DISTRIBUTION PROTECTION
JEANNE HARSHBARGER
MANAGER, SYSTEM PLANNING AND PROTECTION, SNOHOMISH PUD
OUTLINE

Introduction
Overview of utilities
Overview of distribution systems
- radial
- open-loop
- network
- effectively grounded
- general characteristics

Protection
- reliability
- objectives
- Trips
- Methods
- Equipment
- Lessons Learned

Questions welcome at any time
Participation is strongly encouraged!
We bring good things to life.
Commission Officers for 2019

Sidney "Sid" Logan  Rebecca Wolfe  Tanya "Toni" Olson
President  Secretary  Vice President
Commissioner  Commissioner  Commissioner
District 1  District 2  District 3

L-R: Toni Olson, Rebecca Wolfe, Sid Logan
1 mile of line
$10,000 to build
1 mile of line
$10,000 to build

Urban area:
Approximately 600 customers
About $80 per month each
Total revenue about $48,000
1 mile of line
$10,000 to build

Rural area:
Approximately 2 customer
About $80 per month each
Total revenue about $80
Typical PUD substation

- One or two 115-12.47 kV, 16.8 / 22 / 28 MVA banks
- Wye/Delta/Grounded Wye
- Neutral reactor
- Four or five feeder breakers
- Circuit switcher for bank
- Ideally, looped through on the transmission line
Scope for today

Today we will cover only the distribution feeder breaker and line
Radial Feeder

Substation

No feeder ties available beyond here
Open-Loop Feeders
Network Feed

Open primary or secondary for reverse flow

Figure 5. Spot network system
Distribution system characteristics

- One direction of power flow
- Faults near the station have highest available short-circuit current
- Farther away magnitudes drop
- Short-circuit current is usually 10x or more load values except possibly near the ends of the line
Distribution system characteristics

- **Three-phase**
  - Balanced magnitude (mostly)
  - 120 degrees apart in phase (mostly)

- **Four-wire**
  - Fourth wire is the neutral

- Effectively grounded
Effectively grounded IEEE 142 definition:

\[ 0 \leq \frac{X_0}{X_1} \leq 3 \]
and

\[ 0 \leq \frac{R_0}{X_1} \leq 1 \]

Typical PUD 12 kV bus:

<table>
<thead>
<tr>
<th>Bus Fault on:</th>
<th>21 MARTHA K-153 12.47kV 1L0 Type=A</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ SEQ</td>
<td>- SEQ</td>
</tr>
<tr>
<td>1784.1@ -87.4</td>
<td>1784.1@ -87.4</td>
</tr>
<tr>
<td>0 SEQ</td>
<td>A PHASE</td>
</tr>
<tr>
<td>1784.1@ -87.4</td>
<td>5352.2@ -87.4</td>
</tr>
<tr>
<td>B PHASE</td>
<td>0.0@ 0.0</td>
</tr>
<tr>
<td>C PHASE</td>
<td>0.0@ 0.0</td>
</tr>
<tr>
<td>ZEVENIN IMPEDANCE (OHM)</td>
<td></td>
</tr>
<tr>
<td>0.05231+j0.99133</td>
<td>0.05234+j0.99156</td>
</tr>
<tr>
<td>0.07354+j2.04839</td>
<td></td>
</tr>
<tr>
<td>SHORT CIRCUIT MVA= 115.6</td>
<td>X/R RATIO= 21.8863</td>
</tr>
<tr>
<td>0.08024</td>
<td>X0/X1= 2.0663</td>
</tr>
</tbody>
</table>
Distribution system characteristics

- Distribution is more prevalent than transmission
- Clearances are less than transmission
- Distribution goes everywhere there is load
- Lots of exposure to faults
- People ARE the load
- Distribution can be three-phase, two-phase, or single-phase
- Three types of customers
  - Residential
  - Commercial
  - Industrial
System load

Typical summer day

Typical winter day
Reliability

The big questions:

- How do you know something is wrong?
- What will you do about it?
DEPENDABILITY — SECURITY

RELIABILITY
The quintessential protection engineer’s nightmare
Security-related event from August 14, 2003
Sensitivity
Selectivity
Speed
Sensitivity
Selectivity
Speed
Sensitivity

Selectivity

Speed
Sensitivity Selectivity Speed
Distribution protection principles

- Simple is good
- Don’t trip on load
- Be able to clear for a fault anywhere on the system
- Allow for any one element to be out of service
- Clear as quickly as possible
- Be selective – outage should affect fewest customers
- Load balance matters
- Don’t seek out fame
- Use automatic restoration whenever possible
ANSI/IEEE protective device functions

- 50 – Instantaneous Overcurrent Relay
- 51 – AC Inverse Time Overcurrent Relay
- 52 – AC Circuit Breaker
- 79 – AC Reclosing Relay
- 81 – Frequency Relay
Functions used:
50/50N
51/51N
Breaker failure
Breaker control
79
81 is optional
Fault Causes
Outage cause choices

1 = Unknown
0 = No reason assigned
4 = Equipment Failure
5 = Prearranged / Planned
6 = Bird or Animal
7 = Motor Vehicle
8 = Underground Dig-In
9 = Tree, Man-Caused
10 = Human Caused
11 = Other Utility
12 = Unknown
13 = Other (See Comments)
14 = Lightning
15 = Fatigued Fuse
15 = Substation Breaker
16 = Tree Non-Preventable
25 = Tree, Preventable
Fault Types

- Three-phase
- Phase to phase
- Line to line
- Line to line to ground

Which is the most prevalent?
Three phase faults

- Balanced current
- Magnitude higher than load
- 120 degree separation
- Looks like a BIG load
Phase to phase faults

- High magnitude
- Two phases at 180 degrees
Phase to phase fault

IB

Flux in B-phase opposes flux in C-phase

IC

Pushes the conductors apart until fault is cleared
Line to ground fault
This is the most prevalent type
Trips – Load shedding

➢ Underfrequency
➢ Undervoltage
➢ Manual
Load Shedding
Or – the ultimate indignity
<table>
<thead>
<tr>
<th>Block</th>
<th>Percent of Frequency Load Shedding Balancing Authority Set-Point Block</th>
<th>Area Load Dropped (Hz)</th>
<th>Tripping Time*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.3</td>
<td>59.1</td>
<td>no more than 14 cycles</td>
</tr>
<tr>
<td>2</td>
<td>5.9</td>
<td>58.9</td>
<td>no more than 14 cycles</td>
</tr>
<tr>
<td>3</td>
<td>6.5</td>
<td>58.7</td>
<td>no more than 14 cycles</td>
</tr>
<tr>
<td>4</td>
<td>6.7</td>
<td>58.5</td>
<td>no more than 14 cycles</td>
</tr>
<tr>
<td>5</td>
<td>6.7</td>
<td>58.3</td>
<td>no more than 14 cycles</td>
</tr>
</tbody>
</table>
Undervoltage load shedding

- Used where VAR support is lacking
- Planners decide when it’s needed by using reactive margin studies
- Reactive reserves in the area are the solution
  - Typical settings 80% voltage
  - Time delay 3 – 10 seconds
  - No automatic reclosing

Manual load shedding

- Can be local or via SCADA
- Plans are required by NERC and must be updated annually
- (Not implemented in relays)
Methods – guidelines & standards
A-phase fault with relay out of service
A-B fault with relay out of service
Distribution protective equipment

- Feeder breaker
- Line recloser
- Line sectionalizer
- Fuses

Less commonly used:
- Vacuum fault interrupter
- Submersible or padmounted reclosers
- Network protectors
Phase and ground overcurrent time-current curves

Log-log scale
Conductor damage curves

Slope = 2
Conductor Annealing Damage Curve

\[ T = (k \times \frac{A}{I})^{\times 2} \]

- \( k = 0.0862 \)
- Conductor ACSR

- A (circular mils) = 211600
- AWG Size 4/0

Comments

[Input field for comments]
1. Phase relay POC-251 451 Pri 421-U4 TD=4.5
21 MARTHA K-153 12.47kV - EG-19 12.47kV L MLKC500308
CTR=120:1 Pickup=6.8 A No inst. TP@ 5.0=1.167s
la=5352.3A (44.6 sec A) T=0.577s

2. Ground relay GOC-251 451 Pri 421-U4 TD=8.7
21 MARTHA K-153 12.47kV - EG-19 12.47kV L MLKC500308
CTR=120:1 Pickup=3.3 A No inst. TP@ 5.0=2.2563s
3io=5352.3A (44.6 sec A) T=0.435s
1. Phase relay POC-251 451 Pri 421-U4 TD=4.5
21 MARTHA K-153 12.47kV - EG-19 12.47kV L MLKC580308
CTR=120:1 Pickup=6A No inst. TP@ 5.0=1.167s
Ia= 5352.3A (44.6 sec A) T=0.577s

2. Ground relay GOC-251 451 Pri 421-U4 TD=8.7
21 MARTHA K-153 12.47kV - EG-19 12.47kV L MLKC580308
CTR=120:1 Pickup=3A No inst. TP@ 5.0=2.2563s
3lo= 5352.3A (44.6 sec A) T=0.435s

5.352 A L-G fault
0.435" relay time
0.0833" breaker opening time
0.5183" clearing time
Relay settings – phase overcurrent relays

28 MVA bank with 4-12 kV feeders – load in each:
28,000 kVA/(sqrt(3)\times12.47 \text{kV}) = \text{bank load of 1,296 A}

Bank load / 4 feeders = 324 A per feeder

Available short-circuit current approximately 8,000 A

Feeders rated about 600 A continuous
Relay setting criteria – phase overcurrent relays

- Set at some margin above load
  - District value is 25% above highest contingency loading
- Set low enough to clear for all faults in its zone
  - District value is less than 0.25 times minimum 3-phase fault
- Time dial is chosen to coordinate with downstream devices
  - Coordinating time interval depends on downstream device
Line reclosers ("breaker on a stick")

- Self-contained protection unit
  - Integrated instrument transformers
  - Control panel
  - Battery
- Phase and ground overcurrent elements
  - May trip and reclose single-phase or three-phase
- Automatic reclosing
- Interrupting ratings are somewhat lower than feeder breakers
- Can have sophisticated functions similar to a feeder breaker
Relay setting criteria – overcurrent relays (continued)

- Allow 0.3” coordinating time interval between electronically – controlled devices
  - E.g. feeder breaker and modern recloser
  - Allow higher interval if one is hydraulic
- Allow 0.1-0.2” between fuse max clear and feeder or recloser
- Allow 0.4” coordinating time interval between the feeder and the bank overcurrent relay
  - Impact is higher
  - Bank loading is higher than the feeder
Typical feeder

Coordinating time interval 0.3"

560 A phase pickup
320 A ground pickup

720 A phase pickup
360 A ground pickup
Time dial to allow CTI
Phase –
Feeder breaker = 720 A pickup
Recloser = 300 A pickup
Ground –
Feeder breaker = 360 A pickup
Recloser = 240 A pickup

CTI = 0.34” (ground element to ground element)
Typical feeder
Typical feeder

Coordination time interval 0.1-0.2” (fuse TCC and recloser)

100A fuse max
2. Ground relay GOC-251 451 Pri 421-U4 TD=8.7
   21 MARTHA K-153 12.47kV - EG-19 12.47kV L MLKC590308
   CTR=120:1 Pickup=3.6 A No inst. TP@ 5.0=2.2563s
   3I0= 3344.7A (27.9 sec A) T=0.787s

3. Ground relay ELDEC GND RECL SEL-EI TD=5.4
   EG-19 12.47kV - EG-24 12.47kV L MLKC590308
   CTR=240 Pickup=1.6 A No inst. TP@ 5.0=1.4658s
   3I0= 3344.7A (13.9 sec A) T=0.349s

Current div=1.00 Time mult=1.00
Ia= 3344.6A T(T. Clear)=0.088s
Neutral reactor
Feeder unbalance current

Feeder unbalance shows up in the neutral
Relay setting criteria – ground overcurrent relays

- Set at some margin above unbalance current
  - District value is 2 x highest expected neutral current
  - Minimum 3x largest downstream fuse size
- Set low enough to clear for all faults in its zone
  - District value is less than 0.25 times minimum line to ground fault
- Time dial is chosen to coordinate with downstream devices
  - Coordinating time interval depends on downstream device
Things to watch out for
Close-in fault
Things to look out for – Phase vs. ground clearing times

This is the magnitude of the ground fault – 3I0

MARTHA K-153
12.47kV 21
2.9@0
4242@-88

MARTHA TERT
7.2kV
0.0@0
0.00@0

0.06@49 0.06@131

MARTHA LAKE
115.kV 1114
0.0@33
Things to look out for – Phase vs. ground clearing times
For a phase-phase-ground fault, the phase relay clears faster.
For a line to ground fault the ground relay trips faster.
It’s always a good double-check to have every relay on the screen while you’re coordinating.
Automatic Reclosing

- Reclosing is helpful in restoring service automatically
- Temporary faults
- Fuse blows for permanent faults, restoring most customers
- Doesn’t’ work well for underground
- Allows sectionalizers to work
Sectionalizers

- Not rated to interrupt fault current
- Counts how many times currents exceeds the pickup
- Opens while the circuit is dead
- Allows a portion of the circuit to be restored
Count = 1
Count = 1
Count = 2
Count = 2

Customers restored
Instantaneous tripping

• Fuse saving
  • Low-set instantaneous element
  • Enabled on initial trip only
  • After a temporary fault, all customers are restored with only a momentary fault

Very sensitive
Very speedy
Not selective
Instantaneous tripping – fuse saving

• PROS
  • Limits the through-fault energy to the bank
  • If the fault is temporary in nature, the circuit can be restored on reclose
    • no need for a truck roll

CONS
• All customers experience an outage
• Not secure
Sympathetic Tripping

Close-in fault
Sympathetic Tripping

Brief period where feeder #1 current exceeded low-set instantaneous
Capacitive current on feeder #2 briefly exceeds low-set instantaneous
Every feeder trips and recloses (except the faulted one)
Instantaneous tripping

• High-set instantaneous
  • Set for 95% of the available short-circuit current at the station
  • Because most getaways are underground these are not usually temporary
  • Limits through-fault damage to transformers
  • Drives reclosing relay to lockout

Speed is good (no intentional delay)
Selectivity is good (magnitude discriminates – set for 125% of fault at next device)
Sensitivity is low (only responds to close-in faults)
Instantaneous tripping – high-set

• PROS:
  • Limits the through-fault energy to the bank
More to watch out for
Each feeder’s trip time at 3,800 A = 1.22”
Feeder trip time at 7,600 A = 0.39”

Bank trip time 1.13”
Conductor slap example
2,076 A downstream fault

First fault, beyond the recloser cleared some time after 45 cycles
Event Time: 6/7/2012 14:36:14.683000

T = 1.408 sec.

Close-in fault cleared by the feeder breaker.
Load 200 A
Inrush 800 A

T = 6.408"

Five-second reclose by feeder breaker
A load of 2,000 A fault beyond recloser

T = 12.850 “Five second” reclose by downstream recloser into a persistent fault. Once again clears after about 45 cycles.
Fault evolves to 3-phase and trips by high-set INST

T = 14.015
2.165 seconds after the second downstream fault is initiated (1.6 seconds after it’s cleared), the close-in fault reoccurs.
EXAMPLE: Cold-load pickup
## PROTECTIVE RELAY SETTING

**Digital Relay**

**SEU-J41**

### Substation:

Westgate

### Primary Breaker:

12-405

### Backup Breaker:

12-404

### Relay Information:

- **Vendor Data:** PUD 401
- **Primary Vendor:** TMS
- **Primary Breaker:** 120/230V, 3000VA
- **Field Verify:** TD 5.2

### Information:

- **Year/Model:** 3 cycles

### PRIMARY RELAY SETTINGS & TEST SUMMARY

<table>
<thead>
<tr>
<th>Relay Description</th>
<th>Setting Name</th>
<th>Relay Setting</th>
<th>Primary Value</th>
<th>Field Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station ID</td>
<td>SI</td>
<td>2402</td>
<td>2402</td>
<td>SI</td>
</tr>
<tr>
<td>Relay ID</td>
<td>RDO</td>
<td>720 A</td>
<td>720 A</td>
<td>TD 5.2</td>
</tr>
<tr>
<td>CT Winding W</td>
<td>CTW1W</td>
<td>600.5</td>
<td>600.5</td>
<td>TD 5.2</td>
</tr>
<tr>
<td>CT Winding X</td>
<td>CTW1X</td>
<td>600.5</td>
<td>600.5</td>
<td>TD 5.2</td>
</tr>
</tbody>
</table>

### PRIMARY BACKUP SETTINGS & TEST SUMMARY

<table>
<thead>
<tr>
<th>Backup Breaker</th>
<th>Setting Name</th>
<th>Relay Setting</th>
<th>Primary Value</th>
<th>Field Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1200 Volt Phase</td>
<td>LPA</td>
<td>4.0</td>
<td>4.0</td>
<td>TD 5.2</td>
</tr>
<tr>
<td>1200 Volt Volt</td>
<td>LPA</td>
<td>14.0</td>
<td>14.0</td>
<td>TD 5.2</td>
</tr>
<tr>
<td>1200 Volt Phase</td>
<td>LPA</td>
<td>7.0</td>
<td>7.0</td>
<td>TD 5.2</td>
</tr>
<tr>
<td>1200 Volt Volt</td>
<td>LPA</td>
<td>6.0</td>
<td>6.0</td>
<td>TD 5.2</td>
</tr>
</tbody>
</table>

### Testing Element:

- **Time Curve Testing**
  - **Phase:**
    - **500% Tap:** 3.485 seconds
    - **500% Tap:** 3.485 seconds
  - **Phase:**
    - **1000% Tap:** 2.203 seconds
    - **1000% Tap:** 2.203 seconds
  - **Phase:**
    - **2000% Tap:** / /
    - **2000% Tap:** / /

### Comments:

- This relay serves as the Primary relay for Breaker 12-405. Mag overtripping is not active on this relay.
- Phase and ground high set instantaneous are set for 95% of maximum SLG and LLG fault currents respectively.
- This relay serves as the Backup relay for Breaker 12-404.
- 1 shot reclosure is enabled on this relay for Breaker 12-405 only. UF is not active on this relay.
- This relay coordinates with 30% SLG, recloser 2664, and the feeder backup overcurrent relay.
NOVA Recloser Settings

Form 6
Panel Number 335

Substation: Westgate Feeder 12-405 Recloser 2664

**DATA**

<table>
<thead>
<tr>
<th>Relay Information:</th>
<th>Vendor Data</th>
<th>Ratings</th>
<th>Serial Number</th>
<th>Software Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooper</td>
<td>120V Power Supply</td>
<td>4/0, 1</td>
<td>4/0, 1</td>
<td></td>
</tr>
<tr>
<td>CT Information:</td>
<td>Cooper 100:1</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

**RELEY SETTINGS & TEST SUMMARY**

<table>
<thead>
<tr>
<th>Setting Description</th>
<th>Relay Setting</th>
<th>Primary Value</th>
<th>Field Check</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCC1</td>
<td>Phase</td>
<td>Kyle 101</td>
<td>Kyle 101</td>
</tr>
<tr>
<td>Curve Type</td>
<td>Phase Ground</td>
<td>Phase Ground</td>
<td>Phase Ground</td>
</tr>
<tr>
<td>Minimum Trip</td>
<td>Phase Ground</td>
<td>Phase Ground</td>
<td>Phase Ground</td>
</tr>
<tr>
<td>Time Multiplier</td>
<td>Phase Ground</td>
<td>Phase Ground</td>
<td>Phase Ground</td>
</tr>
<tr>
<td>Time Adder</td>
<td>Phase Ground</td>
<td>Phase Ground</td>
<td>Phase Ground</td>
</tr>
<tr>
<td>Num of Trips to LO</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Open Interval #1</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

**Testing**

<table>
<thead>
<tr>
<th>Element</th>
<th>Test Current Value</th>
<th>Curve Time</th>
<th>Field Test Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase</td>
<td>200% tap 7.70</td>
<td>1.906</td>
<td>0.416</td>
</tr>
<tr>
<td></td>
<td>500% tap 1.906</td>
<td>1.906</td>
<td>0.416</td>
</tr>
<tr>
<td></td>
<td>1000% tap 1.906</td>
<td>1.906</td>
<td>0.416</td>
</tr>
</tbody>
</table>

**Comments:**

- This coordinates with feeder QC relay and Recloser 2514 @ Edmonds Sub
- Firmware upgraded to 4.01
- User 1 curve is a U4 with a time delay of 4.0
- User 2 curve is a U4 with a time delay of 4.5

600 A phase
PU
TD 4.0
Multiplier = 1
Adder = 0
So far, So good!
Great CTI for normal operation
Initial fault as seen from the feeder breaker
The fault is cleared by the downstream recloser.
An hour or so later after patrol, the recloser is closed back in, inadvertently re-energizing the fault.
This time the feeder breaker trips.
On the reclose, the recloser clears.

0.4" later the feeder breaker sees a higher-magnitude (closer in) fault.
...and the feeder breaker eventually locks out.

SO – What happened?!?
**PROTECTIVE RELAY SETTING**

**Digital Relay:** SEL-431

**Substation:** Wedgite

**Primary Breaker:** 12-406

**Backup Breaker:** 12-404

<table>
<thead>
<tr>
<th>Setting Description</th>
<th>Setting Name</th>
<th>Scope Setting</th>
<th>Primary Value</th>
<th>Field Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water 1D</td>
<td>STG</td>
<td>t0.0724</td>
<td>240</td>
<td>-1</td>
</tr>
<tr>
<td>Ely 1D</td>
<td>STL</td>
<td>t0.064</td>
<td>240</td>
<td>+1</td>
</tr>
</tbody>
</table>

**PRIMARY RELAY SETTINGS & TEST SUMMARY**

<table>
<thead>
<tr>
<th>Primary Breaker</th>
<th>Setting Name</th>
<th>Scope Setting</th>
<th>Primary Value</th>
<th>Field Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary RLR Clsd 1</td>
<td>STG</td>
<td>0.5</td>
<td>0.5</td>
<td>-1</td>
</tr>
<tr>
<td>Primary RLR Clsd 2</td>
<td>STL</td>
<td>0.5</td>
<td>0.5</td>
<td>-1</td>
</tr>
<tr>
<td>Primary RLR</td>
<td>STG</td>
<td>0.5</td>
<td>0.5</td>
<td>-1</td>
</tr>
<tr>
<td>Primary RLR Phase 1</td>
<td>STG</td>
<td>0.5</td>
<td>0.5</td>
<td>-1</td>
</tr>
<tr>
<td>Primary RLR Phase 2</td>
<td>STG</td>
<td>0.5</td>
<td>0.5</td>
<td>-1</td>
</tr>
<tr>
<td>Primary RLR Phase 3</td>
<td>STG</td>
<td>0.5</td>
<td>0.5</td>
<td>-1</td>
</tr>
<tr>
<td>Primary RLR Phase 4</td>
<td>STG</td>
<td>0.5</td>
<td>0.5</td>
<td>-1</td>
</tr>
<tr>
<td>Primary RLR Phase 5</td>
<td>STG</td>
<td>0.5</td>
<td>0.5</td>
<td>-1</td>
</tr>
</tbody>
</table>

**Comments:**

- Increase phase TD to coordinate with the new relay 3608.
- This relay serves as the primary relay for Breaker 12-405.
- Changes are for transformer primary TD settings on this relay.
- These and ground high set limitations are set for 90% of maximum THD and THD fault currents respectively.
- The relay serves as the Skidmore relay for Breaker 12-404.
- 30° reclose is enabled on the relay for Transformer 12-405 only.
- UF is not used on this relay.
- This relay operates with the 1007 fuse, resistor 2646, and the faster backup reclosure rules.

**CLPU:** Add 4" TD to 50P1 (fuse saving) and 50P3 (non-reclose low-set IT) trip

**BACKUP RELAY SETTINGS & TEST SUMMARY**

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Scope Setting</th>
<th>Primary Value</th>
<th>Field Test</th>
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**Time Curve Testing**

- Ground: 500% Tip, 0.60 seconds
- Phase: 500% Tip, 1.34 seconds

106

Phase pu
720 A
TD 5.2

CLPU: Add 4" TD to 50P1 (fuse saving) and 50P3 (non-reclose low-set IT) trip
<table>
<thead>
<tr>
<th>Phase</th>
<th>Normal</th>
<th>Alternate 1</th>
<th>Alternate 2</th>
<th>Alternate 3</th>
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**Ground:**

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in CLPU settings
Min pu = 1080; > feeder
Multiplier = 5; > feeder
Adder = 2;
Consistency matters when coordinating cold-load pickup settings between devices.
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<th>Code Word</th>
<th>Size (AWG or kcmil)</th>
<th>Strand-Ing (All/Stl)</th>
<th>Diameter (ins.)</th>
<th>Weight Per 1000 ft. (lbs.)</th>
<th>Content (%)</th>
<th>Rated Strength (lbs.)</th>
<th>Resistance OHMS/1000 ft.</th>
<th>Allowable Ampacity (Amps)</th>
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To delta-connected CTs on the load side of each breaker

Bank overcurrent relay
Sudden pressure → Lockout relay #1
Differential relay → Lockout relay #2