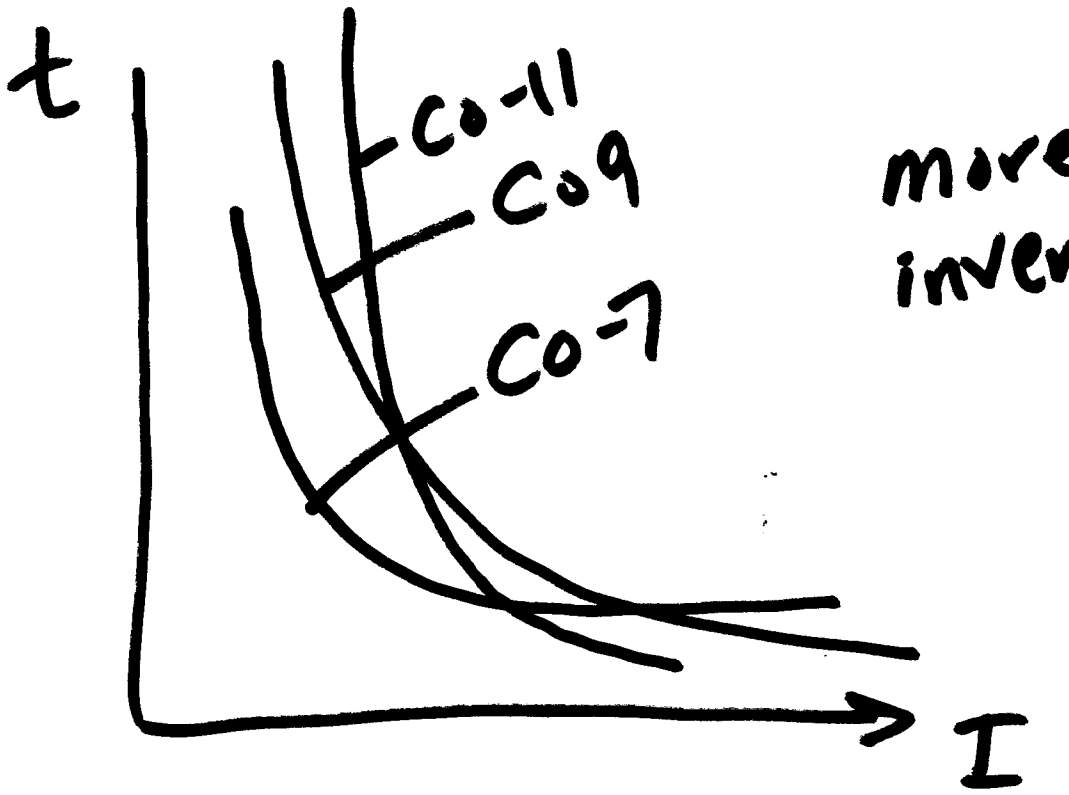
EE 5223 - Lecture 9 Fri Jan 27, 2023

Ongoing List of Topics:

- URL: http://www.ece.mtu.edu/faculty/bamork/EE5223/index.htm
- Labs - EE5224 should be on track.
- Term Project ?? – teams of 3. Spread 5224 folks (1 per team).
- Aspen -- need to use for Assn. #6. View tutorial!

Ongoing list of topics:

- Radial coordination - basic approach to coordinate “51" relays
- CT ratios, MR (multi-ratio) CTs (Print out CT handout)
- CT saturation & accuracy issues: deration for less than full turns
- Iterative method to calculate CT measurement error
- Print out MOCT & CCVT handout from web page
- MOCTs - Magneto-Optic Current Transformers
- CCVTs
- Voltage & Current relationships during faults
    - X/R ratio, dc offset, decay of dc offset
    - relative angles and magnitudes of all Vs & Is during fault



G1: Separate Relay.

more inverse ↑

Co-11
Co-9
Co-8
Co-7

$t \times I = C$

G2: Select from Curves

G3: " Add'l Functions

E-mail Forum:

ee5223-L@mtu.edu

- Technologies, examples, questions...
- Homeworks: Conceptual, not solns.

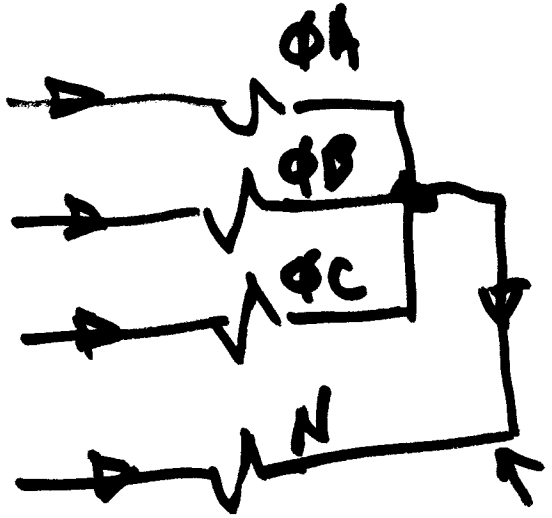
Time = Damage !

Thermal Damage $\propto t$

$\propto I^2$

$P = I_F^2 R$

$J = Pt$

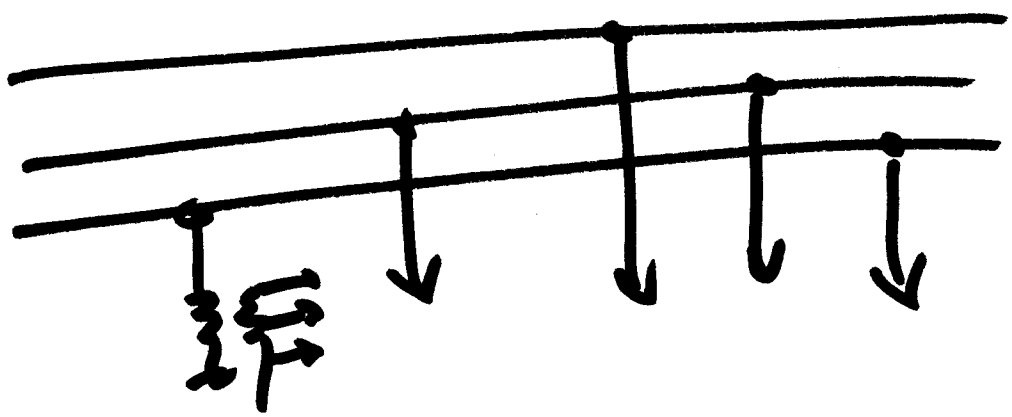


Fault Types

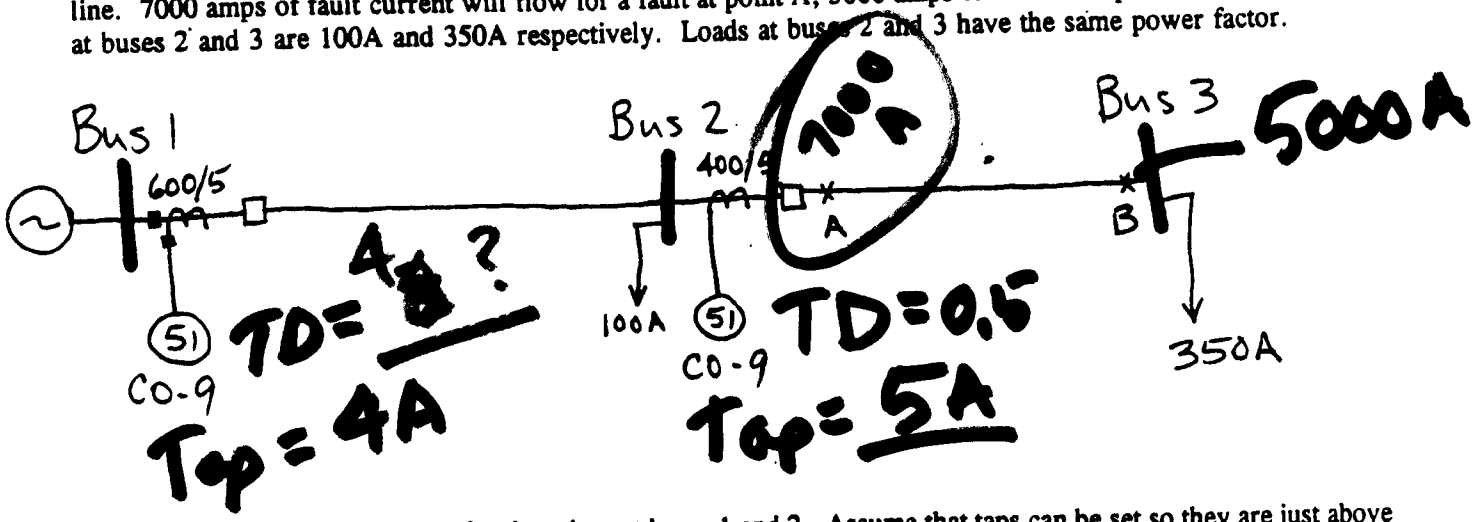
- 3Φ
- L-L
- L-G
- L-L-G

- Triplen Harm
- Phase Imbalance

- Max Load Current
- Min Fault Current



2. [20 pts] Two time-overcurrent relays protect adjacent sections of a radial system. Bus 3 is at the end of the radial line. 7000 amps of fault current will flow for a fault at point A; 5000 amps for a fault at point B. Load currents at buses 2 and 3 are 100A and 350A respectively. Loads at buses 2 and 3 have the same power factor.



a) Determine the tap settings for the relays at buses 1 and 2. Assume that taps can be set so they are just above rated load current. Available tap settings are: 1.0, 1.2, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 5.0, 6.0, 7.0, 8.0, 10.0, and 12.0 amps.

R2: $I_{R_{XL}} = \frac{350}{80} = 4.375A \Rightarrow$ 5A Tap?

R1: $I_{R_{XL}} = \frac{450}{120} = 3.75A \Rightarrow$ 4A Tap

b) Keeping in mind that the relay at bus 2 protects the last section at the end of the line, what must its time dial setting be? Why?

R2: $I_{R,F} = \frac{7000}{80} = 87.5A$

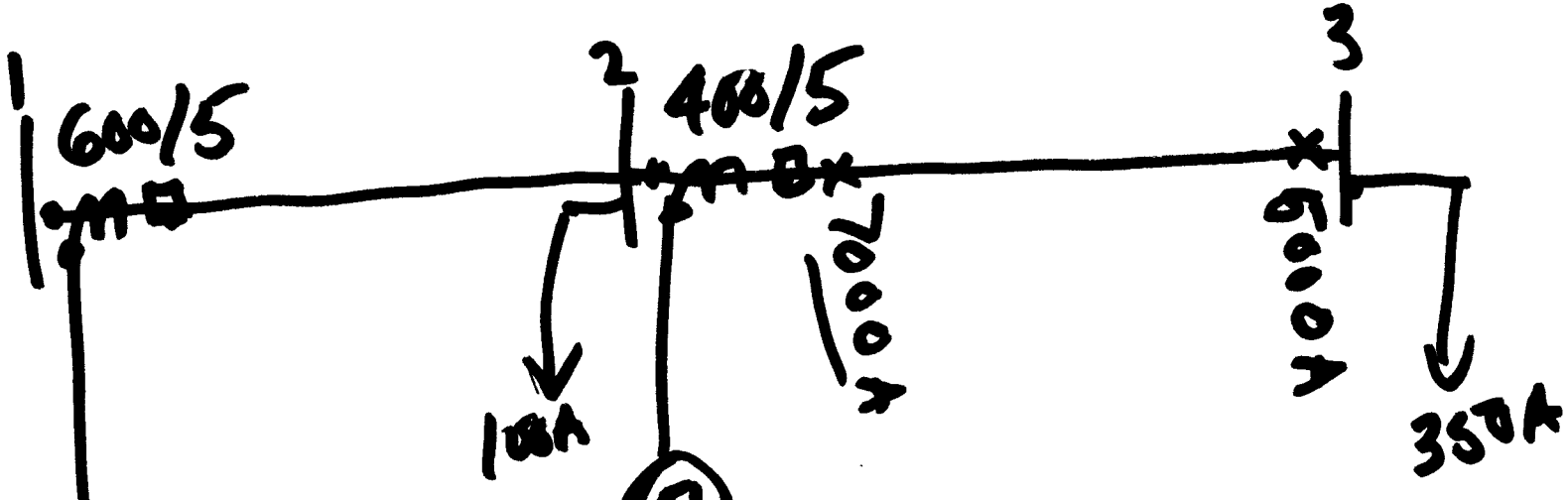
R1: $I_{R,F} = \frac{7000}{120} = 58...$

c) Based on the fault at point A, what should the time dial setting be for the relay at bus 1? Assume that the circuit breakers operate in 4 cycles, and that the CTI is 0.25 seconds.

R2 trips at 0.1s

R1: waits $0.1 + 4/60 + 0.25s$

d) How long will it take for the relay at bus 1 to pick up for a fault at point B if the relay at bus 2 fails to operate?



$$I_{R1,L} = \frac{450A}{120} = 3.75A$$

Tap: 4A

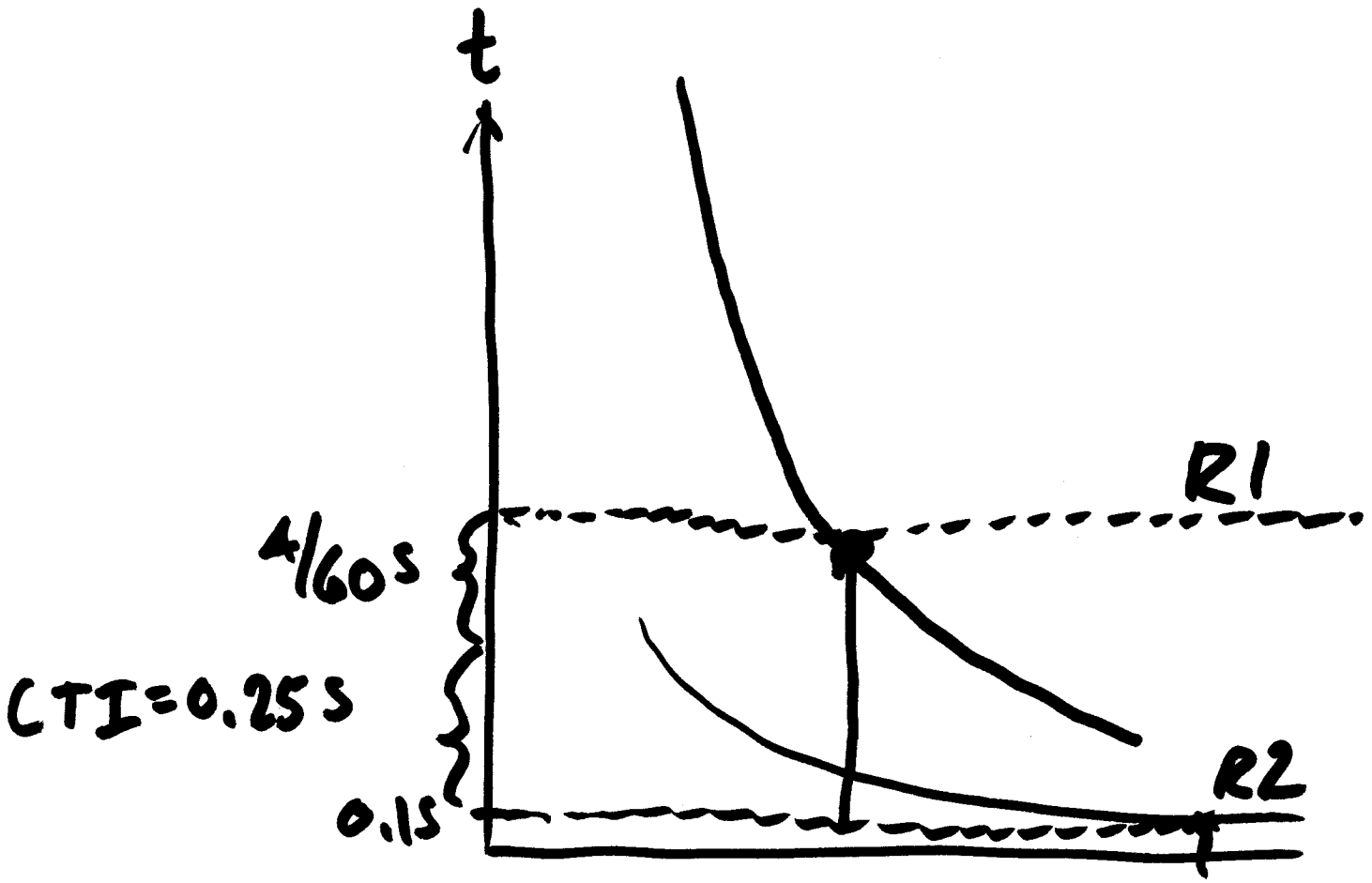
$$I_{R1,F\ (Max)} = \frac{7000A}{120} = 58A$$

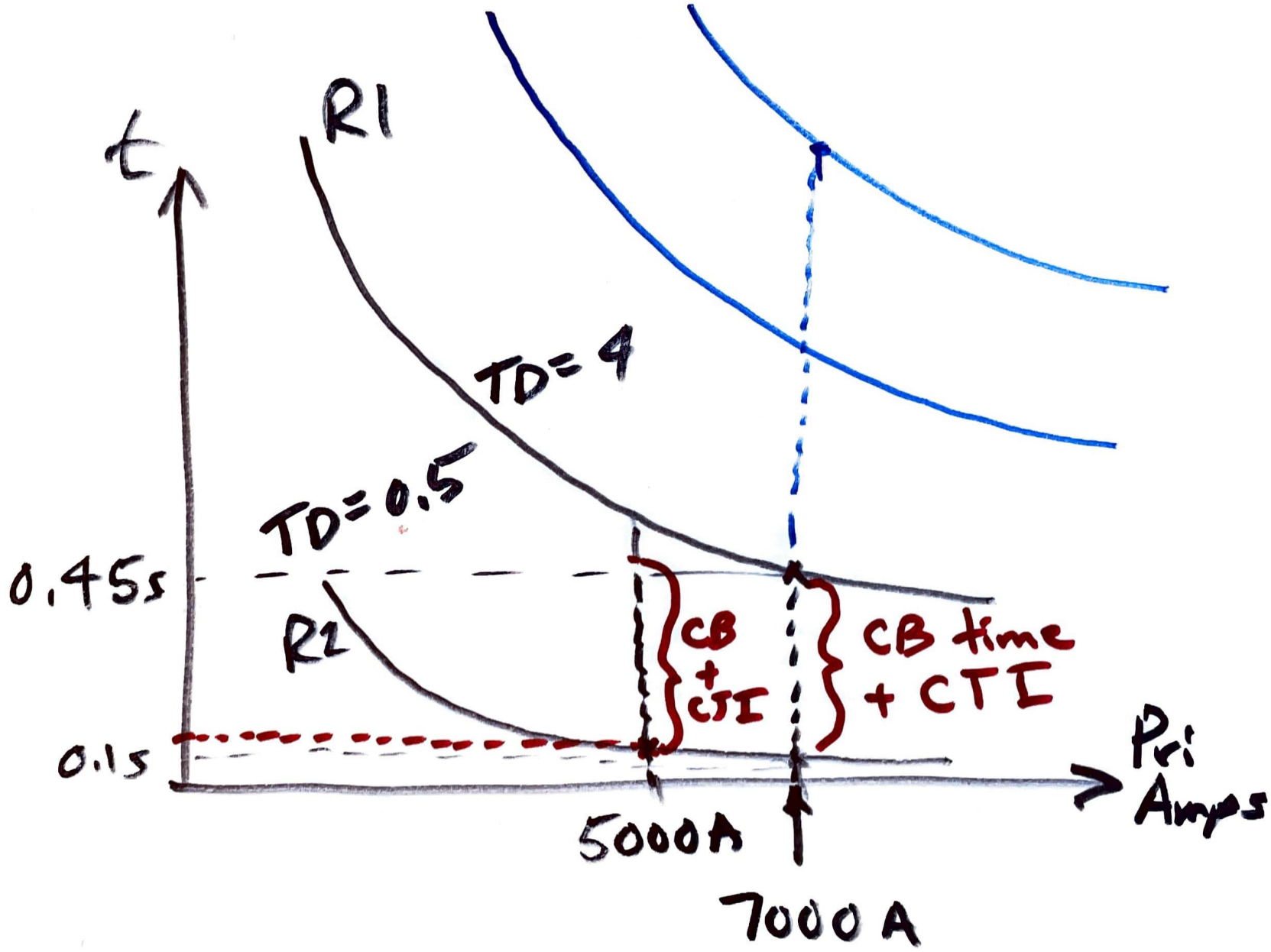
$$I_{R2,L} = \frac{350}{80} = 4.35A$$

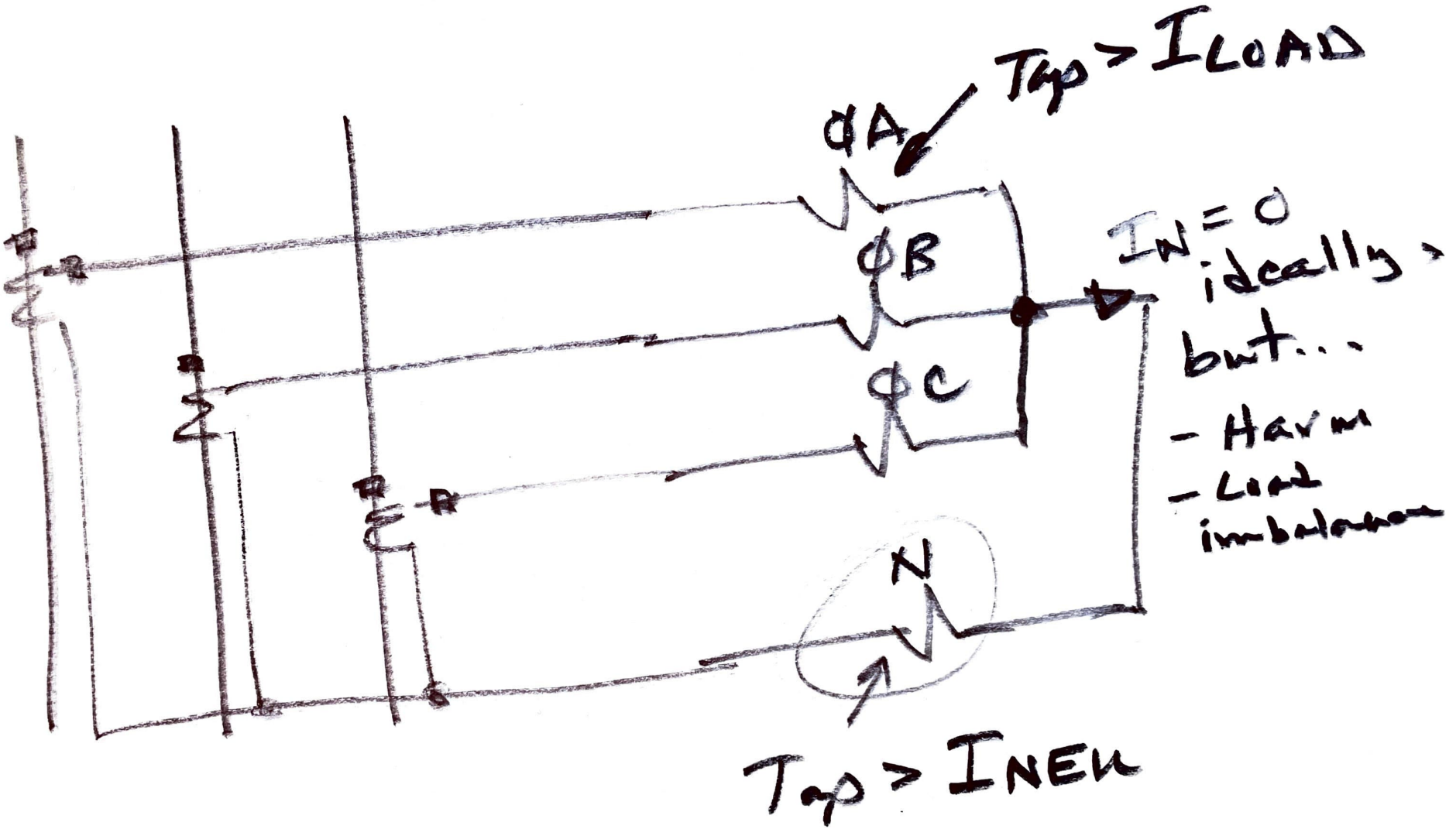
Tap: 5A

TD = 1/2

$$I_{R2,F\ (Max)} = \frac{7000}{80} = 87.5A$$


t
R1
4/60s
CTI=0.25s
R2
0.15


t
R1
TD=4
TD=0.5
0.45s
R2
0.1s
CB + CTI
CB time + CTI
Pri Amps
5000A
7000A


$T_{ap} > I_{LOAD}$
ϕA
ϕB
ϕC
N
$I_N = 0$
ideally
but...
- Harm
- Load
imbalance
$T_{ap} > I_{NEU}$

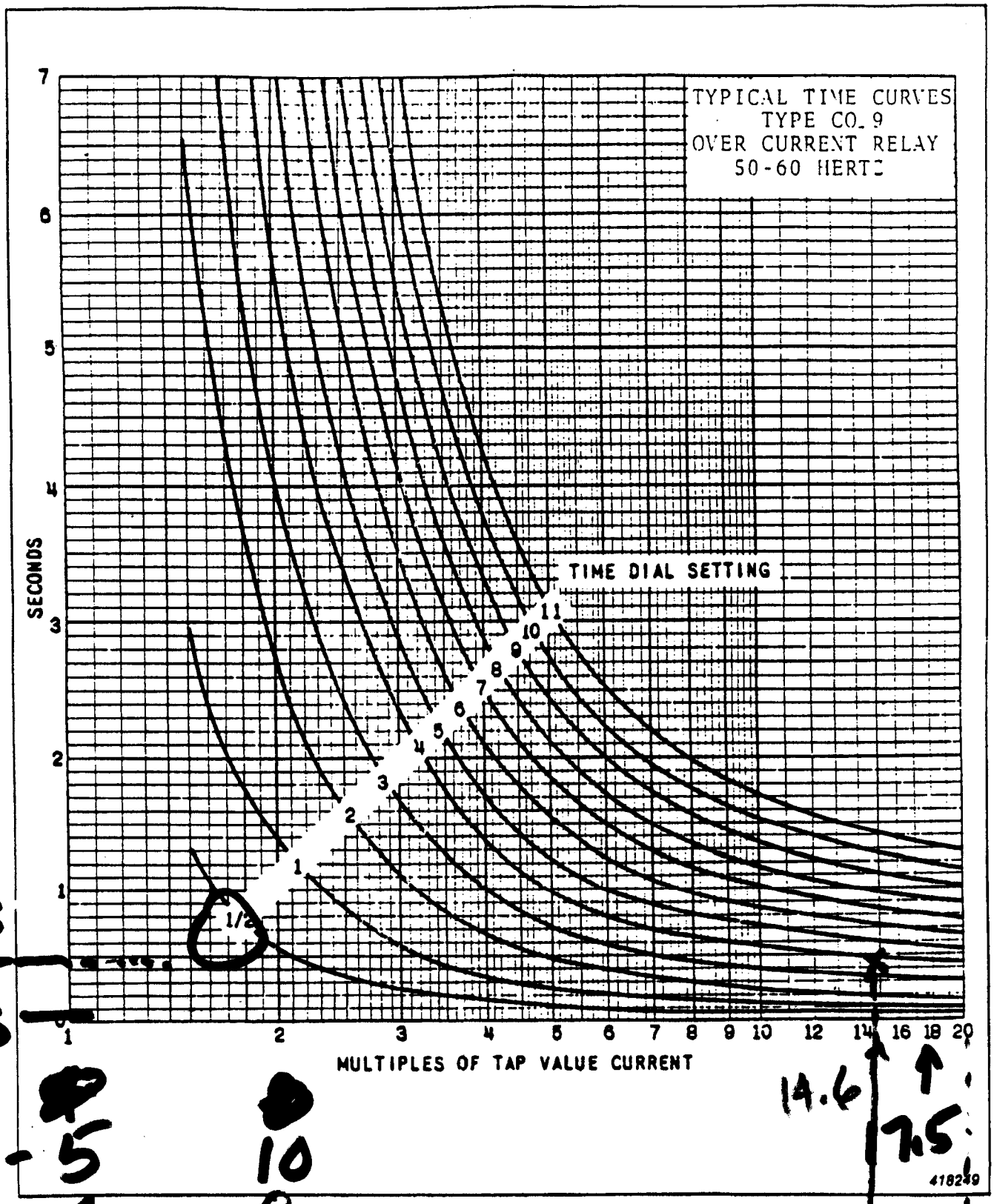
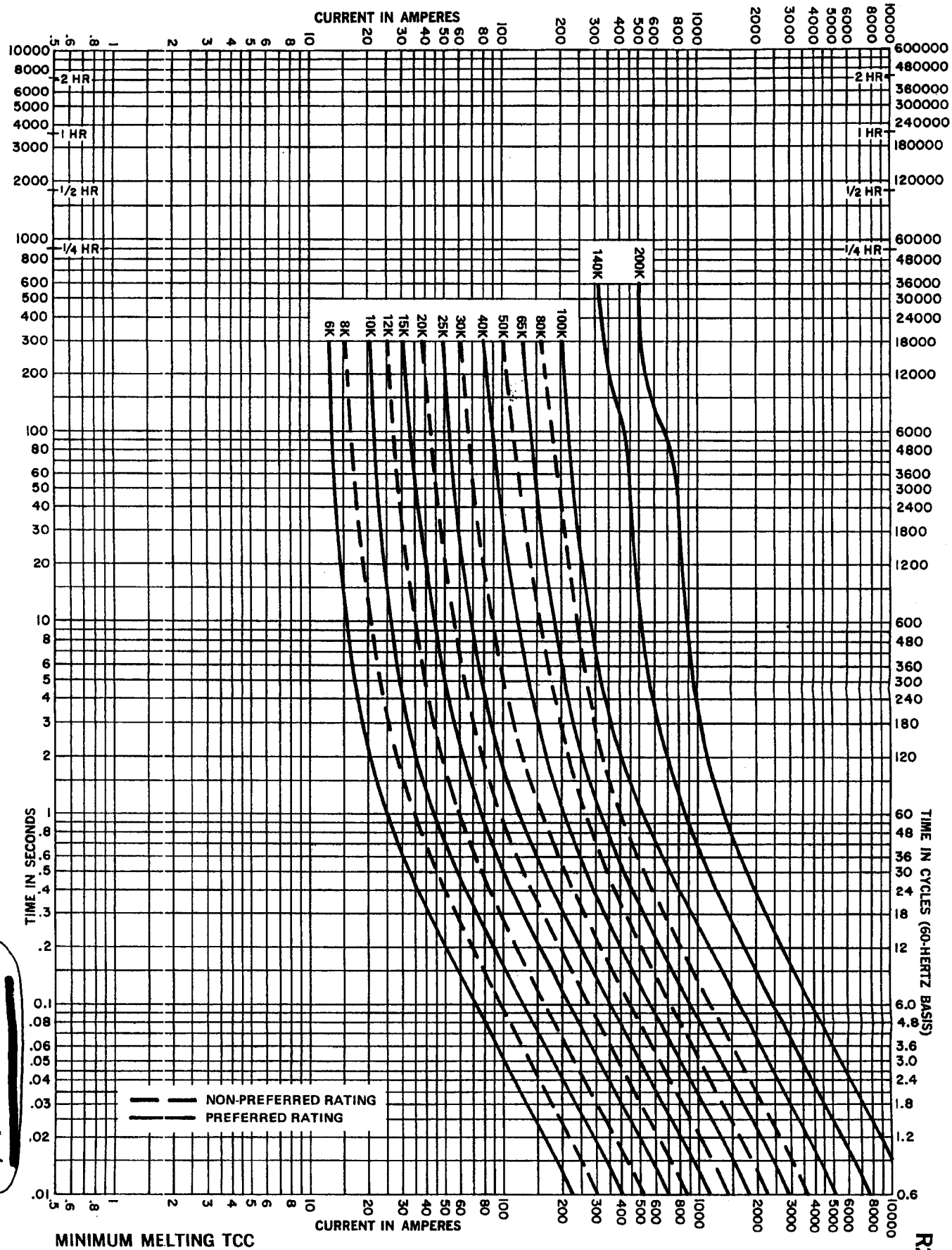


Fig. 15. Typical Time Curve of the Type CO-9 Relay

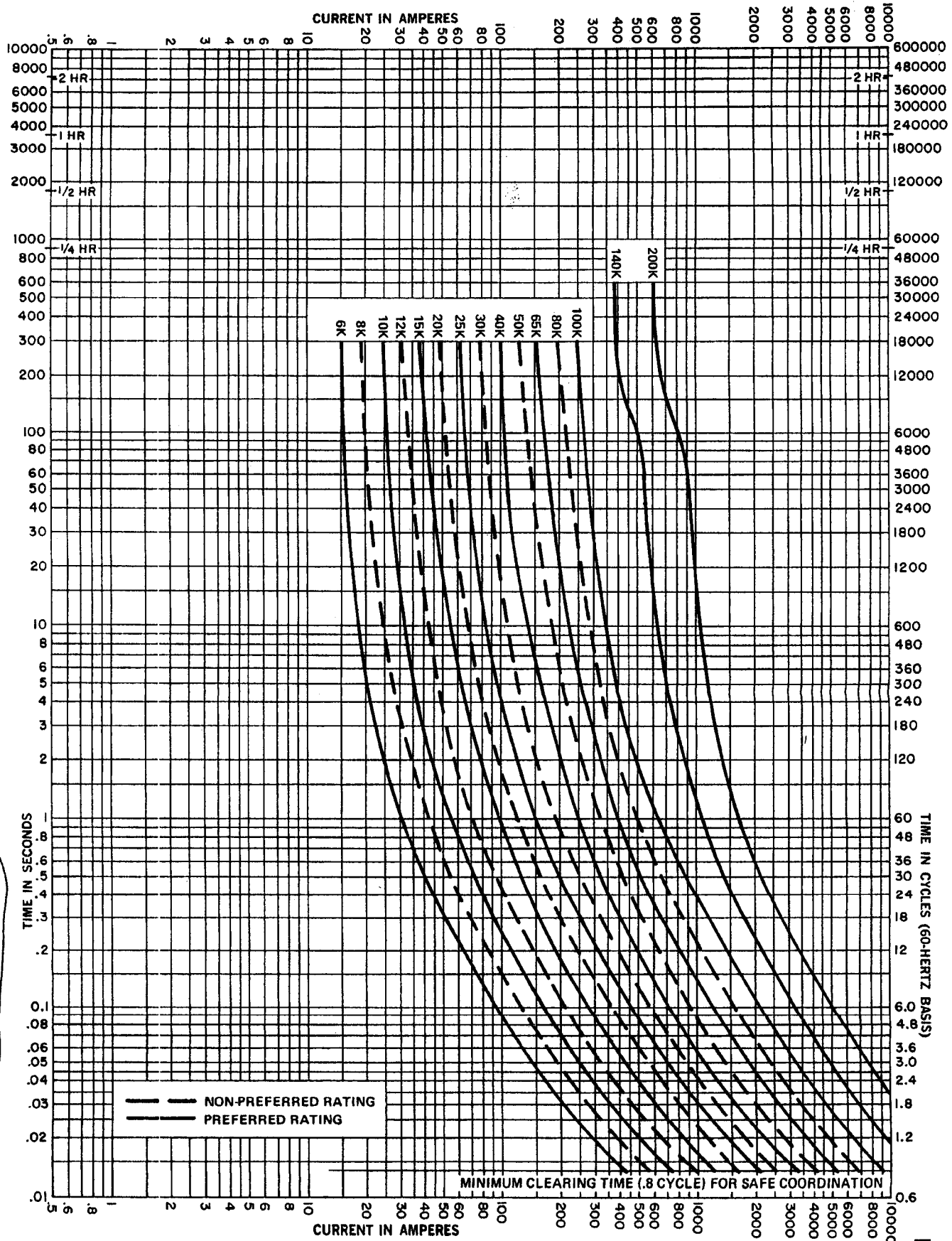


MIN MELT

MINIMUM MELTING TCC

Curves of M-E fuse links in M-E cutouts • Basis for data: NEMA Standard SG2
Tests at 240 Volts ac, high pf, starting at no initial load, 25C
Minimum test points plotted so variations should be plus

EEI-NEMA TYPE K-TIN



MAX CLEAR

MAXIMUM CLEARING TCC

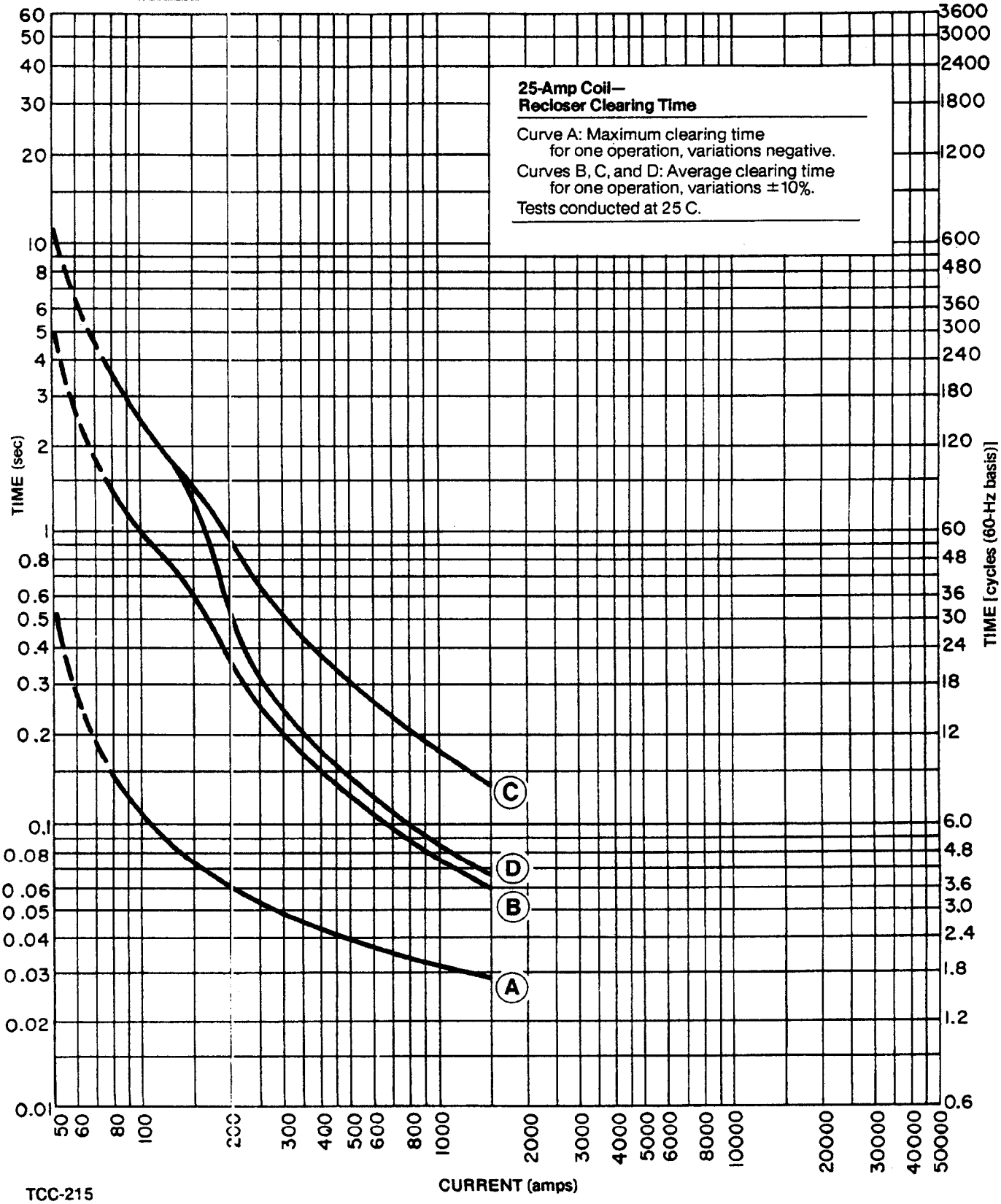
Curves of M-E fuse links in M-E cutouts • Basis for data: NEMA Standard SG2
Tests at rated-cutout Volts ac, low pf, starting at no initial load, 25C
Maximum test points plotted so variations should be minus

EEI-NEMA TYPE K-TIN

Reference
R240-9

Reclosers
Type L
Time-Current Curves

R280-91-3
Reference Data



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