

Medium-Voltage Breaker & Protective Relay Testing 2026

Job Details

Client:	
Site:	
Location:	
Job No.:	
Client Contact:	
Scope Reference:	
Equipment:	21 × GE Power/Vac VB1-4.16-250 vacuum breakers, ML-18 mechanism (8 generator + 13 feeder · tie breaker 2000 A)
Relays:	8 × SR-489 · 1 × SR-750 · 3 × SR-735 · 9 × Multilin 350
Single Line Dwg:	22046-E005 Sht 1 Rev D — 4.16 kV Permanent Power House Generator & Switchgear SLD
References:	GE GEK-86132G (shop-order W1001483) · GE GEK-39672F · ANSI/NETA ATS-2013 · GE/Powell 1047150601 (SS-TR Fdr & Tie, Stacks 111/112, As-Built)
Offline Resources:	6.0 Test Equipment Manuals · 7.0 Relay Software (EnerVista) — in the DTI-26688 job folder
Test Dates:	
Technician(s):	
Report Date:	

LEGEND

GRAY CELLS = technician input. Fill every gray cell (or select from its drop-down).

Drop-down cells: click the cell, then pick from the list (example →).

RESULT cells calculate automatically and are LOCKED — do not type in them. DEFICIENT / FAIL flags turn red.

Units are shown inside every value cell. Readings display to 0.01; erosion / wipe / switch-recess rows use 0.001 (GEK limits are 3-decimal).

Worked example — contact erosion measured 0.130 in. against max 0.125 in. limit:

Parameter	Pole 1	Pole 2	Pole 3	Min	Max	Result	Notes
Contact erosion (example)	0.055 in	0.130 in	0.060 in	—	0.125 in	DEFICIENT	example row

TEST ORDER — work each breaker top-to-bottom on the BKR TEST SHEET (SOW Rev 5, 13 steps)

Step 1	Nameplate & as-found condition, counter reading, photos, rating interference plate
Step 2	Withdraw breaker — isolate 125 VDC control, discharge both springs, verify OPEN / DISCHARGED
Step 3	Visual & mechanical inspection — use the COMPONENT LOCATOR figures to find each item
Step 4	Clean primary insulation; inspect & re-lubricate disconnect fingers and contact rods
Step 5	Slow-close check via closing-spring gag plate & manual charge
Step 6	Dimensional checks all 3 poles — contact erosion, wipe, gap (adjust only if out of limits)
Step 7	Mechanism lubrication per GEK-86132 (synthetic oil bearings; 0282A2048P009 grease points)
Step 8	Insulation resistance — primary @ 2500 VDC; secondary control @ 500 VDC
Step 9	Contact resistance — 100 A micro-ohmmeter, each pole, breaker closed
Step 10	Vacuum interrupter integrity — 36 kV AC, 10 s, each pole, breaker open
Step 11	Electrical operation via test coupler — close/trip, charge time, anti-pump, trip-free, timing
Step 12	Compartment — shutters, stabs, CTs, heaters, MOC/TOC, racking screw, secondary disconnect
Step 13	Reinstall — verify racking interlocks through travel, electrical op from door, as-left record

Relays: RLY VALIDATION SHEET sections 1-5 (as-found capture → wiring → status → trip path → as-left). Wiring validation & status verification only — element/injection testing is a priced option.

KEY ACCEPTANCE LIMITS — flag DEFICIENT when outside these values

Test	Acceptance	Source
Contact erosion	≤ 0.125 in (1/8") — replace interrupter at limit	GEK-86132G §8.1/11.4
Contact wipe	> 0.075 in; if ≤ 0.075 adjust to 0.15–0.18 in (ML-18H: belleville-to-trunnion method)	GEK-86132G §8.2/8.3/16.2
Contact gap	0.54 – 0.60 in (Figs 7/12: 0.545–0.600; centre pole normally highest)	GEK-86132G §8.4
Close coil plunger gap C	0.25–0.30 in (ML-18 -0/-1/-2) · 0.35–0.40 in (ML-18H & ML-18 -3)	GEK-86132G §8.5.1
Trip coil plunger gap T	0.20 – 0.25 in (T = 0.250 +0.000/-0.050)	GEK-86132G §8.5.2
Primary insulation resistance	≥ 1,500 MΩ @ 2500 VDC (GE guideline ≥ 10,000 MΩ — trend)	NETA T100.1 / 86132G §9.5
Control wiring insulation	≥ 2 MΩ @ 500 VDC (motor leads off, all pins except #24)	NETA 7.6.3 / GEK §9.5
Contact resistance (by rating)	30–60 μΩ (1200 A) · 25–50 μΩ (2000 A) @ 100 A; poles within 50% of lowest	GEK-86132G §9.3 / NETA 7.6.3
Vacuum interrupter integrity	36 kV AC @ 500 V/s (or 50 kV DC) · 10 s · clean bottle exteriors first · no breakdown	GEK-86132G §9.4
Control voltage (closing, 125 VDC)	100 – 140 VDC at coupler; ≥ 112.5 V while closing	NETA T100.20 / GEK-39672F
Trip coil minimum pickup	operates ≤ 70 VDC (range 70–140)	NETA Table 100.20
Trip time	32 – 45 ms · pole spread ≤ 2 ms	GEK-86132G §12
Close time	35 – 75 ms · pole spread ≤ 2 ms	GEK-86132G §12
Opening / closing speed (if travel analyzer)	open ≥ 4.5 ft/s (nom 5.0) · close ≤ 4.0 ft/s (nom 3.5)	GEK-86132G §13
Spring discharge interlock	discharges ≤ 5 turns racking in (typ 3–4) · ≤ 3 turns racking out	GEK-86132G §10/16.7
Racking	60 turns to CONNECT · max 60 ft-lb on handle	GEK-39672F p.39
Switchgear bus hi-pot (optional extra)	≤ 14 kV AC for 4.16 kV class — VTs/CPTs/arresters disconnected	GEK-39672F / NETA T100.2

SAFETY CAUTIONS (GEK-86132G / GEK-39672F / SOW §4)

▲ **CSA Z462 electrically safe work condition. LOTO with personal locks. Test before touch. Arc-rated PPE per site study.**

▲ **De-energize BOTH primary and control power before any breaker work. Isolate 125 VDC control before withdrawal.**

▲ **Never work on the breaker with the closing spring charged unless it is secured by the gag plate.**

▲ **With gag installed, breaker closed and opening springs charged, THE BREAKER CAN TRIP AT FULL SPEED.**

▲ **Stop manual charging as soon as the indicator shows CHARGED — forcing the handle damages the closing latch.**

▲ **Maximum TWO electrical operations per minute — charging-motor overheat limit.**

▲ **Vacuum integrity test: AC test sets only unless DC ≤ 50 kV peak. NEVER use a half-wave-rectified DC hi-pot on a vacuum bottle (false readings + X-radiation). Only test a correctly adjusted breaker; discharge the interrupter after test.**

▲ **Do NOT readjust the erosion indicator reference arm except when installing a new interrupter.**

▲ **Never use sandpaper, steel wool, or abrasives on silver-plated contact surfaces.**

BREAKER & RELAY TEST SCHEDULE

Tracking index — one row per breaker position · verify IDs against E005 Rev D and site nameplates

Feeder breaker IDs below are PLACEHOLDERS — confirm each against drawing 22046-E005 Sht 1 Rev D and the cubicle nameplate before testing (SOW Deliverable 4).

#	Breaker ID	Description / Cubicle	Type	kV	Relay	Relay ID	Date tested	Breaker sheet	Relay record	Deficiency?	Drawing ref	Notes
1	52G1	Generator breaker — Unit #1 (D3020-GE-9001)	Generator	4.16	GE Multilin SR-489						E005 Rev D	
2	52G2	Generator breaker — Unit #2 (D3020-GE-9002)	Generator	4.16	GE Multilin SR-489						E005 Rev D	
3	52G3	Generator breaker — Unit #3 (D3020-GE-9003)	Generator	4.16	GE Multilin SR-489						E005 Rev D	
4	52G4	Generator breaker — Unit #4 (D3020-GE-9004)	Generator	4.16	GE Multilin SR-489						E005 Rev D	
5	52G5	Generator breaker — Unit #5 (D3020-GE-9005)	Generator	4.16	GE Multilin SR-489						E005 Rev D	
6	52G6	Generator breaker — Unit #6 (D3020-GE-9006)	Generator	4.16	GE Multilin SR-489						E005 Rev D	
7	52G7	Generator breaker — Unit #7 (D3020-GE-9007)	Generator	4.16	GE Multilin SR-489						E005 Rev D	
8	52G8	Generator breaker — Unit #8 (D3020-GE-9008)	Generator	4.16	GE Multilin SR-489						E005 Rev D	
9	52F-01	SWG-9009 SS-TR Feeder — Stack 111B · 1200 A · CTs 3×400:5 + CTGS 50:5 grd	Feeder	4.16	GE Multilin SR-750						GE 1047150601	Site tag TBC vs E005 / nameplate
10	52F-02	SWG-9009 Tie breaker — Stack 112A · 2000 A · CTs 3×2500:5	Tie	4.16	GE Multilin SR-735						GE 1047150601	2000 A limits auto on BKR sheet; site tag TBC
11	52F-03	SWG-9010 SS-TR Feeder — Stack 111B · 1200 A · CTs 3×400:5 + CTGS 50:5 grd	Feeder	4.16	GE Multilin SR-750						GE 1047150601	Site tag TBC vs E005 / nameplate
12	52F-04	SWG-9010 Tie breaker — Stack 112A · 2000 A · CTs 3×2500:5	Tie	4.16	GE Multilin SR-735						GE 1047150601	2000 A limits auto on BKR sheet; site tag TBC
13	52F-05	Breaker Feeder #1	Feeder	4.16	GE Multilin 350						E005 Rev D	
14	52F-06	Breaker Feeder #2	Feeder	4.16	GE Multilin 350						E005 Rev D	
15	52F-07	Breaker Feeder #3	Feeder	4.16	GE Multilin 350						E005 Rev D	
16	52F-08	Breaker Feeder #4	Feeder	4.16	GE Multilin 350						E005 Rev D	
17	52F-09	Breaker Feeder #5	Feeder	4.16	GE Multilin 350						E005 Rev D	
18	52F-10	Breaker Feeder #6	Feeder	4.16	GE Multilin 350						E005 Rev D	
19	52F-11	Breaker Feeder #7 (Spare)	Feeder	4.16	GE Multilin 350						E005 Rev D	
20	52F-12	Breaker Feeder #8	Feeder	4.16	GE Multilin 350						E005 Rev D	
21	52F-13	Breaker Feeder #9	Feeder	4.16	GE Multilin 350						E005 Rev D	

Relay assignment per SOW Rev 5: 8 × SR-489 (generators) · 1 × SR-750 · 3 × SR-735 · 9 × Multilin 350 (feeders). Owner-identified out-of-service breaker serves as working spare. SE-330 NGR monitor excluded per Owner direction.

GE Power/Vac VB1-4.16-250 · ML-18 mechanism · 4.16 kV Power House

Client	0			Job #	0
Site	0			Location	0
Single line dwg	22046-E005 Sht 1 Rev D — 4.16 kV Power House SLD			Schematic ref	
References	GE GEK-86132G (W1001483) · GEK-39672F · ANSI/NETA ATS-2013 · SOW Rev 5 · E005 Rev D · GE 1047150601 Sh.6–8 (internals/elementaries)				
Breaker ID		Cubicle / Position		Date	
Technician(s)				Counter as-found	
Ambient temp		°C	Humidity		Weather

STEP 1 · NAMEPLATE & AS-FOUND CONDITION

Manufacturer	General Electric	Type	VB1-4.16-250
Mechanism	ML-18	Serial number	
Rated max voltage (kV)	4.76	Continuous current (A)	1200
Interrupting rating (kA)	29	BIL (kV)	60
Control voltage (VDC)	125	Date manufactured	

Ratings pre-filled from SOW Rev 5 — verify against the breaker nameplate and correct if different. Tie breaker (stack 112A) is 2000 A, cat. PVEA2A1A2A2202H1A1; SS-TR feeder (111B) 1200 A (GE 1047150601).

Check	YES / NO	Notes
Nameplate photographed		
As-found condition photographed		
Rating interference plate matches compartment rating		
Operations counter reading recorded above (as-found)		

STEP 2 · WITHDRAWAL & SPRING DISCHARGE

▲ LOTO applied with personal locks · test before touch · isolate 125 VDC control before withdrawal. Springs must be discharged (close then trip) before hands-on work.

Check	YES / NO	Notes
Electrically safe work condition confirmed (CSA Z462) — LOTO verified		
125 VDC control supply isolated		
Breaker racked to DISCONNECT — springs discharged during racking (≤ 3 turns)		
Manual close then trip pressed — indicators read OPEN / DISCHARGED		
Breaker withdrawn with site breaker lift — no impact/damage		

GE PowerVac VB1-4.16-250 · ML-18 mechanism · 4.16 kV Power House

Client	0	Job #	0
Site	0	Location	0
Single line dwg	22046-E005 Sht 1 Rev D — 4.16 kV Power House SLD	Schematic ref	
References	GE GEK-86132G (W1001483) · GEK-39672F · ANSI/NETA ATS-2013 · SOW Rev 5 · E005 Rev D · GE 1047150601 Sh.6–8 (internals/elementaries)		
Breaker ID	Cubicle / Position	Date	
Technician(s)		Counter as-found	
Ambient temp	°C	Humidity	Weather

COMPONENT LOCATOR — GEK-86132G REFERENCE FIGURES (shop-order manual W1001483)

Use these figures to identify every item referenced in Steps 2–6. Printed legends appear within Figures 1, 3 and 19; the typed legend below Figures 19 & 20 lists shared items 1–10 (both views).

Controls & indicators — GEK-86132G Figures 1 & 3 (front view, with / without cover)



Figure 1 Front view of PowerVac breaker with front cover

- | | |
|-------------------------|------------------------------|
| 1. Front cover | 6. Manual charge lever |
| 2. Cover mounting bolts | 7. Counter |
| 3. Manual trip button | 8. Spring charge indication |
| 4. Manual close button | 9. Closing spring gag access |
| 5. Nameplate | 10. Open/Close indicator |

GEK-86132G Figure 1 — Front view with front cover (legend in figure)

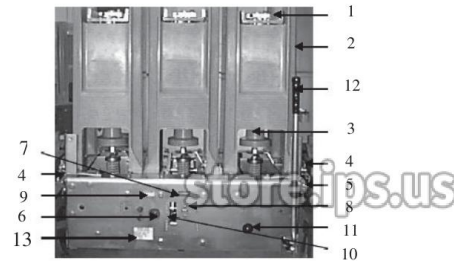


Figure 3 Front view of PowerVac breaker without front cover

- | | |
|-------------------------------|---------------------------------|
| 1. Upper interrupt connection | 8. Counter |
| 2. Interrupter support | 9. Spring charge indication |
| 3. Operating rod | 10. Manual charge lever |
| 4. Racking arm | 11. Manual close button |
| 5. Compartment track rollers | 12. Secondary disconnect handle |
| 6. Manual trip button | 13. Closing spring gag access |
| 7. Open/Close indicator | |

GEK-86132G Figure 3 — Front view without front cover (legend in figure)

Interlocks & rollers — GEK-86132G Figures 19 & 20 (left-front & right-rear views)

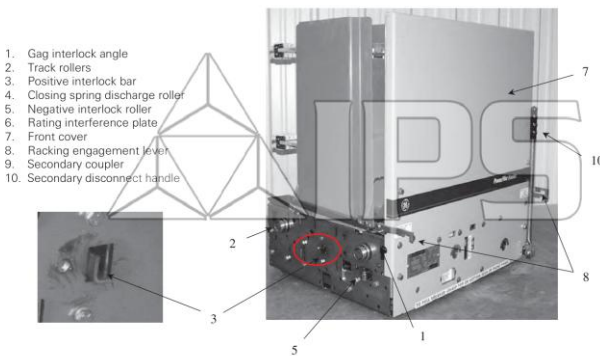


Figure 19 PowerVac® breaker left-front view

GEK-86132G Figure 19 — Left-front view (legend items 1–10 in figure)

- | |
|-------------------------------------|
| 1 — Gag interlock angle |
| 2 — Track rollers |
| 3 — Positive interlock bar |
| 4 — Closing spring discharge roller |
| 5 — Negative interlock roller |

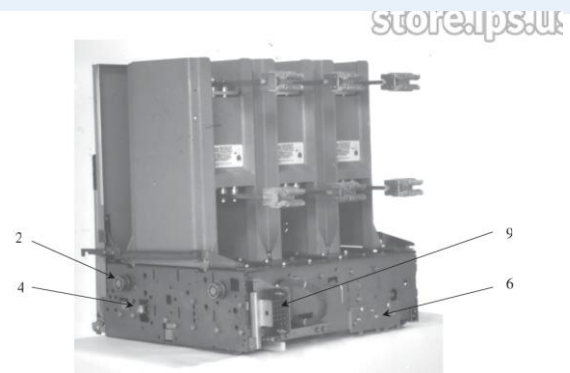


Figure 20 PowerVac® breaker right-rear view

GEK-86132G Figure 20 — Right-rear view

- | |
|----------------------------------|
| 6 — Rating interference plate |
| 7 — Front cover |
| 8 — Racking engagement lever |
| 9 — Secondary coupler |
| 10 — Secondary disconnect handle |

GE PowerVac VB1-4.16-250 · ML-18 mechanism · 4.16 kV Power House

Client	0	Job #	0
Site	0	Location	0
Single line dwg	22046-E005 Sht 1 Rev D — 4.16 kV Power House SLD	Schematic ref	
References	GE GEK-86132G (W1001483) · GEK-39672F · ANSI/NETA ATS-2013 · SOW Rev 5 · E005 Rev D · GE 1047150601 Sh.6–8 (internals/elementaries)		
Breaker ID		Cubicle / Position	
Technician(s)		Date	
Ambient temp		Counter as-found	
	°C	Humidity	Weather

STEP 3 · VISUAL & MECHANICAL INSPECTION (breaker withdrawn)

Item	Cond.	Clean/Lube	Notes
Overall cleanliness	OK	N/A	
Frame & structural members			
Vacuum interrupter supports / insulating members			
Operating rod insulators			
Primary bars & heat-dissipation fins			
Hardware / fastener torque check			
Primary disconnect fingers — silver condition			
Movable contact rods — silver condition (wipe lube off to inspect, re-lube after)			
Transfer fingers — burnished silver, no copper showing at >1 location			
Racking arms, track rollers & guides			
Positive interlock bar			
Negative interlock roller			
Spring-discharge interlock roller			
Closing-spring gag interference angle intact (do not modify)			
Rating interference plate condition			
Secondary coupler & pins			
Auxiliary switch & secondary wiring			
Operating mechanism — loose/damaged/missing parts			
Contact erosion indicators visible each pole			
Ground shoe / ground connection			

Cond.: OK = satisfactory · DEF = deficient (log it) · N/A. Clean/Lube: C = cleaned, L = lubricated, C+L = both. Transfer fingers: copper visible at more than one location per pole, or torn plating → replace interrupter assembly (GEK §11.5).

STEP 4 · CLEANING & LUBRICATION — PRIMARY CIRCUIT

▲ Discharge interrupter static at the mid-band ring before cleaning. Never use abrasives on silver surfaces.

Check	YES / NO	Notes
Primary insulation cleaned (lint-free wipes / approved cleaner)		
Disconnect fingers cleaned, inspected & re-lubricated — GE 0282A2048P009		
Movable contact rods wiped & lightly re-coated — GE 0282A2048P009		
Secondary coupler pins cleaned & greased		

STEP 5 · SLOW-CLOSE CHECK (closing-spring gag plate)

▲ Gag only a CHARGED closing spring. With gag installed + breaker closed + opening springs charged, the breaker can trip at FULL SPEED. Do not energize secondary control while gagged.

Check	YES / NO	Notes
Closing spring charged manually (~8 handle strokes) — indicator CHARGED		
Gag plate installed — detents fully seated in spring guide slots		
Manual close with gag — partial close achieved		
Slow-close through full stroke — smooth, no binding (charge handle on manual charge lever)		
Gag removed with spring fully CHARGED · close + trip pressed — all energy discharged		

GE Power/Vac VB1-4.16-250 · ML-18 mechanism · 4.16 kV Power House

Client	0	Job #	0
Site	0	Location	0
Single line dwg	22046-E005 Sht 1 Rev D — 4.16 kV Power House SLD		
References	GE GEK-86132G (W1001483) · GEK-39672F · ANSI/NETA ATS-2013 · SOW Rev 5 · E005 Rev D · GE 1047150601 Sh.6–8 (internals/elementaries)		
Breaker ID	Cubicle / Position	Date	
Technician(s)		Counter as-found	
Ambient temp	°C	Humidity	Weather

STEP 6 · DIMENSIONAL CHECKS — ALL 3 POLES (GEK-86132G §8)

MEASUREMENT LOCATIONS — GEK-86132G Fig 6 (operating rod: erosion disk, wipe indicator, reference arm) & Fig 7 (contact gap · ML-18H wipe point)

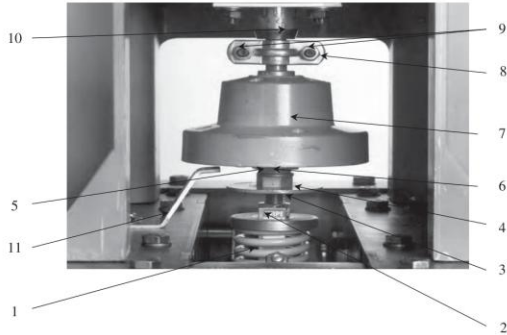


Figure 6 Operating rod assembly

- | | | |
|--------------------------------|----------------------------|-------------------------------------|
| 1. Wipe spring | 5. Lock washer | 9. Clamp screws |
| 2. Wipe indicator (ML 18 only) | 6. Hexagon projection | 10. Interrupter movable contact rod |
| 3. Erosion disk | 7. Operating rod insulator | 11. Reference arm |
| 4. Lock nut | 8. Coupling clamp | |

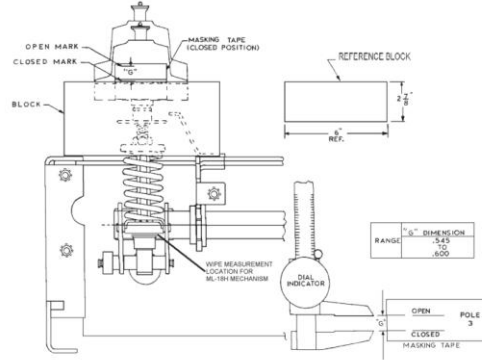
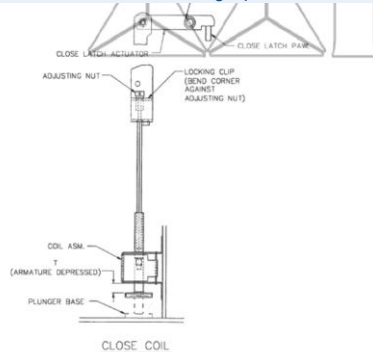


Figure 7 Contact gap

GEK-86132G Figure 6 — Operating rod assembly (legend in figure)

GEK-86132G Figure 7 — Contact gap / ML-18H wipe measurement location

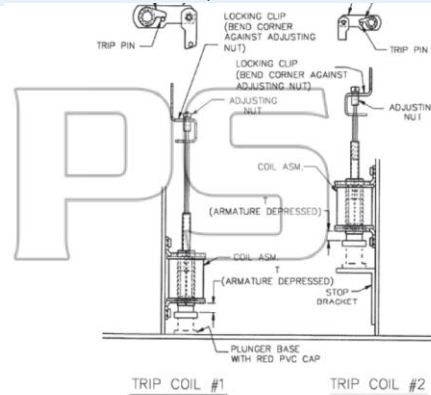
PLUNGER GAPS — GEK-86132G Fig 9 (close coil — ML-18/ML-18H type table) & Fig 10 (trip coil, $T = 0.250 + 0.000/-0.050$)



- ML-18 Breakers with type designation
-0, -1 & -2 $T = 0.25" \text{ to } 0.30"$
ML-18 Breakers with type designation
-3 $T = 0.35" \text{ to } 0.40"$
ML-18H Breakers with type designation
-0, -1 & -2 $T = 0.35" \text{ to } 0.40"$

Figure 9 Close coil plunger gap

GEK-86132G Figure 9 — Close coil plunger gap (type table in figure)



Plunger Gap $T = .250 + .000/-0.050$

Figure 10 Trip coil plunger gap

GEK-86132G Figure 10 — Trip coil plunger gap

GE Power/Vac VB1-4.16-250 · ML-18 mechanism · 4.16 kV Power House

Client	0					Job #	0
Site	0					Location	0
Single line dwg	22046-E005 Sht 1 Rev D — 4.16 kV Power House SLD					Schematic ref	
References	GE GEK-86132G (W1001483) · GEK-39672F · ANSI/NETA ATS-2013 · SOW Rev 5 · E005 Rev D · GE 1047150601 Sh.6–8 (internals/elementaries)						
Breaker ID	Cubicle / Position					Date	
Technician(s)						Counter as-found	
Ambient temp		°C	Humidity		Weather		
Parameter (measured)	Pole 1	Pole 2	Pole 3	Min	Max	Result	Notes / breaker state
Contact erosion (disk to reference arm)				—	0.125 in		CLOSED · cl spring DISCH · op spring CHG. At 0.125 replace interrupter.
Contact wipe (open minus closed reading)				> 0.075 in	—		Gagged; ML-18: indicator vs erosion disk · ML-18H: Teeler belleville-to-trunnion (§8.3). Same limits. DEFICIENT if ≤ 0.075.
Contact gap, Dimension G (tape method)				0.54 in	0.60 in		OPEN · cl spr CHG+gag; centre pole highest. §8.4: 0.54–0.60 (Figs 7/12 show 0.545–0.600).
As-left wipe (only if adjusted, target 0.15–0.18)				0.150 in	0.180 in		Adjust per §16.2 — one turn of op-rod insulator = 0.078 in.
Additional checks — as required (GEK-86132G §8.4–8.6; bottom access, breaker on right side — NOT on lift truck)							
Close coil plunger gap, Dim. C				0.25 in	0.30 in		OPEN · cl spr CHG+gag. ML-18 (-0/-1/-2): 0.25–0.30 · ML-18H & ML-18 -3: 0.35–0.40 (86132G §8.5.1, Fig 9)
Trip coil plunger gap, Dim. T				0.20 in	0.25 in		CLOSED · cl spring DISCH.
LCS / SM-LS & CHG plunger recess				0.000 in	0.031 in		OPEN · springs DISCH; flush–1/32 recess (§8.6.1). ML-18H: verify IL/MS plunger fully extended (§8.6.3).
CL/MS (rear-terminal) plunger-to-bracket				0.99 in	1.01 in		ML-18 -0/-1/-2 only (§8.6.2): 0.99–1.01. ML-18H & type -3: factory-shimmed — N/A.

STEP 7 · MECHANISM LUBRICATION (GEK-86132G §11.8)

Check	YES / NO	Notes
Light synthetic machine oil (e.g. Mobil 1) — few drops at each bearing		
GE 0282A2048P009 grease — four corners of closing-spring guide		
Metal-to-metal contact surfaces cleaned & greased		
All silvered primary contact surfaces wiped & lightly coated		

STEP 8 · INSULATION RESISTANCE

REQUIRED EQUIPMENT & OPERATION — Megger MIT515-class 5 kV insulation tester (DTI) — manual in 6.0 Test Equipment Manuals

Required: 5 kV silicone lead set (red +, black –, blue guard) · charged battery (charge indoors — will not charge below 0 °C) · grounding stick

- Confirm the model on the case (steps below match MIT515/525/1025). Battery: charge fully indoors before each shift - it will NOT charge below 0 degC, and tests are blocked on an empty battery.
- Breaker racked out, isolated, discharged, safety grounds applied; lift the ground only from the part being tested. Connect leads before switching on: for pole-to-ground, (+) red to a pole stab, (–) black to frame ground; other two poles grounded. Breaker CLOSED for pole tests.
- If the display shows a live voltage (>= 50 V) with beeper when leads go on - stop, the item is not dead; re-verify isolation and discharge.
- Primary IR: rotate the central switch from OFF to 2500 V. Set the left mode switch to IR(t); timer default is 1:00 min (reset via the spanner/settings position if someone changed it).
- Press and hold TEST ~3 s to start (HV warning lamp on). The test self-terminates at 1 minute - record the displayed 1-min value (MΩ/GΩ), test voltage, and temperature. MIT515 has no Save button: write every reading on the test sheet immediately.
- On stop the instrument auto-discharges the item. DO NOT lift a lead until the terminal-voltage readout/warning clears (< 50 V) - bushings and interrupters hold real charge.
- Repeat 2500 VDC / 1 min for: each pole to ground (breaker CLOSED, other poles grounded) and across each OPEN interrupter (breaker OPEN, top-to-bottom stab of the same pole), per the test sheet. Benchmark: >= 1,000 MΩ class value for 4.16 kV apparatus - use the test-sheet acceptance.
- Secondary/control IR: central switch to 500 V; first isolate electronics and motor leads and short/ground CT secondaries per the test sheet; test control bus to frame 1 min; record.
- Finish: confirm discharge on the display, rotary to OFF, re-apply safety grounds, restore every secondary link/lead lifted in step 8. Use the blue GUARD lead only when surface leakage over a wet/dirty bushing must be excluded.

Note: Instrument beeps + shows voltage if the item is live (> 50 V) — stop and re-verify isolation. Auto-discharges on stop: do not lift leads until < 50 V shown. Note ambient temp with every reading.

Primary test voltage	2500 VDC	Secondary test voltage	500 VDC	1-minute readings · record temp/humidity in header			
Test connection	Reading		Min	—	Result	Notes	
Pole 1 to ground — breaker CLOSED			1,500 MΩ	—		NETA T100.1 (5 kV); GE guide ≥ 10,000 MΩ — trend	
Pole 2 to ground — breaker CLOSED			1,500 MΩ	—		NETA T100.1 (5 kV); GE guide ≥ 10,000 MΩ — trend	
Pole 3 to ground — breaker CLOSED			1,500 MΩ	—		NETA T100.1 (5 kV); GE guide ≥ 10,000 MΩ — trend	
Pole 1 – Pole 2 — breaker CLOSED			1,500 MΩ	—		NETA T100.1 (5 kV); GE guide ≥ 10,000 MΩ — trend	
Pole 2 – Pole 3 — breaker CLOSED			1,500 MΩ	—		NETA T100.1 (5 kV); GE guide ≥ 10,000 MΩ — trend	
Pole 1 – Pole 3 — breaker CLOSED			1,500 MΩ	—		NETA T100.1 (5 kV); GE guide ≥ 10,000 MΩ — trend	
Across open contacts — Pole 1			1,500 MΩ	—		NETA T100.1 (5 kV); GE guide ≥ 10,000 MΩ — trend	
Across open contacts — Pole 2			1,500 MΩ	—		NETA T100.1 (5 kV); GE guide ≥ 10,000 MΩ — trend	
Across open contacts — Pole 3			1,500 MΩ	—		NETA T100.1 (5 kV); GE guide ≥ 10,000 MΩ — trend	
Control wiring to ground @ 500 VDC (motor leads off; all pins except #24)			2 MΩ	—		NETA 7.6.3: ≥ 2 MΩ	

GE PowerVac VB1-4.16-250 · ML-18 mechanism · 4.16 kV Power House

Client	0				Job #	0
Site	0				Location	0
Single line dwg	22046-E005 Sht 1 Rev D — 4.16 kV Power House SLD				Schematic ref	
References	GE GEK-86132G (W1001483) · GEK-39672F · ANSI/NETA ATS-2013 · SOW Rev 5 · E005 Rev D · GE 1047150601 Sh.6–8 (internals/elementaries)					
Breaker ID		Cubicle / Position			Date	
Technician(s)					Counter as-found	
Ambient temp		°C	Humidity		Weather	

STEP 9 · CONTACT RESISTANCE (breaker CLOSED)

REQUIRED EQUIPMENT & OPERATION — Broman 210 (Miller Instruments) 100 A micro-ohmmeter (rental) — manual in 6.0 Test Equipment Manuals

Required: 100 A current-lead pair + shielded potential-lead pair (confirm in case at pickup) · grounded 120 V supply · unit level, meters read square-on

- Breaker racked out on stand, primary de-energized, and NO ground path in parallel with the pole being measured (a parallel ground falsifies the microhm reading). CLOSE the breaker (125 VDC control power via the test coupler, or per GE manual method).
- Before power-up: CURRENT SET control fully counter-clockwise at ZERO. Plug into a grounded 120 V outlet; if the line-monitor lamp by the inlet flashes, the supply is ungrounded or line/neutral reversed - correct before proceeding.
- Press ON/OFF to power up. Zero the meter: clip the two current-lead ends together, clip both potential leads onto the NEGATIVE current clip, adjust ZERO SET until the MICROHM meter reads zero.
- Connect 4-terminal Kelvin to the pole: current clamps on the top and bottom stabs, potential clips inside them (closer to the interrupter), red-to-red, black-to-black (manual Fig. 1).
- Set MICROHM RANGE = 100 (PowerVac primary loop readings are typically well under 100 microhm; if unknown start at 5000 and range down). Advance CURRENT SET until the DC AMPERE meter reads exactly 100 A.
- Read the MICROHM meter. If deflection < 20% of scale: select the next more-sensitive range, momentarily wind current to zero, re-verify ZERO SET, then re-set exactly 100 A and read.
- Work fast - reading secured in 10-15 s. HARD LIMITS: never more than 2 min at 100 A, 20% duty cycle (thermal cutout needs ~5 min to reset if tripped). Wind CURRENT SET to zero the moment you have the number.
- Record microhms per pole; repeat all 3 poles. Investigate any pole reading > 50% above the lowest pole (NETA benchmark) or above the GE/test-sheet limit.
- Current at zero, disconnect leads, power off. Field sanity check after the cold flight: CAL CHECK terminals on the 500-microhm range must read 500 +/- 10 microhm at 100 A.

Note: Max 2 min at 100 A, 20% duty (thermal cutout ≈ 5 min reset). Field check: CAL CHECK terminals on 500 μΩ range must read 500 ± 10 μΩ at 100 A.

Test current	100.00 A Across primary bars on breaker side of disconnect fingers · breaker CLOSED					
Parameter (measured)	Pole 1	Pole 2	Pole 3	Min	Max	Result
Primary circuit resistance				30.00 μΩ	60.00 μΩ	
Pole-to-pole deviation check (NETA: investigate > 50% above lowest pole)				auto	≤ 50 %	
						GEK-86132G §9.3 @ 100 A: 1200 A = 30–60 μΩ · 2000 A = 25–50 μΩ (limits follow nameplate rating).
						NETA ATS-2013 7.6.3

STEP 10 · VACUUM INTERRUPTER INTEGRITY (breaker OPEN)

▲ AC test set only unless DC ≤ 50 kV peak — NEVER half-wave-rectified DC (X-radiation + false readings). Only test a correctly adjusted breaker at normal open gap. Discharge each interrupter after test.

REQUIRED EQUIPMENT & OPERATION — High Voltage Inc. PFT-503CM 50 kV AC hipot (rental) — manual in 6.0 Test Equipment Manuals

Required: Panel ground lead FIRST · EXT INTLK jumper plug (HV will not energize without it) · 20 ft shielded HV cable + return lead · discharge stick · barriers, personnel 2–3 m back

- GROUND FIRST: connect the front-panel GROUND post to station ground with the black boot lead BEFORE plugging into AC power. Insert the EXT INTLK jumper plug. Verify OUTPUT dial fully counter-clockwise at 0 (zero-start interlock blocks HV otherwise).
- Breaker racked out on stand, OPEN, springs discharged, stabs discharged. Clip the red-boot HV clamp to the TOP stab of the pole under test; run the shielded return lead from that pole's BOTTOM stab to LOAD RETURN. Set RETURN MODE = GROUND. Ground the stabs of the two poles not under test.
- Clearances: min 10 kV/inch in air - keep >= 4 in (100 mm) from grounded metal at 36 kV. Rope off; all personnel 2-3 m back (an open vacuum gap at 36 kV can emit X-radiation - do not stand at the breaker).
- Plug into grounded 120 V. Press MAIN POWER (lamp on). KILOVOLT METER range switch to HIGH (0-50 kV); current-meter multiplier to X100 to start.
- With OUTPUT at 0, press HV ON (red LED). Raise OUTPUT smoothly to 36.0 kV and hold 10 s (count aloud or stopwatch). A steady 13-18 mA is NORMAL (grounded cable-shield charging current); a current jump, kV collapse, or overload trip = loss of vacuum - FAIL.
- PASS = 36 kV held 10 s, no trip. Record pole, kV, hold time, mA. Rotate OUTPUT back to 0 FIRST, then press HV OFF (green LED).
- Ground the tested stabs with the discharge stick before touching any lead. Move connections to the next pole; repeat for all 3 poles.
- 14 kV bus test (if on the sheet): same sequence with HV clamp on the isolated bus phase, other phases + enclosure grounded; raise to 14.0 kV, hold per test-sheet duration, record kV/mA/time.
- Shutdown: OUTPUT to 0, HV OFF, MAIN POWER off, unplug, ground everything tested, remove the panel ground lead LAST. Coil the HV cable in its bay with ground/return leads coiled inside it.

Note: 13–18 mA steady is normal background (grounded-shield charging current). A current jump, kV collapse, or overload trip during the hold = FAILED interrupter. GUARD return mode not usable here — leave in GROUND.

Note (86132G §9.4): wipe interrupter exteriors COMPLETELY clean before test. On failure: clean pole piece & retest — 2nd-pass pass is acceptable; 3rd failure = replace interrupter.

Test type	36 kV AC	Hold time	10.00 s	Hot lead upper stud · ground lead lower stud · RAISE AT 500 V/s · hold 10 s (§9.4)		
Interrupter		Applied kV	Breakdown? (YES/NO)	Result	Notes	
Pole 1 vacuum interrupter					Breakdown = replace interrupter	
Pole 2 vacuum interrupter					Breakdown = replace interrupter	
Pole 3 vacuum interrupter					Breakdown = replace interrupter	

GE Power/Vac VB1-4.16-250 · ML-18 mechanism · 4.16 kV Power House

Client	0			Job #	0
Site	0			Location	0
Single line dwg	22046-E005 Sht 1 Rev D — 4.16 kV Power House SLD			Schematic ref	
References	GE GEK-86132G (W1001483) · GEK-39672F · ANSI/NETA ATS-2013 · SOW Rev 5 · E005 Rev D · GE 1047150601 Sh.6–8 (internals/elementaries)				
Breaker ID		Cubicle / Position		Date	
Technician(s)				Counter as-found	
Ambient temp		°C	Humidity	Weather	

STEP 11 · ELECTRICAL OPERATION (secondary test coupler + DC supply)

▲ Maximum TWO operations per minute (charging motor). Leave breaker OPEN and springs DISCHARGED when done.

REQUIRED EQUIPMENT & OPERATION — BHD PS15-2.1 AC/DC control supply, 0–120 V / 15 A (rental) — reference sheet in 6.0 Test Equipment Manuals

Required: Output lead set · DMM to verify voltage AT THE COUPLER (do not trust the panel meter) · GE secondary test coupler

1. Selector to DC, output control at ZERO before switching on — assume NO zero-start interlock; you are the interlock.

2. Supply OFF: land leads on the coupler control-power terminals, polarity per the GE elementary.

3. Switch on, wind up slowly to 125 VDC — verify with the DMM at the coupler.

4. Motor/close/trip checks: let every spring-charge cycle complete; expect ~23 A motor inrush settling to ~8 A windup (86132G Table 1); sustained draw ≤ 15 A supply rating.

5. Coil minimum pickup: wind to ZERO, raise SLOWLY until the coil just operates, record the voltage; repeat per coil, then return to 125 V.

6. Always wind to zero and switch OFF before moving any lead — never break an energized coil circuit at the clip.

Note: Rectified unfiltered DC — fine for coils and the spring motor, NEVER for relay electronics. Verify at pickup that DC output actually reaches 125 VDC.

REQUIRED EQUIPMENT & OPERATION — Vanguard CT-7000 S-series breaker analyzer (rental) — manual in 6.0 Test Equipment Manuals

Required: C1–C3 contact-channel cables · 4-pin INITIATE cable · V1 voltage lead · GE secondary test coupler (mandatory) · spare 5 A fast-blow initiate fuses · spare printer roll

1. Breaker racked out on the test stand, OPEN, primary isolated. Connect the CT-7000 GROUND terminal to station ground FIRST, then plug into 120 V. Install the GE secondary test coupler on the breaker.

2. Contact channels: C1, C2, C3 clipped across poles A, B, C - top stab to bottom stab of each vacuum interrupter. Channel sensing is dry/low-energy (<= 6 VDC class) and safe across the bottles. Dress leads clear of the operating mechanism.

3. INITIATE cable (4-pin): OPEN pair to the trip-coil terminals, CLOSE pair to the close-coil terminals, through the test coupler per the GE elementary (mind polarity). Connect V1 across the 125 VDC control bus to record the voltage dip during coil operation.

4. Energize 125 VDC control power (see BHD PS15 procedure); let the spring-charge motor finish; electrically CLOSE the breaker - trip timing starts from CLOSED.

5. Power on. From the START-UP menu key: [1] TIME BREAKER -> [1] TIME DRY CONTACTS -> INSERTION RESISTOR? [1] NO -> TIMING WINDOW [1] 1 SEC -> TRIGGER MODE [1] INTERNAL -> TIMING MODE [1] OPEN.

6. All hands clear of the breaker. Hold the spring-loaded PUSH TO ARM button and press [START]; keep ARM held until TEST COMPLETES (up to 25 s). The set fires the trip coil and records all poles.

7. Print the tabulated + graph report: ACCEPT if trip time 32–45 ms every pole AND pole spread <= 2 ms. Also review the trip-coil current signature and V1 dip for a healthy coil/latch.

8. Breaker is now OPEN with springs recharging - repeat steps 5–6 with TIMING MODE [2] CLOSE: accept 35–75 ms, spread <= 2 ms. Optional [4] C-O shot for the trip-free function if the sheet calls for it.

9. Save every shot (thermal printout stapled to the test sheet + record to USB MEM). De-energize control power BEFORE lifting the initiate leads; remove leads; panel ground disconnects last.

Note: Menu path: TIME BREAKER → TIME DRY CONTACTS → insertion resistor NO → window 1 s → trigger INTERNAL → mode OPEN (then CLOSE). Hold PUSH-TO-ARM + START until test completes. Staple printout to this sheet.

Check	Measured	Min	Max	Result	Notes
Control voltage at coupler		100 VDC	140 VDC		GE 86132G Table 1 (125 VDC): close 100–140 · trip 70–140
Spring charge time		—	—	record	· close coil 6 A · trip coil 5.9 A Record & trend — motor inrush ~23 A → windup ~8 A (table 1) · full charge ~2 s
Trip coil minimum pickup (optional)		—	70 VDC		Must trip at ≤ 70 VDC (T100.20)
Close coil minimum pickup (optional)		—	100 VDC		Must close at ≤ 100 VDC (T100.20)
Functional checks		YES / NO		Notes	
Electrical close & trip — several operations, reliable					
Anti-pump (52Y) verified — close signal maintained, single close only					
Trip-free operation verified (simultaneous close + trip)					

Trip / close timing — contact monitor ≤ 6 VDC / 1 A through interrupter

Parameter (measured)	Pole 1	Pole 2	Pole 3	Min	Max	Result	Notes / breaker state
Trip time (signal to contact part)				32.00 ms	45.00 ms		GEK-86132G §12 — 5-cycle: 32–45 ms (3-cycle breakers: 25–30 ms)
Trip pole spread (auto = max – min)				—	≤ 2 ms		GEK §12: ≤ 2 ms
Close time (signal to contact touch)				35.00 ms	75.00 ms		GEK §12 nominal range
Close pole spread (auto = max – min)				—	≤ 2 ms		GEK §12: ≤ 2 ms
Counter reading after electrical checks				—	—	record	Counter must advance 1 per close-open cycle (NETA)

GE Power/Vac VB1-4.16-250 · ML-18 mechanism · 4.16 kV Power House

Client	0			Job #	0
Site	0			Location	0
Single line dwg	22046-E005 Sht 1 Rev D — 4.16 kV Power House SLD			Schematic ref	
References	GE GEK-86132G (W1001483) · GEK-39672F · ANSI/NETA ATS-2013 · SOW Rev 5 · E005 Rev D · GE 1047150601 Sh.6–8 (internals/elementaries)				
Breaker ID		Cubicle / Position		Date	
Technician(s)				Counter as-found	
Ambient temp		°C	Humidity		Weather

STEP 12 · COMPARTMENT / CUBICLE (breaker out · bus isolated per outage plan)

Item	Cond.	Clean/Lube	Notes
Shutters exercise freely & fully cover stabs with breaker withdrawn			
Stationary stabs — silver condition, no overheating; thin coat 0282A2048P009			
Current transformers — visual condition & connections			
Compartment insulation / standoffs			
Space heaters operating (stacks 111/112 shipped UNWIRED per GE 1047150601 — mark N/A unless site-wired)			
MOC / TOC switches exercised			
Secondary disconnect block & wiring			
Racking screw cleaned & lubricated (0282A2048P009)			
Rails, guides & rollers			
Compartment vacuumed & cleaned			
Ground shoe contact surface			
Optional — contact wipe impression (GEK-39672F p.39)	YES / NO		Notes
Primary disconnect wipe impression checked (de-energized only): all fingers, ≥ 1/2 in from front edge, ≥ 3/16 in from bar sides — if improper DO NOT adjust, report to GE			

STEP 13 · REINSTALLATION & AS-LEFT

Check	YES / NO	Notes
Breaker OPEN & springs discharged before insertion; mating surfaces cleaned & greased		
Racked to TEST — BOTH racking arms engaged on drive blocks before racking (jam risk, 86132G §10); coupler engages		
POSITIVE interlock: racking crank BLOCKED with breaker closed		
SPRING-DISCHARGE interlock: springs discharge ≤ 5 turns racking in (typ 3rd–4th)		
NEGATIVE interlock: breaker trip-free between positions		
Electrical close/trip from door-front control switch		
Racked to as-left position · 60 turns to CONNECT · max 60 ft·lb		
Keys / padlocks restored · door closed & latched		
As-left position	As-left status	Counter as-left

GE PowerVac VB1-4.16-250 · ML-18 mechanism · 4.16 kV Power House

Client	0			Job #	0
Site	0			Location	0
Single line dwg	22046-E005 Sht 1 Rev D — 4.16 kV Power House SLD			Schematic ref	
References	GE GEK-86132G (W1001483) · GEK-39672F · ANSI/NETA ATS-2013 · SOW Rev 5 · E005 Rev D · GE 1047150601 Sh.6–8 (internals/elementaries)				
Breaker ID		Cubicle / Position		Date	
Technician(s)				Counter as-found	
Ambient temp		°C	Humidity		Weather

COMMENTS / DEFICIENCIES

Comments:

Deficiencies (also log in DEFICIENCY LOG):

TEST EQUIPMENT USED

Instrument	Make / model	Serial no.	Cal. due
Insulation resistance tester (5 kV)	Megger MIT		
AC hi-pot (vacuum integrity)	HV PFT 503CM		
Micro-ohmmeter (100 A)	Broman 210		
Breaker analyzer / timing	Vanguard CT7000		
AC/DC control supply	BHD PS15-2.1		
DC coil supply 0–150 VDC			

Tested by		Signature		Date	
Reviewed by		Signature		Date	

GE Multilin SR-489 / SR-750 / SR-735 / 350 · wiring & status validation (SOW Part B)

Client	0	Job #	0
Site	0	Location	0
Single line dwg	22046-E005 Sht 1 Rev D — 4.16 kV Power House SLD	Schematic ref	
Scope	As-found capture · wiring vs schematics · status · trip path · as-left — NO injection testing · NETA MTS §7.9 V/M portions		
Relay ID / Position		Breaker	
Relay type		Model	
Firmware rev		Control voltage	125 VDC
Technician(s)		CT / VT ratio	
		Setting file rev	

SECTION 1 · AS-FOUND SETTINGS & RECORDS CAPTURE

▲ Drawout SR-series units: withdraw only with protected equipment out of service. Never open-circuit an energized CT secondary.

REQUIRED EQUIPMENT & OPERATION — Field laptop + EnerVista setup software — installers in 7.0 Relay Software (install & test BEFORE travel)

Required: USB-RS232 adapter (FTDI, driver pre-installed) · straight-through DB9 M-F cable (NOT null-modem) · USB-A to mini-B cable · laptop admin rights

- Before mobilization: run all three installers as Administrator (489setup407, 3seriessetup262, 750setup746) and test-launch each — no internet at site.
- SR-489 / SR-750: front DB9 RS232 port via USB-RS232 adapter — Quick Connect at 9600 baud, 8N1, Modbus RTU (if no response, check the relay's S1 comms setpoints).
- Multilin 350: SR3 Setup must be installed BEFORE first USB plug-in (installer includes the USB virtual-COM driver); connect USB mini-B, port enumerates as COM, Quick Connect.
- Read settings and SAVE the setpoint file as <RelayID>_as-found_<date> into the job folder; do not write or change any setting.
- SR-735: no comms — photograph every dial and DIP switch; the photos ARE the settings record.
- As-left must equal as-found: re-read (or re-photograph) after work and file beside the as-found capture.

Note: SR3 Setup v2.62 matches the site FW 2.6x fleet (setup version must be ≥ relay firmware). All installers carry valid GE digital signatures — accept the SmartScreen prompt. Windows 11 untested by GE: test-install first.

Capture method	489/750: RS232+EnerVista · 350: USB+EnerVista SR3 · 735: photos ARE the record		
Setpoint file / photo refs			
	Capture checks	YES / NO	Notes
As-found settings captured & archived (file saved to job folder / photos taken)			
As-found alarms, targets & fault records recorded (before clearing anything)			
Front panel / DIP-dial settings photographed			

SECTION 2 · WIRING VERIFICATION vs OWNER SCHEMATICS

Schematic / drawing ref	Verify vs Owner schematics · SS-TR fdr: 3×400:5 + CTGS 50:5 (SCTB1/SCTB2) · Tie: 3×2500:5 (SCTB1) — GE 1047150601 Sh.7/8		
	Item	Cond.	Notes
CT circuit wiring & polarity per schematic			
VT circuit wiring per schematic			
Trip circuit wiring per schematic			
Close circuit wiring per schematic			
Rear terminal tightness (torque screwdriver)			
Case / frame ground connection			

GE Multilin SR-489 / SR-750 / SR-735 / 350 · wiring & status validation (SOW Part B)

Client	0	Job #	0
Site	0	Location	0
Single line dwg	22046-E005 Sht 1 Rev D — 4.16 kV Power House SLD	Schematic ref	
Scope	As-found capture · wiring vs schematics · status · trip path · as-left — NO injection testing · NETA MTS §7.9 V/M portions		
Relay ID / Position		Breaker	
Relay type		Model	
Firmware rev		Control voltage	125 VDC
Technician(s)		CT / VT ratio	
		Setting file rev	

SECTION 3 · DEVICE STATUS VERIFICATION

Status checks	YES / NO	Notes
Self-test clean — no active self-test errors / alarms		
LEDs & display functional		
Targets operate & reset correctly		
In-Service indication correct		

SECTION 4 · TRIP-PATH CONTINUITY (breaker in TEST position)

Trip-path checks	YES / NO	Notes
Breaker confirmed in TEST position · outage window confirmed with operations		
Relay output operated → breaker TRIPPED via trip coil		
Trip target / event record confirmed on relay		
Method / output used		

SECTION 5 · AS-LEFT RESTORATION

As-left checks	YES / NO	Notes
Test switches / links restored to service position		
Settings verified UNCHANGED from as-found capture		
Targets cleared · In-Service indication restored		
As-left condition photographed		

COMMENTS / DEFICIENCIES

Comments:

Deficiencies (also log in DEFICIENCY LOG):

Tested by		Signature		Date	
Reviewed by		Signature		Date	

 **DTI Technical Services**[illegible]