

AMERICAN NATIONAL STANDARD

NECA 405-2001



Recommended Practice for
Installing and Commissioning

Interconnected Generation Systems



Published by
National Electrical
Contractors Association



An American National Standard

NECA 405–2001

Recommended Practice for

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Interconnected Generation Systems**



*National
Electrical
Installation
Standards™*

Published by
**National Electrical
Contractors Association**



National Electrical Installation Standards™

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(This foreword is not a part of the standard)

Foreword

National Electrical Installation Standards™ are designed to improve communication among specifiers, purchasers, and suppliers of electrical construction services. They define a minimum baseline of quality and workmanship for installing electrical products and systems. *NEIS™* are intended to be referenced in contract documents for electrical construction projects. The following language is recommended:

Interconnected generation systems shall be installed in accordance with NECA 405-2001, *Recommended Practice for Installing and Commissioning Interconnected Generation Systems* (ANSI).

Use of *NEIS™* is voluntary, and the National Electrical Contractors Association assumes no obligation or liability to users of this publication. Existence of a standard shall not preclude any member or nonmember of NECA from specifying or using alternate construction methods permitted by applicable regulations.

This publication is intended to comply with the edition of the National Electrical Code (NEC) in effect at the time of publication. Because they are quality standards, *NEIS* may in some cases go beyond the minimum safety requirements of the NEC. It is the responsibility of users of this publication to comply with state and local electrical codes when installing electrical products and systems.

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This recommended practice was developed in conjunction with T.A. Engineering Inc. of Baltimore, Maryland. T.A. Engineering has extensive experience designing distributed power systems and combined heat/power generation systems for industrial and commercial clients. Projects have included both conventional co-generation installations up to 10 Megawatts and a 200 kilowatt fuel cell installation.

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1. Scope

This recommended practice describes procedures for installing, commissioning, relaying, and metering of electric power production sources operating in parallel with an electric utility source. It does not cover the use of on-site generators for emergency, legally-required standby, or optional standby systems.

This recommended practice should be used together with other *NEIS™* documents to ensure the proper installation of equipment. When installing generator sets refer to NECA/ EGSA 404-2000, *Recommended Practice for Installing Generator Sets*. When installing switchboards refer to NECA/EGSA 400-1998, *Recommended Practice for Installing and Maintaining Switchboards*. (See Annex B for related references.)

1.1 Systems and Equipment Included

This recommended practice includes, but is not limited to, the following:

- a) Protective relays for disconnecting generation equipment from the utility electrical system under specified conditions.
- b) Metering for local and remote indication of generation system operation.

1.2 Systems and Equipment Excluded

While this recommended practice generally covers most interconnected generation systems, the following are specifically excluded:

- a) Protective equipment for the prime mover, generator, and regulator.
- b) Protective equipment for the electrical utility service equipment.

Some discussion of generator and other protective devices is included to the extent necessary to describe the interconnection system.

1.3 Regulatory and Other Requirements

All recommendations of the publication are intended to comply with the National Electrical Code (ANSI/NFPA 70) and in general the typical recommendations of industrial equipment manufacturers. Installers should always comply with the NEC, applicable state and local codes, manufacturer's installation instructions, electric utility interconnection regulations, and contract obligations when installing these systems.

2. Definitions

2.1 Terminology

Definitions are consistent with IEEE Standard 100 as the generally accepted reference for such use.

Backfeed Electric power flow from the generation unit into the utility source.

Breaker Failure Condition where a circuit breaker or switch does not operate properly after receiving a signal to operate.

Fault An unintentional high current resulting from any of several possible unusual conditions such as a short-circuit or a loss of conductor insulation.

Differential The difference between two measured characteristics of the system. These characteristics are normally similar in magnitude.

Generator Field Regulator Device necessary to maintain the generator voltage at a predetermined level when isolated from the electric utility and maintain preset VAR flow when connected with the utility electric service.

Generation Unit Assembled package including the prime mover, generator, and auxiliary devices that are normally operated together as a single source of power.

Governor

Electro-mechanical system for controlling the prime mover and generator speed when isolated from the utility service and controlling the generator load when paralleled with the utility service.

Instantaneous

The shortest operating time available for a protective device. Generally recognized as having no intentionally added time delay.

Interconnection

The combination of the electrical utility service and the on-site generation unit feeder into a single coordinated system supplying common loads.

Islanding

Continued operation of a generation unit while isolated from the rest of the interconnected utility service.

Isolate

Disconnect a generation unit, utility service, or load from the electrical system.

Lock Out

Prevent a device from performing an undesired operation by using a mechanical or electrical means.

Mechanical Interlock

The means of restricting operation to a desired pattern using a system of mechanical locks, often with controlled keys.

Offline Test	Testing equipment while it is removed from its normal operating environment.	Synchronize	Process for adjusting separate electric services until they possess identical electrical components of voltage, frequency, and phase rotation.
Online Test	Testing equipment while it is connected with its normal operating environment.	Time-current Curve	Graph showing the characteristic performance of a device as related to time and current. Generally used for choosing components of a coordinated system protection.
Overcurrent	Any current greater than the rated current of a conductor, component, or equipment. Causes include overload, ground fault, and short circuit.	Time Delay	The time elapsed between a device receiving an operating signal and the device's output transmission.
Overfrequency	Any frequency greater than the rated frequency of an alternating current system.	Undercurrent	Any current less than the rated current of a conductor or equipment.
Overvoltage	Any voltage greater than the rated voltage of a system.	Underfrequency	Any frequency less than the rated frequency of a conductor or equipment.
Overspeed	Any rotational velocity greater than that desired of a system.	Undervoltage	Any voltage less than the rated voltage of a conductor or equipment.
Paralleling	Connecting separate electrical services after confirming they are in synchronization.	2.2 ANSI Device Numbers and Functions	
Prime Mover	The mechanical device driving a connected generator to produce electrical power.	Numbers and functions conform to ANSI/IEEE C37.2.	
Programmable Logic Controller	Solid state micro-processor device for controlling other hardware to accomplish specific tasks or processes.	1	Master Element
Reclose	Reconnect the generation unit with the utility electrical service. This operation is initiated by the protective system for isolation or islanding	2	Time Delay Starting or Closing Relay
Reverse Phase	Any phase rotation other than that desired on a polyphase system.	3	(reserved for future application)
		4	Master Relay
		5	Stopping Device
		6	Starting Circuit Breaker or Relay
		7	Anode Circuit Breaker
		8	Control Power Switch
		9	Reversing Device
		10	Unit Sequence Switch
		11	Control Power Transformer
		12	Overspeed Device

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13	Synchronous Speed Device	60	Voltage Balance Relay
14	Underspeed Device	61	Current Balance Relay
15	Speed regulating Device	62	Time Delay Relay
16	Battery Charging Control Device	63	Fluid Pressure, Level, or Flow Relay
17	Series Field Shunting Device	64	Ground Protection Relay
18	Accelerating or Decelerating Relay	65	Governor
19	Starting to Running Transition Relay	66	Notching Relay
20	Electrically Operated Valve	67	AC Directional Overcurrent Relay
21	Impedance Relay	68	DC Thermal Relay
22	Equalizer Circuit Breaker	69	Permissive Control Device
23	Temperature Regulating Device	70	Electrically Operated Rheostat
24	Volts per Hertz Device	71	DC Line Emergency Circuit Breaker
25	Synchronizing Device	72	DC Line Circuit Breaker
26	Apparatus Thermal Device	73	Load Resistor Circuit Breaker
27	AC Undervoltage Relay	74	Alarm Relay
28	Resistor Thermal Device	75	Position Changing Mechanism
29	Isolating Circuit Breaker or Switch	76	DC Overcurrent Relay
30	Annunciator Relay	77	Impulse Transmitter
31	Separate Excitation Device	78	Phase Angle Measuring Device
32	Directional Power Relay	79	AC Reclosing Relay
33	Position Switch	80	DC Undervoltage Relay
34	Motor Operated Sequence Switch	81	Frequency Relay
35	Brush Operated Short Circuit Device	82	DC Reclosing Relay
36	Polarity Device	83	Selective Control or Transfer Relay
37	Undercurrent Relay	84	Operating Mechanism
38	Bearing Thermal Device	85	Carrier or Pilot Wire Receiver Relay
39	Field Reducing Contactor	86	Lockout Relay
40	Field Relay	87	Differential Current Relay
41	Field Circuit Breaker or Switch	88	Auxiliary Motor
42	Running Circuit Breaker or Switch	89	Line Switch
43	Transfer Device	90	Regulating Device
44	Sequence Starting Device	91	DC Directional Voltage Relay
45	DC Overvoltage Relay	92	DC Directional Current Relay
46	Phase Balance Relay	93	Field Changing Relay
47	Reverse Phase Relay	94	Tripping or Trip Free Relay
48	Incomplete Sequence Relay	95	(reserved for future application)
49	AC Thermal Relay	96	(reserved for future application)
50	AC Instantaneous Overcurrent Relay	97	(reserved for future application)
51	AC Time Delay Overcurrent Relay	98	(reserved for future application)
52	AC Circuit Breaker	99	(reserved for future application)
53	Exciter or Generator Relay		
54	High Speed Circuit Breaker		
55	Power Factor Relay		
56	Field Application Device		
57	(reserved for future application)		
58	(reserved for future application)		
59	AC Overvoltage Relay		

3. Functions and Applications

Typical functions and applications for the protection and control systems covered by this recommended practice are discussed below as they perform during various operating sequences.

A simplified schematic diagram showing typical protection and control system elements is shown in Figure 1. This diagram is a functional illustration of the interconnection system and how it relates to the other protective and control devices associated with the generator and the utility power source. Many different arrangements can be furnished and installed. (See Annex A for additional discussion.)

3.1 Control Panels

Figure 1 shows protective relays clustered into three control panels. This clustering is shown for purposes of associating a protective or control device with its related major component. The Generator Control Panel is usually supplied by the manufacturer along with the generation unit. The Interconnection Control Panel and Utility Control Panel are supplied by an independent switchgear manufacturer. All three control panels should be installed and connected in the field.

The device numbers mentioned in the text below are listed in 2.2 along with a brief explanation of each

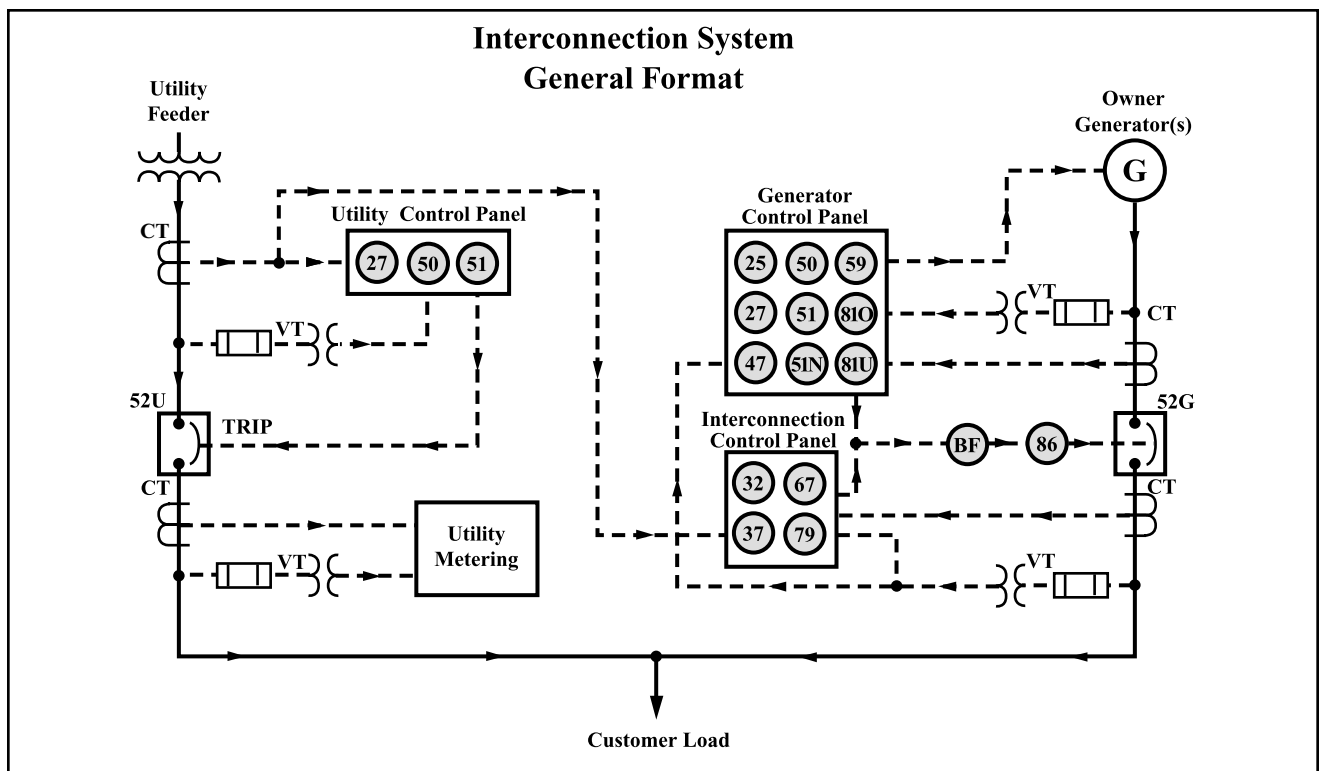


Figure 1. Interconnected generation system schematic diagram

device's function. Table 1 displays setting parameters for commonly-used devices.

Normally, relay settings are provided by the electrical design engineer determined through a coordination study performed by a testing company acceptable to the authority having jurisdiction.

3.2 Generator Start

Paralleling the generator to the utility service should be controlled by the Generator Control Panel (by manufacturer) and the Interconnection Control Panel (field assembled).

Paralleling the generator to the utility service is accomplished either manually or automatically by starting the prime mover of the generation unit, exciting the generator field, and bringing the generator to near synchronous speed. The generator synchronizes to the bus to which it is connected using a programmable logic controller (PLC) and synchronizing relay (device 25).

3.3 Normal Operation

The generator regulator (also supplied by the generator manufacturer) and PLC control the output of the generator based upon an external signal indicating the customer load.

Metering instruments provide generator load output to the controls and compares it to the generator load set point. This set point is either a constant value or varies according to a predetermined logic. This setting is selected to ensure that the generator does not intentionally permit generated power to backfeed into the utility service.

Alternatively, a fixed power output level can result in some power export to the utility service. An increase in the generation unit output should be triggered by a PLC signal to increase the unit's throttling method. Similarly, a decrease in output is controlled by a reduction in the generation unit's throttling method.

3.4 Generator Protection

As furnished by the manufacturer, the generator regulator's functions are supported with protective relaying in the event of an operating failure. Such relaying will typically shutdown the generator if the generator, prime mover, or generator regulator malfunctions.

Any such shutdown follows the opening of the generator circuit breaker (52G) by these same protective relays.

3.5 Interconnection Protection

3.5.1 Primary backfeed protection

Primary backfeed protection is provided by various protective devices such as:

- a) Undervoltage device (27) opens the utility circuit breaker (52U) based upon a specified minimum allowable utility voltage setting.
- b) Reverse phase relay (47) opens the generator circuit breaker (52G) based upon a phase rotation different than that defined by the device settings.

Multifunction relays are frequently used. These devices combine several individual functions within a single relay structure to share sensing and processing components while reducing the physical space required for installation. The increased use of multifunction relays has resulted in relay manufacturers producing standardized relays containing functions commonly used together.

(NOTE: Installers should be aware that standardized multifunction relays sometimes contain functions not required for a specific application. Unused functions can be disabled by following the manufacturer's instructions.)

3.5.2 Redundant backfeed protection

Redundant backfeed protection in the event of a generation unit regulator malfunction is provided by various optional protective devices such as:

a) Undercurrent device (37) opens the generator circuit breaker (52G) based upon a specified minimum allowable utility current setting. Such minimum settings may be required as a result of utility tariff provisions that customers maintain consumption levels at or above a specified minimum level. This relay also does not allow the generator circuit breaker to be reclosed while current is below the same specified minimum allowable utility current setting.

b) Breaker failure relay (BF) operates the generator circuit breaker (52G) only after sensing that the circuit breaker has not operated despite having received a signal from another protective device to operate.

c) Directional power relay (32) opens both the generator circuit breaker (52G) and the utility service circuit breaker (52U) to prevent any undesired backfeeding into the utility service. Both breakers are opened only if one breaker fails to open. This relay may be used as a back up to a directional overcurrent relay (67) which opens the generator circuit breaker (52G) when directional current exceeds a preset maximum. The use of a directional power relay (32) may be contractually required to maintain a minimum import of power from the utility.

Some of this same protective equipment may be duplicated on the customer's main circuit breaker for additional protection of the overall system. Additionally, a protective relay will provide an alarm if the control voltage source drops below a specified voltage level.

3.6 Loss of Utility Power

A complete loss of the electric utility source requires the generator output to be isolated from the utility source wiring. This results in the generation unit either shutting down or islanding from the rest of the interconnected system by providing its own excitation of the control circuits. Which of these two options occur is dependent upon the overall system performance design.

If the utility power is lost, the generator disconnects from the remainder of the interconnected system by

opening the generator circuit breaker (52G) and shutting down the generator. These actions are triggered by the relays sensing the generator overload or frequency deviation caused by the utility loss.

Functions are provided for backup protection of the utility in case of an electric service outage.

The generator circuit breaker (52G) does not reclose automatically if the utility source protective device recloses after an event. Functions related to utility reclosing should be coordinated with the utility.

Mechanical locking out of devices is required for periods of generation unit operation when the utility system is shut down for repair or maintenance. Mechanical interlocking may use such hardware as Kirk-type locking cylinders or padlocks using controlled access keys.

This interlocking permits repairs or maintenance to be performed on equipment without the threat of the equipment being accidentally energized.

Generator shutdown in many circumstances is a utility requirement used as a precaution to prohibit backfeed from a source that may not be known to the utility employees working on the system. The operating agreement between the local utility and the generator owner will determine the specifics of such operating parameters.

ANSI DEVICE DESIGNATION	PROTECTIVE FUNCTION	SETTING PARAMETER	EQUIPMENT LOCATION	COMMENTS
27	Undervoltage	Trip (volts) Time Delay (seconds) Reset (volts)	Utility Control Panel	Individual Functions May Be Combined By Using Multifunction Relays
50	Instantaneous Overcurrent	Trip (amperes) Time Curve Reset (amperes)		
51	Time Delay Overcurrent	Trip (amperes) Time Curve Reset (amperes)		
25	Synchronizing	Phase Angle (degrees) Time Delay (seconds) Slip Frequency (hertz)	Generator Control Panel	Individual Functions May Be Combined By Using Multifunction Relays
27	Undervoltage	Trip (volts) Time Delay (seconds) Reset (volts)		
47	Reverse Phase Voltage	Trip (volts) Time Delay (seconds) Reset (volts)		
50	Instantaneous Undercurrent	Trip (amperes) Time Curve Reset (amperes)		
51	Time Delay Undercurrent	Trip (amperes) Time Curve Reset (amperes)		
50	Instantaneous Overcurrent	Trip (amperes) Time Curve Reset (amperes)		
51N	Time Delay Neutral Overcurrent	Trip (amperes) Time Curve Reset (amperes)		
59	Overvoltage	Trip (volts) Time Delay (seconds) Reset (volts)		
81O	Overfrequency	Trip (hertz) Time Delay (seconds) Reset (hertz)		
81U	Underfrequency	Trip (hertz) Time Delay (seconds) Reset (hertz)		
32	Directional Power	Trip (watts) Time Curve Reset (watts)	Interconnection Control Panel	Individual Functions May Be Combined By Using Multifunction Relays
37	Undercurrent	Trip (amperes) Time Delay (seconds) Reset (amperes)		
67	Directional Overcurrent	Trip (amperes) Time Delay (seconds) Reset (amperes)		
79	Reclosing	Time Delay (seconds)		

Table 1. Protective relay setting parameters

4. Component and Hardware Installation

The components of an interconnected generation system are described in this section. Descriptions provide information about an item's function.

4.1 Description of Items

Principal elements of an interconnected system include the following equipment. Particular components will vary as required for each installation.

- a) Factory-manufactured generation unit with prime mover and generator. These two major items come supplied by individual devices for their control and protection.
- b) Factory-manufactured switchgear with circuit breakers, protective relays, metering instruments, metering transformers, and control devices.
- c) Additional field-installed circuit breakers, protective relays, metering instruments, metering transformers, and control devices as necessary to modify an existing system.
- d) Control wires, communications wires, power cables, and fiber optic cables along with associated hardware including cable trays and raceways.
- e) Battery systems including battery cells, charging systems, and protective systems.
- f) Auxiliary devices including panelboards, indicating lights, annunciators, alarms, space heaters, and ventilation fans.

Install these assemblies and components in accordance with the manufacturers' instructions in addition to the requirements of this publication. Also review and comply with contract document provi-

sions for installation of components into switchgear, cabling, and wiring.

4.1.1. Protective relays

Protective relays function by processing an input signal into an output signal. The process usually is triggered by the input signal meeting or exceeding a set parameter limit.

The process output signal is then transmitted either instantaneously or after a preset time delay. This output signal is used to activate another device, either another relay or a mechanical disconnecting means.

Protective relays perform either a single function or multiple functions depending on the manufacturer and the design engineer's preference.

- a) Synchronizing Relay (25): Function triggered when either phase angle or slip frequency equals preset levels.
- b) Undervoltage Relay (27): Function triggered when voltage is below a preset level.
- c) Directional Power Relay (32): Function triggered when power in a particular direction is above a preset level.
- d) Undercurrent Relay (37): Function triggered when current is below a preset level.
- e) Reverse Phase Voltage Relay (47): Function triggered when phase rotation is different than the specified direction.
- f) Instantaneous Overcurrent Relay (50): Function triggered when instantaneous current is above a preset level.

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- g) Time Overcurrent Relay (51): Function triggered when time current is above a preset level.
- h) Overvoltage Relay (59): Function triggered when voltage is above a preset level.
- i) Directional Overcurrent Relay (67): Function triggered when current is above a preset level in the specified direction.
- j) Reclosing Relay (79): Function triggered by a signal from the voltage sensors.
- k) Overfrequency Relay (81O): Function triggered when frequency is above a preset level.
- l) Underfrequency Relay (81U): Function triggered when frequency is below a preset level.
- m) Lock Out Relay (86): Trips the generator circuit breaker open and prevents automatic reset.
- n) Breaker Failure Relay (BF): Senses when the generator circuit breaker has not operated despite having received a signal to operate.
- o) Generator Circuit Breaker (52G): Switchgear-mounted circuit breaker with electrically operated spring charging mechanism, remote tripping, remote closing, and backup tripping system (either capacitors or batteries) for operation during complete loss of normal power.

5. Testing and Commissioning

All preliminary testing of the generation unit by the manufacturer should be performed at the factory prior to shipment. In the field, the generation unit should be tested after installation, and prior to start-up. All testing of the generation unit should be performed with the generator circuit breaker (52G) placed in its test position and tagged or locked out to prevent unintentional paralleling of the generator output with the utility service.

Any testing of the utility equipment should be performed by utility personnel prior to start-up. Any utility protective equipment disconnects should be either closed or the automatic transfer trip function disabled during tests of the generator circuit breaker (52G).

5.1 Documentation

All testing should be documented. This includes factory testing of manufactured equipment, field testing of installed equipment, and field testing of utility equipment. At least one copy of all test documentation records should be maintained on-site to allow field personnel to review test results while inspecting or operating equipment. Examples of typical testing records are shown as Figures 2 and 3. Refer to equipment manufacturer's test requirements and NFPA 70B for examples of test reports.

5.2 Offline Testing

Test the interconnecting system's protective relays in accordance with the manufacturer's recommended procedure to verify all wiring connections for instrument transformer polarity, output values, and operational values of adjustable settings. Relay operation should be tested and verified by the use of injected current, test voltage, simulated signals, and other means to insure that the programmed settings match actual operating setpoints.

Test inputs for electrically interlocked devices to verify proper sequencing with other protection and control components within the system. Component testing should be performed by a third party (separate from the design engineer and the manufacturer) in order to provide independent confirmation of the components' performance.

All offline component test results should be satisfactory to the manufacturer, installing contractor, owner's representatives, and the utility before proceeding to online system testing.

Testing requirements are normally specified in the contract documents. In the absence of such requirements, perform the following typical offline testing requirements:

- a) Review instructions on all related equipment.
- b) Check that all device adjustments and settings match recommendations.
- c) Review design information for setpoints.
- d) Test any equipment as required. Perform all tests either on-site or in remote test lab.
- e) Provide calibrated test current and voltage sources for field testing where necessary. Verify that all test equipment is calibrated to test standards.
- f) Record all tests and compare results of field tests with those of either lab tests or factory tests.
- g) Record any anomalies and report them to the design engineer for evaluation.
- h) Where necessary, arrange all power outages with

both the utility and the owner's representative. Provide written requests for all outages sufficiently prior to the time required for outage to allow all necessary arrangements to be completed.

i) When working during outage conditions all work should conform to utility and owner's representative requirements for safety as well as all such federal, state, and local requirements.

5.3 Online Testing

Perform online testing of the entire inter-connection system at a time and date acceptable to all parties. In some applications, it will be necessary for the utility and the owner's representative to arrange the testing time to prevent an unplanned outage on either the utility service or the facility, as a result of testing.

All utility service feeders should be energized during testing of the interconnection system. All involved parties should witness initial online testing.

5.3.1. Islanding operation test

If the interconnected generation system is to be operated in an islanding arrangement, conduct a test of the synchronizing and reconnecting to the utility grid to assure proper operation.

This test simulates the loss of utility service to an interconnected generation system capable of islanding operation. It reduces the simulated utility voltage input until the trip setting of the undervoltage relay (27) is reached and the utility circuit breaker (52U) receives a trip signal.

A representative of the generation unit should act as the lead technical person during initial operation of the unit in parallel with the utility service.

5.3.2. Manual operating mode

Initial paralleling of the generator and utility feeders will be performed with the generator regulator in its manual operating mode to isolate potentially variable effects due to customer loads. Such isolation allows the generation unit to demonstrate its stability prior to further testing.

5.3.3. Automatic operating mode

Following satisfactory test results with the regulator in the manual operating mode, switch the regulator to the automatic operating mode. This mode accepts inputs from the customer loads and the utility electrical service and automatically compensates for such instabilities of the actual operating application.

It is not standard practice to stop the generation unit as the result of a simulated fault, provided that the interconnected system is shown to be stable while operating in automatic mode.

The automatic tests do not have to occur at the same time as the manual tests. Automatic tests may be performed at a preferred time with normal electrical operating conditions. Test all automatic functions and operations as required in the contract documents.

All system test results will be accepted by the manufacturer, installation contractor, the owner's representatives, and the utility before proceeding to normal system operation.

Typical system testing requirements include:

- a) Confirm that all components passed the required tests.
- b) Confirm that all adjustments and settings match those recommended by the design engineer.
- c) Review all test and start-up procedures as specified by the design engineer.
- d) Provide calibrated test current and voltage sources for field testing where necessary. Verify that all test equipment is calibrated to test standards.
- e) Record all test results and report them to the design engineer for evaluation.
- f) Record any anomalies and report them to the design engineer for evaluation.

g) Where necessary, arrange all power outages with both the utility and the owner's representative. Provide written requests for all outages sufficiently prior to the time required for outage to allow all necessary arrangements to be completed.

h) When working during outage conditions all work should conform to utility and owner safety requirements as well as applicable federal, state, and local requirements.

Upon completion of those tests listed above, all test reports will be analyzed by the owner's representative, the utility representative, and the design engineer.

Final settings and performance test results for protective devices will be acceptable to this group to assure that the interconnected system performs as required.

5.4 System Commissioning

Final commissioning of the generation system should be performed with all of the involved parties in attendance. The commissioning procedure should be detailed in a document agreed upon by the owner and the utility. This document will describe the following:

- a) Conditions under which the generation system can be used and those under which it cannot be used.
- b) Minimum amount of power to be imported from the utility.
- c) Maximum power to be generated.
- d) Procedures for operation during emergencies, periodic testing, and preventive maintenance.

All parties involved should sign this agreement before the system is completely interconnected.

CIRCUIT BREAKER TEST												
										JOB NO. _____		
LOCATION _____						DATE _____						
CIRCUIT _____						TECHNICIAN _____						
BREAKER		Drawout ☐	Fixed ☐	Molded ☐	Elect Oper ☐	_____ V		Shunt Trip ☐				
MFR _____				FRAME _____		SERIAL NO. _____						
FUSE TYPE _____				SINGLE PHASE PROTECTION _____				P.U. VOLTS _____				
TRIP DEVICE		Series ☐	Static ☐	Other ☐								
MFR _____		STYLE _____		SENSOR RATING _____		RATING PLUG _____						
RANGES												
L.T.D.		P.U. Band		S.T.D.	P.U. Band		INST.	P.U.		Ground Fault	P.U. Band	
SETTINGS From Study ☐ As Found ☐												
L.T.D.		P.U. Band		S.T.D.	P.U. Band		INST.	P.U.		Ground Fault	P.U. Band	
TEST DATA Primary Injection ☐ Secondary Injection ☐												
DEVICE	CALCULATIONS		ALLOWABLE OPERATING SECONDS	PICKUP OR SECONDS TO OPERATE								
	% SETTING	TEST AMPS		AS FOUND			AS LEFT					
				A	B	C	A	B	C			
L.T.D.	Pick Up											
	300											
S.T.D.	Pick Up											
	600											
INST.	Pick Up											
	800											
Ground Fault	Pick Up											
	200											
CONTACT RESISTANCE – Micro Ohms		Poles 1-2		Poles 3-4		Poles 5-6						
Insulation Resistance @ _____ Volts D.C.		Closed	A-G		B-G		C-G		A-B		B-C	
		Open	A-A		B-B		C-C		Values are Expressed in Megohms			
REMARKS _____												
										CB TEST SET _____		
										MEGGER _____		
										DLRO _____ ID _____ CAL _____		

Figure 2. Sample circuit breaker test report

RELAY TEST									
						JOB NO. _____			
LOCATION _____						DATE _____			
CIRCUIT _____						TECHNICIAN _____			
TRANSFORMER DATA Current ☐ Potential ☐									
QUANTITY _____		MFR _____		RATING _____		RATIO _____			
CONNECTION _____									
RELAY DATA									
QUANTITY _____		MFR _____		STYLE _____		RANGE _____			
QUANTITY _____		MFR _____		STYLE _____		RANGE _____			
SETTINGS From Study ☐ Existing, As Apparent ☐									
	TAP		TIME DIAL		INSTANTANEOUS		OTHER		
	FOUND	LEFT	FOUND	LEFT	FOUND	LEFT	FOUND	LEFT	
A									
B									
C									
G									
TEST VALUES/WORK AS APPLICABLE									
					A	B	C	G	OTHER
INSTANTANEOUS DEVICE			PICK UP AMPS	A.F.					
				A.L.					
TIME DELAY DEVICE			PICK UP AMPS	A.F.					
				A.L.					
TIME TEXT @ _____ %			PICK UP _____ Hz	A.L.					
TIME TEXT @ _____ %			PICK UP _____ Sec	A.L.					
			Min						
DIRECTIONAL ELEMENT TESTS					A.L.				
CLEANED	CONTACTS		DISC/MAGNET		DISC BACKSTOP			GENERAL	
INSPECTED	WIRING		AUX RELAYS		CONTACT ALIGNMENT			DISC ALIGN	
CT SHORTING DEVICES					METERS				
RELAY TRIP	BREAKER		AUX. RELAY		TARGET/SEAL-IN OK				
DEVICE 86 RELAY TO									
CT TESTS	VISUAL		BACKFEED		IMPEDANCE COMPARISON			COMP. CIRC.	
ALL CTS FEED RESIDUAL GRD. RELAY					GROUND RELAY ZERO SEQUENCE CONNECTED				
OPERATIONAL	RELAYS OPERATED TO TRIP BREAKER				OPERATIONAL TEST NOT REQUIRED BY CUSTOMER				
REMARKS _____									

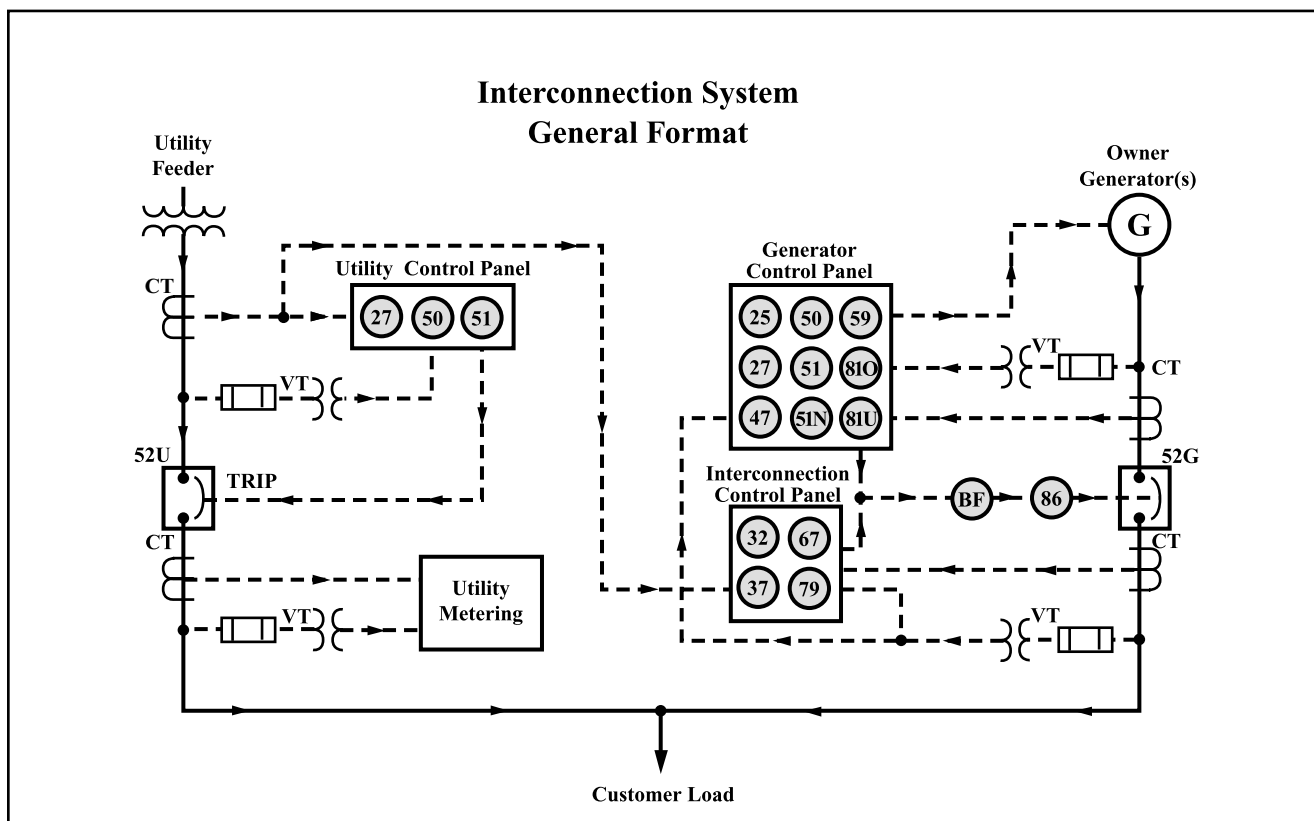
Figure 3. Sample relay test report

(This annex is not a part of the standard)

Annex A: System Purpose

The Interconnection System operates within an overall protection and control system that includes utility equipment protection, and generator protection. Specific interconnection system requirements vary depending on several factors, including the utility service configuration. For a radial utility service, the interconnection system isolates or shuts down the generator through an electrically-operated circuit breaker in the event of events such as: overloads (high customer demand), short circuits (customer side), ground faults (customer side), and loss of utility source (islanding).

As indicated in the figure, various devices can be used to actuate the generator circuit breaker. In addition to breaker actuation, the interconnection system may include provisions for redundancy. This can be especially important when the utility source is a spot network or grid configuration. In these circumstances, the interconnection system can include separate DC power supply for protection relays with battery backup, and alarm and trip capabilities. Breaker failure protection may also be included.



(This annex is not a part of the standard)

Annex B: Reference Standards

This publication, when used in conjunction with the National Electrical Code and manufacturers' literature, provides sufficient information to install and maintaining industrial heat tracing systems. The following publications may also provide useful information:

The Institute of Electrical and Electronics Engineers, Inc.
445 Hoes Lane
P.O. Box 1331
Piscataway, NJ 08855
(908) 981-0060
(908) 981-9667 Fax
www.ieee.org

IEEE 100-1996, *Standard Dictionary of Electrical and Electronics Terms*

ANSI/IEEE C37.2-1991, *Electrical Power System Device Function Numbers*

InterNational Electrical Testing Association
106 Stone Street
P.O. Box 687
Morrison, CO 80465
(303) 697-8441
www.netaworld.org

NETA ATS-1999, *Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems*

NETA MTS-1997, *Maintenance Testing Specifications for Electrical Power Distribution Equipment and Systems*

NETA ETT-2000, *Standard for Certification of Electrical Testing Technicians* (ANSI)

National Electrical Manufacturers Association
1300 North 17th Street
Suite 1847
Rosslyn, VA 22209
(703) 841-3200
www.nema.org

Guide to Preparing a Design Proposal for Paralleling Customer Generation With an Electric Utility

NECA 405 Recommended Practice for Installing and Commissioning Interconnected Generation Systems

National Fire Protection Association
1 Batterymarch Park
P.O. Box 9101
Quincy, MA 02269-9101
(617) 770-3000
www.nfpa.org

NFPA 70-1999, *National Electrical Code* (ANSI)

NFPA 70B-1998, *Electrical Equipment Maintenance* (ANSI)

Other National Electrical Installation Standards published by NECA:

National Electrical Contractors Association
3 Bethesda Metro Center, Suite 1100
Bethesda, MD 20814
(301) 215-4504 tel
(301) 215-4500 fax
www.neca-neis.org

NECA 1-2000, *Standard Practices for Good Workmanship in Electrical Contracting* (ANSI)

NECA 100-1999, *Symbols for Electrical Construction Drawings* (ANSI)

NECA 101-2000, *Standard for Installing Steel Conduits (Rigid, IMC, EMT)*

NECA/AA 104-2000, *Recommended Practice for Installing Aluminum Building Wire and Cable* (ANSI)

NECA/FOA 301-1997, *Standard for Installing and Testing Fiber Optic Cables*

NECA 202-2001, *Recommended Practice for Installing and Maintaining Industrial Heat Tracing Systems* (ANSI)

NECA 400-1998, *Recommended Practice for Installing and Maintaining Switchboards* (ANSI)

NECA 402-2000, *Recommended Practice for Installing and Maintaining Motor Control Centers* (ANSI)

NECA/EGSA 404-2000, *Recommended Practice for Installing Generator Sets* (ANSI)

NECA/IESNA 500-1998, *Recommended Practice for Installing Indoor Commercial Lighting Systems* (ANSI)

NECA/IESNA 501-2000, *Recommended Practice for Installing Exterior Lighting Systems* (ANSI)

NECA/IESNA 502-1999, *Recommended Practice for Installing Industrial Lighting Systems* (ANSI)



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Standards & Safety
Index: NECA 405
10K/9-01

