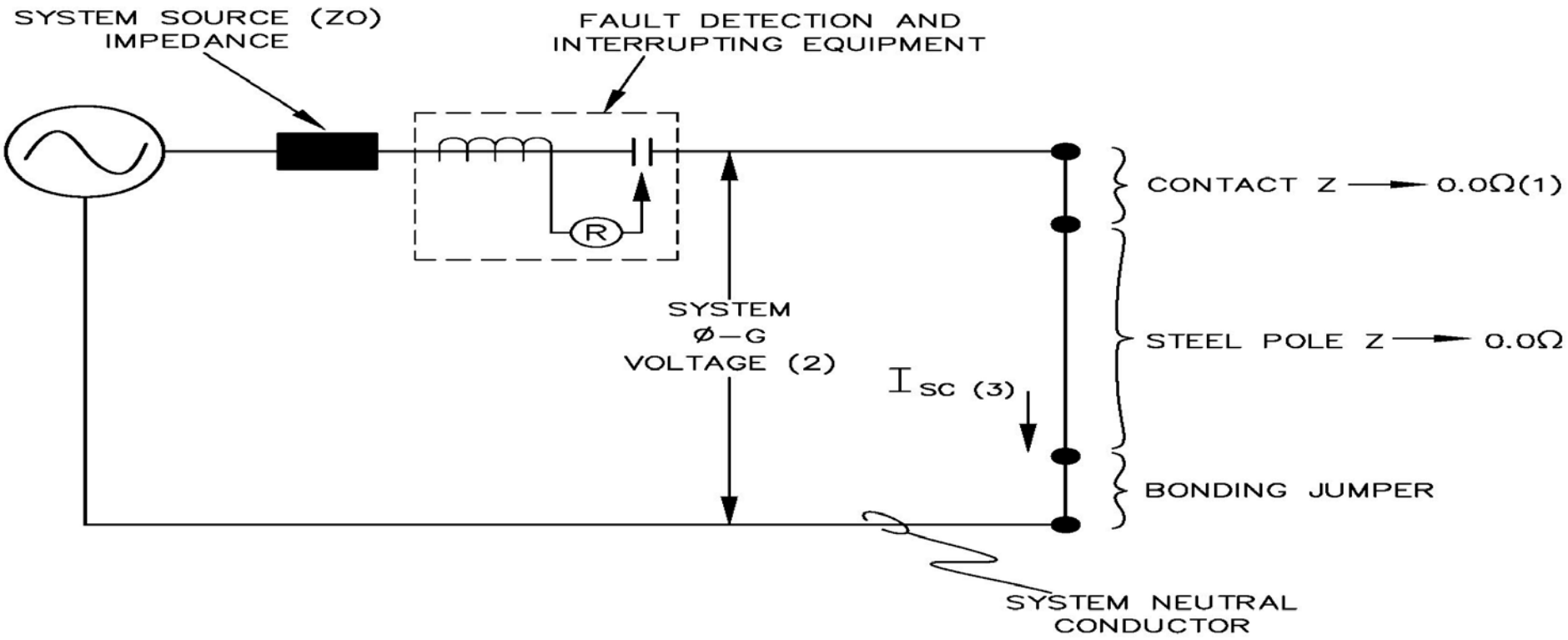


FIGURE 1A
N.T.S.



NOTES:

1. TYPICAL CONTACT IS BARE CONDUCTOR TO METAL POLE SHAFT
2. TYPICALLY 7.2KV TO 14.4KV FOR DISTRIBUTION SYSTEMS.
3. FAULT CURRENT TYPICALLY 5KA TO 15KA

FIGURE 1B

Relative Resistance to Earth

	25 m-Ω	100 m-Ω	1000 m-Ω
5/8" x 8' Rod	10	40	400
Bare Pole (Galvanized)	5.8	23	230
Coated Except 1' @ Butt	9.7	39	390

Fault Current Limitations

Configuration	100 m Ω Soil	1000 m Ω Soil
Bare Pole	250A	25A
Coated Pole	190A	19A

Consequences of Inadequate Bond

- Circuit stays energized after bond is broken.
- Pole is energized by faulted conductor.
- Contact voltage is very high.
- Concrete pole may be structurally damaged.

Advantages of Adequate Bond

- **Minimizes fault impedance to facilitate circuit clearing.**
- **Minimizes fault duration.**
- **Minimizes exposure voltages.**

Two Components of an Effective Pole - Neutral Bond

- **Jumper Conductor**
- **Connectors at each end of bonding jumper.**

Factors Affecting Size of Conductor

- **Material - Cu or Al**
- **Magnitude of Fault Current**
- **Duration of Fault Current**
- **Factor of Safety**

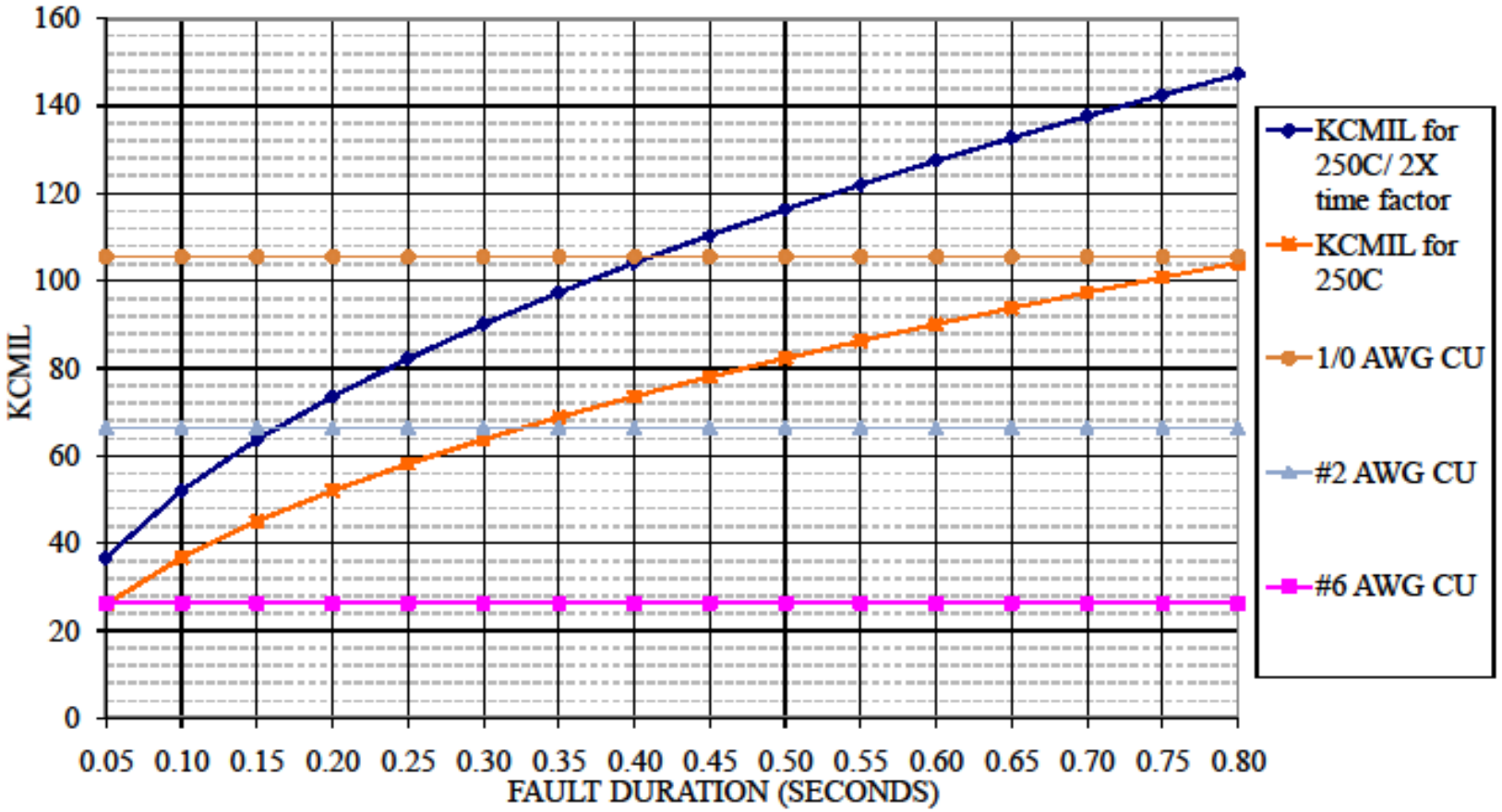
Equation for Copper Conductor

$$t = \frac{7141\ A^2}{I^2}$$

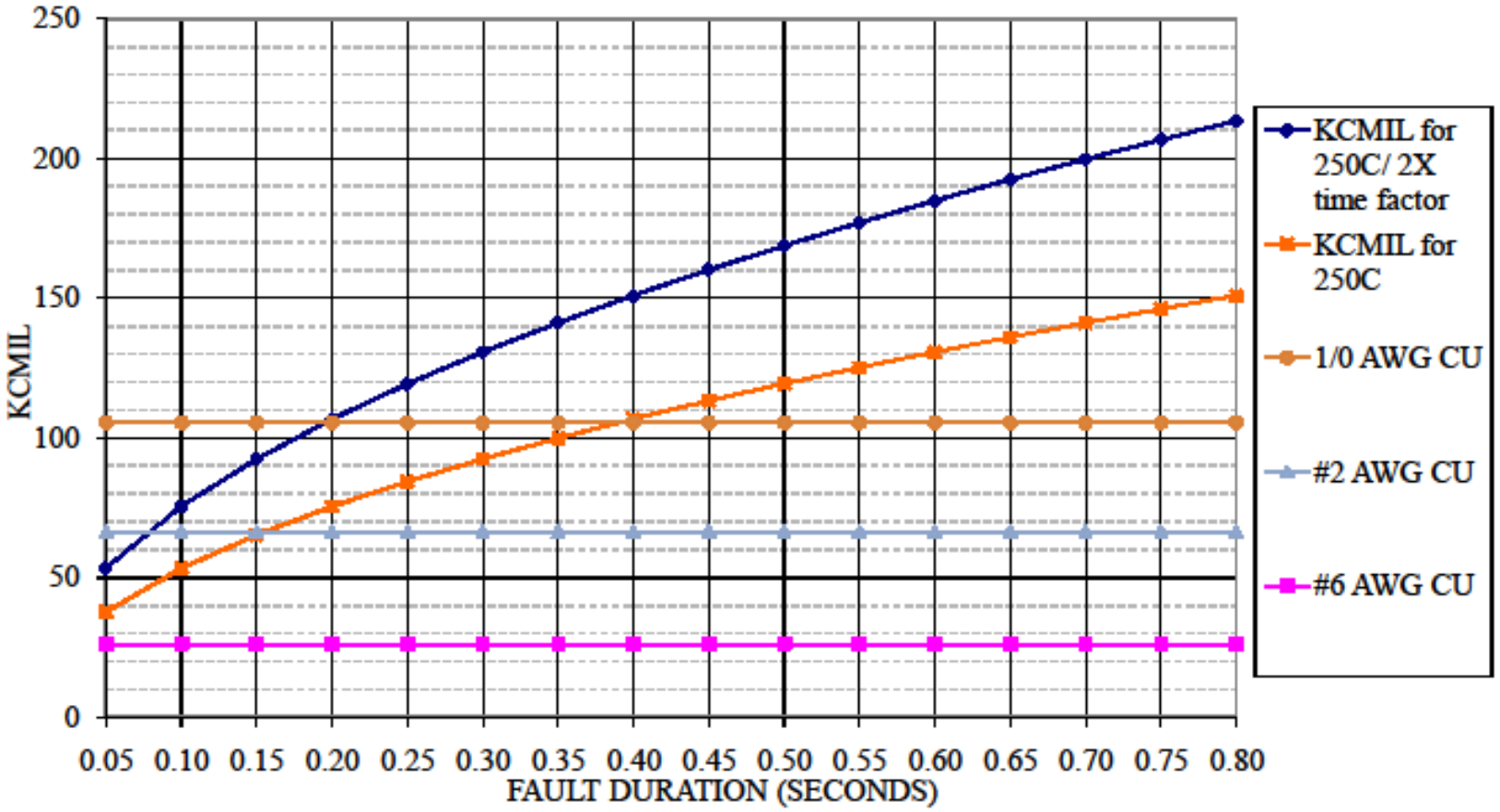
$$A = 0.01183It^{0.5}$$

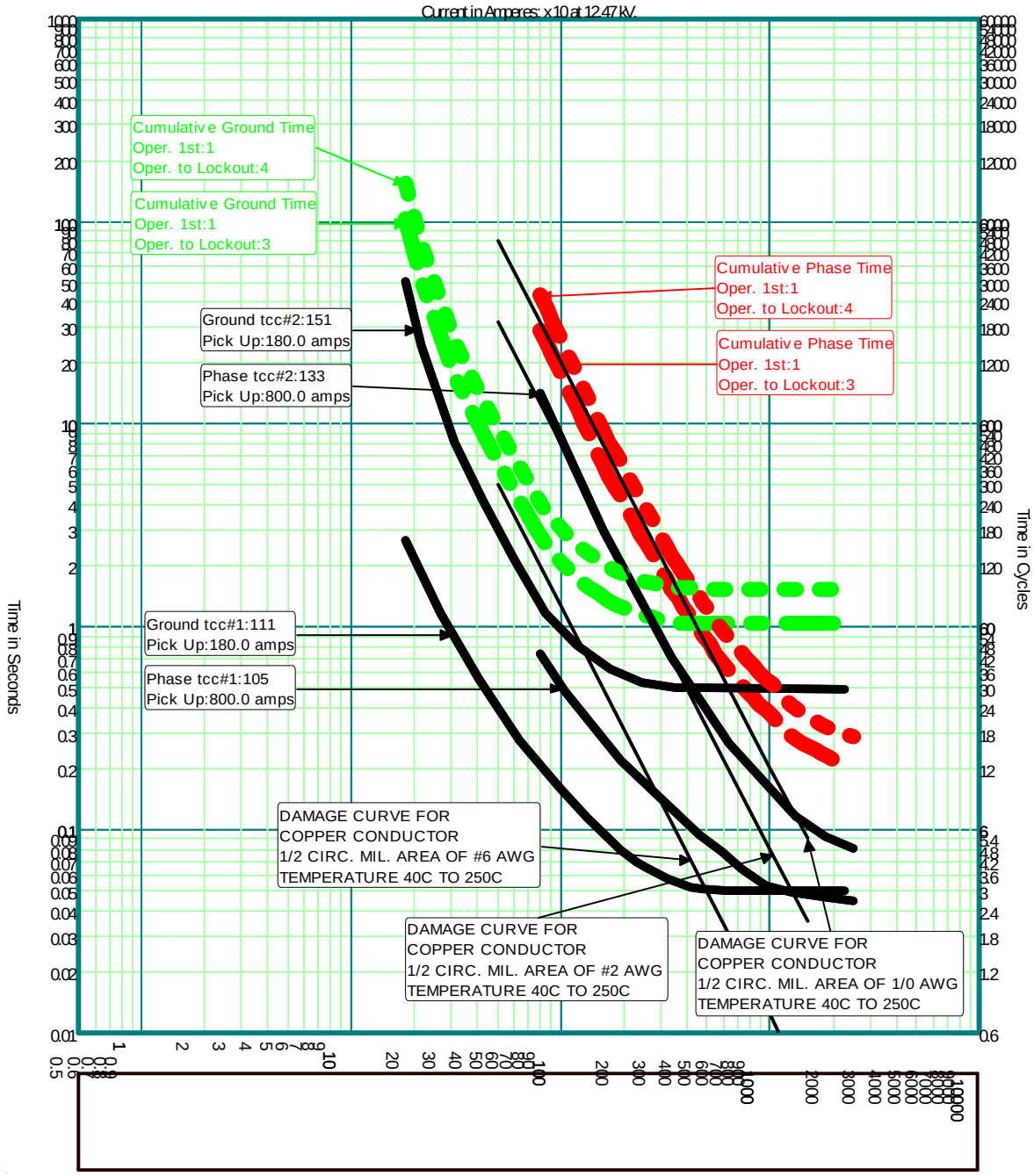
Where: I = Current Amperes
t = Duration, Seconds
A = Conductor Area, kcmil

Conductor Size Required for 10,000 AMP Fault Soft Drawn CU - Start Temp 40ºC



Conductor Size Required for 14,500 AMP Fault Soft Drawn CU - Start Temp 40°C




Current in Amperes: x10 at 12.47 kV.
Time in Seconds
Time in Cycles
Cumulative Ground Time
Oper. 1st:1
Oper. to Lockout:4
Cumulative Ground Time
Oper. 1st:1
Oper. to Lockout:3
Cumulative Phase Time
Oper. 1st:1
Oper. to Lockout:4
Cumulative Phase Time
Oper. 1st:1
Oper. to Lockout:3
Ground tcc#2:151
Pick Up:180.0 amps
Phase tcc#2:133
Pick Up:800.0 amps
Ground tcc#1:111
Pick Up:180.0 amps
Phase tcc#1:105
Pick Up:800.0 amps
DAMAGE CURVE FOR
COPPER CONDUCTOR
1/2 CIRC. MIL. AREA OF #6 AWG
TEMPERATURE 40C TO 250C
DAMAGE CURVE FOR
COPPER CONDUCTOR
1/2 CIRC. MIL. AREA OF #2 AWG
TEMPERATURE 40C TO 250C
DAMAGE CURVE FOR
COPPER CONDUCTOR
1/2 CIRC. MIL. AREA OF 1/0 AWG
TEMPERATURE 40C TO 250C

Jumper Connectors

- **Conductors (Cu) rated for 450°C**
- **Mechanical connections rated for 250°C**
- **Relative reliability for mechanical connection:**
  - **Single Bolt (Transformer Ground)**
  - **Two-bolt on Stainless Steel Pad**

Transformer Grounding Lug

Bolted 2-Hole Terminal Connector


230 kV Transmission with
23 kV Distribution Underbuild


No Pole Bond

Conclusions

- **Proper sizing of bonding jumpers is important to maintain public safety by avoidance of contact voltages on metal poles.**
- **Reasonable factors of safety are advisable in determining the minimum jumper size.**
- **The appropriate jumper size is highly dependent on overcurrent setting of circuit protective equipment. This includes the number of operations to lockout.**
- **Concrete poles are also conductive. Proper bonding is also important on these poles and pole design should be reviewed to minimize loss of structural integrity during the passage of fault currents.**
- **Any bond is better than no bond.**