Evaluation/Disposition of Observations No. 6-17, 6-18, and 6-22 from Site Electrical Assessment Report, 300 Area Powerhouse and Emergency Sys.

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Abstract: Disposition of Observations 6-17, 6-18, 6-22 of Site Electrical Assessment Report. Application of generator differential protection, and synchro-check relay rewiring for generators of building 3621-D.

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9/30/96
Date

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LETTER REPORT
EVALUATION/DISPOSITION OF
OBSERVATIONS NO. 6-17, 6-18, AND 6-22
FROM SITE ELECTRICAL ASSESSMENT REPORT,
300 AREA POWERHOUSE AND EMERGENCY SYSTEM

September 1996

Subcontract WHC-380393

Prepared by
ICF Kaiser Hanford Company
Richland, Washington

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LETTER REPORT

EVALUATION/DISPOSITION OF
OBSERVATIONS NO. 6-17, 6-18, AND 6-22

FROM SITE ELECTRICAL ASSESSMENT REPORT,
300 AREA POWERHOUSE AND EMERGENCY SYSTEM

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LETTER REPORT

**EVALUATION/DISPOSITION OF
OBSERVATIONS NO. 6-17, 6-18, AND 6-22**

**FROM SITE ELECTRICAL ASSESSMENT REPORT,
300 AREA POWERHOUSE AND EMERGENCY SYSTEM**

INTRODUCTION

In 1990, the WHC Site Electrical Task Group issued a Site Electrical Assessment Report, "300 Area Powerhouse and Emergency System." This report included numerous findings and observations relating to observed deficiencies or opportunities for improvement in maintenance of the inspected electrical systems.

The purpose of this letter report is to provide an evaluation and proposed disposition of Observations No. 6-17, 6-18, and 6-22 of the Site Electrical Assessment Report.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

OBSERVATIONS NO. 6-17 AND 6-18

Observations No. 6-17 and 6-18 address the lack of generator differential protection. Without this protection, there is no high-speed mechanism to prevent machine damage due to internal faults and to provide selective coordination of protective devices. Existing backup-type relaying does not provide adequate speed and sensitivity, and selective tripping for a machine internal fault may be adversely affected where multiple generators are paralleled (an internal fault in one machine may trip multiple machines off line). Additionally, the recently installed shunt static exciters on generators 1, 2, and 3 may not provide sufficient energy during high level faults to operate the existing overcurrent relays. Installation of generator differential relaying will provide the sensitivity and selective tripping to alleviate these issues. The configuration of the generator winding terminations will allow installation of a simple, self-balancing type differential protection scheme to provide significantly improved machine and system protection and reliability.

OBSERVATION NO. 6-22

Observation No. 6-22 recommends rewiring the generator synchro-verifier (synch-check) relays to supervise paralleling operations in both automatic and manual modes. Presently, the synchro-verifier relays provides permissive supervision during manual synchronizing only. While the original observation applied only to generators 1, 2, and 3 existing at the time, generator 4 uses a similar scheme. Standard industry practice recommends an independent supervisory device for both manual and automatic synchronizing actions. This recommendation may be executed with existing equipment and minimal generator control cubicle re-wiring.

APPROACH/EVALUATION

METHODOLOGY

The three subject observations will be evaluated, and proposed dispositions will be presented based upon the following tasks:

- Review of assessment observations
- Review of standard industrial recommended practice for generator control and protection
- Review of existing generator control and protection
- Propose potential resolutions for observations
- Prepare order of magnitude cost estimate for proposed resolutions
- Evaluate no action alternative

PROPOSED RESOLUTIONS

Proposed resolutions were prepared based upon review of existing documentation, field inspection, and previous design and troubleshooting experience with the generator system of the 3621-D Building. However, additional detailed engineering will be required prior to implementation of the recommended resolutions to verify assumptions, and identify interfaces and impacts to associated systems and equipment.

COST ESTIMATES

Cost estimates for proposed equipment are based upon review of equipment vendor catalogs and published list prices. A construction estimate was provided by ICF Kaiser Hanford Company based upon sketch of building layout, location of proposed equipment, and estimated scope of interconnecting wiring.

BACKGROUND

- The 3621-D Building is located in the 300 Area. The building houses four, diesel-driven, 2400-V standby electric generators and associated switchgear and controls as part of the 300 Area standby distribution system. Generators 1, 2, and 3 are original 937 kVA machines, derated to 750 kVA; newer generator 4 is rated at 1250 kVA. Generators 1, 2, and 3 have 3-phase shunt static exciters with 720 rpm, salient pole rotors. Generator 4 has a permanent magnet, brushless exciter, with 1800 rpm, wound cylindrical rotor. The machines are capable of automatic operation, and upon loss of normal power, will start and sequentially synchronize on to a common bus to serve multiple feeder loads. See reference drawings H-3-53997 and H-3-60707 for standby system one line diagrams. Machine ratings are summarized in Table 1.
- Generator 4 had not been installed at the time of the original observation. Additionally, the excitation for Generators 1, 2, and 3 was provided by separate, belt-driven, self-excited dc machines. These rotating exciters have since been replaced with shunt, three-phase, static exciter/regulators. The static exciters do not have additional fault-sustaining excitation support equipment.
- Protective devices installed on the generators of this system are summarized in Table 2.

TABLE 1

3621-D GENERATOR STATION									
Unit	Prime Mover		Generator				Exciter		
	Fuel	BHP	Manufacturer	Volt (Delta)	kVA	Rotor	RPM	Type	Fault Support
1	Diesel	900	Westinghouse	2400	750 kVA* 0.8 pf	Salient Pole	720	3-Phase ** Shunt Static	None
2	Diesel	900	Westinghouse	2400	750 kVA* 0.8 pf	Salient Pole	720	3-Phase ** Shunt Static	None
3	Diesel	900	Westinghouse	2400	750 kVA* 0.8 pf	Salient Pole	720	3-Phase ** Shunt Static	None
4	Diesel	1620	Caterpillar	2400	1250 kVA 0.8 pf	Wound Cylindrical	1800	PMG Brushless	300% at 10 sec
Derated from 937.5 nameplate kVA. *Separately Excited Belt-driven at time of original observation.									

TABLE 2

3621-D GENERATOR ELECTRICAL PROTECTIVE DEVICES				
Protective Device	Generator 1	Generator 2	Generator 3	Generator 4
50/51 Instantaneous/Time Overcurrent	GE 121AC538B06A Trip	GE 121AC538B06A Trip	GE 121AC538B06A Trip	ABB 51Y 443P2294 Voltage Controlled by 47 Trip
27/47 Undervoltage/ Negative Sequence	N/A	N/A	N/A	ABB 47D 412N4195 Trip
32 Reverse Power	GE 12PJV11AH1A Single-Phase Trip	GE 12PJV11AH1A Single-Phase Trip	GE 12PJV11AH1A Single-Phase Trip	ABB 32R 437P4691 Trip
46 Current Balance	N/A	N/A	N/A	ABB 46Q 427F1591 Trip
47 Undervoltage	N/A	N/A	N/A	ABB 47H 412N0195 Control for 50/51
59 Overvoltage	Trip	Trip	Trip	ABB 59D 411C4195 Trip
40 Loss of Field	Field Current Relay Trip	Field Current Relay Trip	Field Current Relay Trip	Output Impedance ABB 40 426E170 Trip
81/12 Frequency/Overspeed	GE 121JF1A1A Alarm	GE 121JF1A1A Alarm	GE 121JF1A1A Alarm	ABB 81 422B1295 Trip
81 Frequency	GE 2CFP12B31A (Dead Bus) Close Permissive	GE 2CFP12B31A (Dead Bus) Close Permissive	GE 2CFP12B31A (Dead Bus) Close Permissive	Crompton 253-PHD Close Permissive
25 Paralleling (Synchro-verifier)	GE 121JS51A1A (Manual) Close Permissive	GE 121JS51A1A (Manual) Close Permissive	GE 121JS51A1A (Manual) Close Permissive	Crompton 256-PLU Close Permissive

OBSERVATION NO. 6-17**SEA-90-384-OB6-17, Building 3621-D**

"The generator protective relaying is only marginally adequate and therefore system reliability is jeopardized (see ANSI 446-1987, IEEE "Orange Book," paragraphs 6.4.2.1, 6.4.2.2, and 6.4.2.3.). Generators associated with the 3621-D Building have inadequate fault detection for a critical application where multiple parallel generator are required to support single feeder loads. Differential relays are required to assure that the correct generator is disconnected from the system in case of an internal generator fault, and also to minimize damage which can be caused by the large short circuit currents available from the other machines. Coordination of the relaying will be covered elsewhere in the report."

OBSERVATION NO. 6-18**SEA-90-384-OB6-18, Building 3621-D**

"The generator has no protection for internal faults. Such faults would be undetected and could lead to catastrophic damage."

Discussion

"The common practice for protecting non-paralleled generators is to connect the current transformers for the overcurrent relays between the neutral end of each phase winding and the neutral tie point, so that the overcurrent relays detect both external and internal fault currents. In addition, an undervoltage relay operating from generator voltage is used as back-up for the overcurrent relays, since short-circuits always produce a reduction in voltage."

Recommended Protection

Generator protection is based upon machine size, and additionally, importance to the loads served. Generators 1, 2, and 3 of the 3621-D Building are 2400 V, 750 kVA machines. ANSI/IEEE 242 (ref 1) provides the following definitions of machine size:

- **Small:** 1000 kVA maximum up to 600 V, 500 kVA maximum above 600 V
- **Medium:** From small machine sizes up to 12,500 kVA regardless of voltage

Per this standard, these generators are medium-sized machines. The basic minimum protection recommended by this standard for a medium-sized generator includes:

- (3) Device 51V - Backup overcurrent relays, voltage restraint, or voltage controlled type
- (1) Device 51G - Backup ground time-overcurrent relay
- (3) Device 87 - Differential relays, fixed or variable percentage type
- (1) Device 32 - Reverse power relay
- (1) Device 40 - Impedance relay, offset mho type for loss of field protection
- (1) Device 46 - Negative phase sequence overcurrent relay

These recommendations are consistent with the Westinghouse Synchronous Generator Protection Guide (ref 2).

Protection Schemes

Protection schemes can be classified based upon the zone of protection, and the sensitivity and speed of response.

- Primary type protection is designed to detect and provide high speed response to potentially destructive internal machine faults. Primary protection for generators is typically provided by differential relays.
- Secondary type, or backup, protection is used to detect and respond to fault conditions remote from the machine. Potential damage due to these remote faults may not require the sensitive, high speed response provided by primary type protection. Backup relays are employed to protect the machine in the event that relays more local to the fault

do not isolate the abnormal condition. Selective coordination of relays usually requires intentional delays in the response time of backup devices, to allow the local relays to respond first. The intentional time delay of backup devices does not provide the degree of protection for internal machine faults afforded by primary protection scheme.

Primary Protection

- Common methods of primary protection from generator internal faults include several schemes of differential current relaying. Differential relaying monitors the current flow at each end of the generator's armature windings. A difference in current between the two ends of a winding can indicate a fault condition in the protected zone, either a phase-to-phase, or a phase-to-ground short circuit. Phase differential relaying is the most effective method of detection for phase-to-phase faults, while ground fault relaying may also be used to detect phase-to-ground faults. Properly designed differential relaying can provide very sensitive, high speed, and selective primary fault protection. Two types of differential protection may be employed.
- The basic differential scheme uses two current transformers per phase, one on each end of the generator armature winding, to determine a difference current to operate the relays. With this method, the CTs must be rated for full load current, and they must be a matched pair with similar electrical characteristics. The interpreting relay must accept multiple CT circuit inputs, and must compensate for difference currents due to non-identical CTs. Percentage differential relays are commonly used.

- The second differential method is self-balancing, in that only one CT per phase is used, encircling both ends of the armature winding passing through the CT in opposite directions. With this method, the CT will only respond to the net difference in current between the two ends of the winding, and thus full load current rated CTs are not required. This method requires winding leads that are physically capable of being co-located through the same CT. The responding relay may be a simple instantaneous overcurrent device.

- Another method of internal fault protection is suggested in the Discussion associated with the original Observation No. 6-17. This method, used with wye-connected machines, places phase overcurrent CTs at the common neutral point of the generator windings. Connected to a standard overcurrent relay, the generator windings are included in the protected zone. This will provide some protection for internal faults, but since the relay must not trip for normal load currents, sensitivity is sacrificed. A voltage controlled or restrained overcurrent relay will provide increased sensitivity during the voltage depression caused by a fault. However, for paralleled machines, this type of protection may not adequately respond to potentially large internal fault currents supplied

by other connected machines. Additionally, per drawing H-3-43874 and H-3-33646, generators 1, 2, and 3 have delta-connected armature windings. With this arrangement, the use of overcurrent relays with current transformers at the common neutral point (as suggested by the Discussion associated with the original observation above) to protect the machine from internal faults is not possible.

Secondary Protection

- As noted in Observations No. 6-17 and 6-18, none of the generators of the 3621-D Building have (primary) differential relaying schemes. Without differential relaying, the present system relies on devices normally used for protection of small machines or backup protection on large or critical machines. These backup devices are discussed below.
- Device 50/51, Phase Overcurrent Relays - These relays are installed to sense current at the generators' output. Since the standard overcurrent relays must not trip for normal load currents which may be up to 150 percent or more of the full load rating of the machine, sensitivity to internal faults is diminished. Additionally, as a backup device selectively coordinated with downstream overcurrent devices, an intentional time delay is introduced. This time delay will increase the degree of damage from fault current prior to relay tripping. Selective tripping is also sacrificed with this scheme with two paralleled machines, in that both machines' relaying will see the single generator's internal fault current, and both may trip. As more machines are paralleled, selectivity with this method will increase as each machine contributes a smaller percentage of the fault current seen by the faulted machine.
- An additional misapplication is realized during consideration of the short-circuit characteristics of generators. The capability of the generator to sustain output during a fault condition is determined by its excitation system. With excitation energy supplied from a source separate from the generator, fault currents will be sustained significantly longer than with excitation derived from the generator output. At the time of the original observation, the generators were equipped with separate excitation from belt-driven exciters. Presently, generator excitation is from static

exciters powered from the output of the generator (shunt connected). During a high-magnitude close-in fault, the generator terminal voltage will drop, and thus excitation will also decrease. This will propagate a spiraling collapse of generator output such that the existing standard overcurrent relays may not have time to operate before the generator output drops below the relay pickup value. One solution to this dilemma is to provide voltage sensing capabilities for the overcurrent relay, to increase sensitivity, (lower pickup value) with decreasing voltage. A voltage controlled or voltage restrained overcurrent relay will allow pickup settings below values of normal load current during voltage depressions caused by high magnitude fault currents. This will allow the backup overcurrent relay to operate during the period of generator output decrement. Two types of voltage sensing overcurrent relays are commonly implemented.

- A voltage controlled time overcurrent relay will not operate until the input voltage drops below a predetermined set point (typically around 75% rated generator voltage). At voltages below the set point, the relay will function like a standard time overcurrent relay. Since this relay is effectively disabled for normal values of control voltage, this device will not provide overcurrent protection for unfaulted system operation.
- The voltage restrained time overcurrent relay operates like a standard relay, however, the pickup value is determined by the controlling voltage. With normal control voltage, the pickup value is set above full load current, perhaps 150% or more. With decreasing control voltage, the pickup value is lowered to perhaps 25% of full load current. This relay will provide overcurrent protection in both unfaulted, and faulted operating conditions, and is the minimal recommended protection where differential relaying is not used.
- Assuming the faulted generators will sustain sufficient output, the backup overcurrent relay if applied at the output of a single, isolated generator, will not respond to an internal fault, since output current will not include the fault current. Applied where two similar machines are paralleled, the relay will respond (with delay) to internal fault current above its pickup setting supplied by the other machine,

however, each generator will sense similar current magnitudes and each may trip off line. With more than two paralleled machines, backup overcurrent selectivity is possible as the relays of the faulted machine will sense the sum of the current from the other generators.

- The phase overcurrent relays applied to generators 1, 2, and 3 are of the standard type, without voltage restraint or control. As such, the pickup settings must be set higher than the maximum anticipated load current. Additionally, for selective coordination with downstream devices, a long time delay is required. The high pickup settings sacrifice sensitivity, and the long time delays will increase damage in during faults. Selectivity for internal machine faults will improve as the number of paralleled machines increases, three or more may be required for actual selectivity. High magnitude faults may not be cleared due to generator output decrement.
- Optimum sensitivity and selectivity would be achieved by the installation of differential relaying for the generators. The self-balanced type (single ct per phase) differential scheme would be applicable to generators 1, 2, and 3, as both ends of the windings are accessible at the armature terminal block. This method may also be applicable to generator 4 if all leads are available.
- Improvements to the existing backup time overcurrent relay scheme could be realized by substituting voltage controlled devices for the existing standard overcurrent relays at the generator output. Without the differential scheme, voltage restrained overcurrent relays would provide improved sensitivity and faster response during fault conditions.
- Device 32, Reverse Power Relay - This device is applied as backup protection for the prime mover. The relay functions on real power flow into the generator. A time delay is incorporated into the tripping characteristic to ignore momentary power swings due to paralleling operations, for example. Typical time delays are of the order of 10 seconds, much too long for generator internal fault protection.

OBSERVATION NO. 6-22**SEA-90-384-0B6-22, Building 3621-D**

"The synchro-verifier relays applied to generator control in this building are connected to act as a permissive enable for manual synchronizing only. There is no synchro-verification associated with automatic synchronizing. This compromises reliability if the auto-synchronizer were to malfunction."

Discussion

"Apparently, synchro-verifier relays were added to the generator circuit breaker control scheme some years back. Referring to drawing H-3-43893, zone F-12, the contacts for device 25G and contacts for the BR-1 relay appear only in the manual closing circuit of the generator breaker. Accepted engineering practice suggests that the synchro-verifier contacts should supervise both the manual and automatic synchronizing. The synchro-verifier contacts and the paralleled BR-1 relay contacts should be relocated to be directly below the normally closed 86 contacts, upstream of the 43 selector switch. This should preclude any breaker closing attempt without proper synchronization in either manual or automatic mode."

Present Control System Design

The present control system design provides two modes for generator output breaker closing: manual and automatic (25 CS). In automatic mode, the generator breaker will close on to a dead bus, or on to a live bus after the auto-synchronizer (25A) has adjusted voltage and frequency to be within acceptable ranges. In manual mode, the breaker may be closed on to a dead bus via a generator breaker control switch (52 CS or 52 CS-G), or may be closed on to a live bus provided the synchro-check relay (25G) identifies acceptable voltage and frequency values. In automatic mode, the synchro-check relay does not supervise the auto-synchronizer relay, as standard practice suggests. A failure of the auto-synchronizer, or any of the dead-bus sensing circuits, could allow unsynchronized breaker closing in the automatic mode.

Generator Breaker Close Circuit [Reference Drawing H-3-48393]

Unsynchronized Breaker Closing

Unsynchronized breaker closing can result in very large damaging overcurrents and mechanical forces that can bend or break generator shafts, move equipment from its mounts, and tear apart machines.

Synchro-Check Function

To provide the synchro-check function to both manual and automatic breaker closure modes of generators 1, 2, and 3, the normally open synchro-check relay contacts should be placed directly in series with the lockout relay contacts. To allow dead bus closing, the contacts of the BR- bus voltage relay contacts presently paralleled with the synchro-check relay should also be relocated. These modifications should require only minor rewiring within the generator control cubicles.

COST DATA

Rough Order-of-Magnitude

Cost estimates are included in Table 3 for recommended dispositions of subject observations.

UNCERTAINTIES AND RECOMMENDATIONS FOR FURTHER STUDY

Required Loads

Based upon the interviews with system cognizant personnel and available load data, it is assumed for this evaluation that no more than two generators are required to support the total "survival" load of the system. This will allow loss of two machines without loss of power to critical systems. Accepting this, and that there is an additional 1,500 kVA diesel-driven generator available in the 3621-B/C Building, the justification for the proposed generator relaying may place more weight on individual generator protection, rather than continuity of service to system loads.

TABLE 3

COST ESTIMATES	
INSTALLATION OF DIFFERENTIAL RELAYING, SELF-BALANCING TYPE FOR GENERATORS 1, 2, 3, AND 4	
Engineering	\$3 k
Bassler BE1-50, 3-phase Instantaneous Overcurrent Relay	4 at \$1 k = \$4 k
Current Transformers, 50:5A	4 X 3 at \$0.1 k each = \$1 k
Installation Labor, Miscellaneous Material, and Administration	\$11 k
TOTAL	\$ 19 k
REPLACEMENT OF TIME OVERCURRENT RELAYS WITH VOLTAGE RESTRAINED TYPE*	
Engineering	\$3 k
Bassler BE1-51/27R, 3-phase Voltage Restrained Time Overcurrent Relay	3 at \$1 k each = \$3 k
Installation Labor, Miscellaneous Material, and Administration	\$3 k
TOTAL	\$9 k
SYNCHRONISM CHECK RELAY REWIRING, GENERATORS 1, 2, 3, AND 4	
Engineering	\$3 k
Installation Labor, Miscellaneous Material, and Administration	\$3 k
TOTAL	\$6 k

* This option may be applied in addition to installation of differential relays for improved backup protection, and is recommended for generators 1, 2, and 3 if differential relaying is not installed.

Differential Relaying

Installation of self-balancing differential relaying scheme assumes that the each end of the generator phase windings is accessible, and may be encircled by a window-type current transformer. This assumption is based upon the previous ability to reconnect the windings of generator 1, 2, and 3 from a 4,160-V delta connection to the present 2,400-V wye connection, and a wiring diagram on generator 3 indicating a terminal block with the six terminals. It is also assumed that the connections of generator 4 will allow a similar ct installation.

REFERENCES

1. American National Standards Institute/Institute of Electrical and Electronic Engineers (ANSI/IEEE) Standards

- 141-1986, "IEEE Recommended Practice for Electric Power Distribution for Industrial Plants."
- 242-1986, "IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems."
- 446-1987, "IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications."

2. Publication, "Industrial and Commercial Power Systems Series, Synchronous Generator Protection Guide," prepared by Westinghouse Electric Corporation, Document No. PRSC-1C, 1985.

3. Publication, "Applied Protective Relaying," prepared by Westinghouse Electric Corporation, Relay and Telecommunications Division, 1982.

4. Supporting Document, "Protective Relay Settings for 1250 kVA Generator Addition of 300 Area Emergency Electrical System Safety and Reliability Upgrade," Project 90G-GFL-046, prepared by Westinghouse Hanford Company, Document No. WHC-SD-GN-ES-30004, July 1991.
5. Site Electrical Assessment Report, "300 Area Powerhouse and Emergency System," prepared by Site Electrical Task Group of WHC Instrumentation and Control Engineering, Westinghouse Hanford Company, July 1990.

6. Drawings

- H-3-43862, Rev. 5, "AC Elem Diag with Volt Reg, Gov & Auto Synch Details Emerg Power Sta 3."
- H-3-43863, Rev. 3, "Elec Switchgear Units 1 Thru 6 AC Elem Diag Emerg Power Sta 3."
- H-3-43868, Rev. 4, "Elec Generator #1 Switchboard Wiring Diag Emerg Power Sta-3."
- H-3-43870, Rev. 1, "Elec Switchgear Units 7 Thru 12 AC Elem Diag Emerg Power Sta 3."
- H-3-43872, Rev. 4, "Elec Switchgear DC Elem Diag #2 Emerg Power Sta-3."
- H-3-43874, Rev. 3, "Elec Generator #2 Switchboard Wiring Diag Emerg Power Sta-3."
- H-3-43875, Rev. 3, "Elec Generator #3 Switchboard Wiring Diag Emerg Power Sta-3."
- H-3-43893, Rev. 5, "Emerg Pwr System Unit Start and Load Shedding at Sta No. 3."

- H-3-53997, Rev. 3, "Electrical One Line Diagram 300 Area Emergency Power Distribution System."
- H-3-60707, Rev. 4, "Electrical One-Line Diagram-Operator Aide Power Distribution."

APPENDICES

Appendix A. Proposed Protective Relays

Appendix B. Estimate and Related Drawings

APPENDIX A

Proposed Protective Relays

(Vendor-Furnished Information)

BE1-51 BE1-51/27C BE1-51/27R TIME OVERCURRENT RELAYS

The BE1-51 Series of Time Overcurrent Relays is microprocessor based to provide a new standard in versatility and control.

FEATURES

- One relay can simultaneously monitor three phases plus neutral currents.
- All typical characteristic curves, including inverse, definite, I^2t , and BS 142 functions, are available.
- Characteristics may be field selectable with optional switch.
- BIT (built-in-test) provides a quick operational check to confirm the integrity of outputs, LED's, and targets, and simplifies calibration.
- Large array of options, including voltage control and voltage restraint.
- Pickup repeatability $\pm 2\%$.
- Timing repeatability $\pm 5\%$.
- Qualified to the requirements of
 - ANSI/IEEE C37.90-1978, C37.90a-1974, and IEC 255 for surge withstand capability;
 - IEC 255-5 for impulse.
- UL Recognized under Standard 508, UL File #E97033
- Two-year warranty.

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EXTERNAL CONNECTION

Terminals/Diagrams

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ORDERING

Procedure. Accessories
Style Number Chart.

page 11

INSTRUCTION MANUAL

Reference
Publication Number

9 1372 00 990

SERVICE MANUAL

Reference
Publication Number

9 1372 00 620

INSTALLATION

Case dimensions and
mounting information.

See Bulletin UBY

B Basler Electric
Highland, Illinois

BOX 269 HIGHLAND, ILLINOIS 62249, U.S.A. PHONE 618-654-2341 FAX 618-654-2351

BE1-50 INSTANTANEOUS OVERCURRENT RELAY

The BE1-50 Instantaneous Overcurrent Relay provides high speed detection of phase and/or ground faults. Optional output contacts allow the relay to be used as a phase selective fault detector.

FEATURES

- One relay can simultaneously monitor three phases plus neutral currents.
- Pickup setting is continuously adjustable over a wide range.
- Designed for use with 5A current transformer secondaries.
- Pickup Repeatability $\pm 2\%$ or 40 milliamps, whichever is greater.
- Independent output contacts for each sensing element.
- High speed operation.
- Operating power may be derived from the sensing input or an ac or dc source.
- Qualified to the requirements of
 - ANSI/IEEE C37.90-1978, C37.90a-1974, and IEC 255 for surge withstand capability;
 - ANSI/IEEE C37.90.1-198X for fast transient;
 - IEC 255-5 for impulse.
- UL Recognized under Standard 508, UL File #E97033.
- Two-year warranty.

B Basler Electric
Highland, Illinois

BOX 269 HIGHLAND, ILLINOIS 62249 PHONE 618-654-2341 TWX 510-100-3841 EASYLINK 6287-8226

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SPECIFICATIONS

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INSTRUCTION MANUAL

Reference
Publication Number
9 1710 00 990

SERVICE MANUAL

Reference
Publication Number
9 1710 00 620

INSTALLATION

Case dimensions and
mounting information.
See Bulletin UBY

UBC-5
10-87

APPENDIX B

Estimate and Related Drawings

KAISER ENGINEERS HANFORD
Westinghouse Hanford Company
JOB NO. F9FOH9

** IEST - INTERACTIVE ESTIMATING **
Site Electrical Assessment - 300 Area Powerhouse &
Emergency System - Rough Order of Magnitude
DOE_R02 - WORK BREAKDOWN STRUCTURE SUMMARY

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DATE 09/20/96 12:37:46
BY JJM

WBS	DESCRIPTION	ESTIMATE SUBTOTAL	ONSITE INDIRECTS	SUB TOTAL	ESCALATION % TOTAL	SUB TOTAL	CONTINGENCY % TOTAL	TOTAL DOLLARS
=====	=====	=====	=====	=====	=====	=====	=====	=====
320424	Installation of Differential Relays	6721	2393	9114	0.00 0	9114	20 1823	10936
320433	Replcmnt of Time Overcurrent Relays	1413 1708	503	1916 2211	0.00 0	1916 2211	20 442 185	2299 2653
320442	Synchronism Check Relay Rewiring	1689	601	2290	0.00 0	2290	20 458	2748

CHECK

B-1

1. DOCUMENTS AND DRAWINGS

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DOCUMENTS: Evaluation/Disposition Observation #s 6-17, -18, -22, dated 8/27/96, page 12 of 14, draft copy.

DRAWINGS: 1 sketch of Bldg 3621-D floor plan.

2. MATERIAL PRICES

=====

UNIT COSTS REPRESENT CURRENT PRICES FOR SPECIFIED MATERIAL. VENDOR INFORMATION WAS OBTAINED FOR THE FOLLOWING ITEMS: N/A

3. LABOR RATES

=====

A.) Base craft rates are as issued by KEH Finance (effective 06/28/96). Rates include fringe benefits, labor insurance, taxes, travel, departmental overheads and G&A/SWS.
• SEE HANFORD SOFT REPORTING, FDS BUDGET GUIDELINE HANDBOOK, SECTION 2 - COMPANY INFORMATION, FY 1996 PLANNING RATES.

4. GENERAL REQUIREMENTS/TECHNICAL SERVICES/OVERHEADS

=====

C.) FIXED PRICE CONTRACTOR OVERHEAD, PROFIT, BOND AND INSURANCE COSTS HAVE BEEN APPLIED AT THE FOLLOWING PERCENTAGES AND ARE REFLECTED IN THE "OH&P/B&I" COLUMN OF THE ESTIMATE DETAIL:
LABOR - 25% MATERIAL - 25%

5. ESCALATION

=====

ESCALATION PERCENTAGES WERE CALCULATED FROM THE JANUARY 1996 UPDATE OF THE ECONOMIC ESCALATION PRICE CHANGE INDICES FOR DOE CONSTRUCTION PROJECTS AS PUBLISHED BY THE "OFFICE OF INFRASTRUCTURE ACQUISITION" FM-50.
Escalation is not included in this estimate.

6. ROUNDING

=====

U.S. DEPARTMENT OF ENERGY - DOE ORDER 5100.4 PAGE I-32 SUBPARAGRAPH (M), REQUIRES ROUNDING OF ALL GENERAL PLANT PROJECTS (GPP'S) AND LINE ITEM (LI) COST ESTIMATES. REFERENCE: DOE 5100.4, FIGURE I-11, DATED 10-31-84. N/A

7. REMARKS

=====

- A.) Relay and C/T costs are not included in this estimate. Costs for these were provided by design.
- B.) Estimate costs include standard %s for contract administration (in Onsite Indirects). Bid package preparation is not included.
- C.) Engineering costs are not included. Estimate for construction cost only.
- D.) Assume all construction by fixed price contractor.

KAISER ENGINEERS HANFORD
Westinghouse Hanford Company
JOB NO. F9FH9

** TEST - INTERACTIVE ESTIMATING **
Site Electrical Assessment - 300 Area Powerhouse &
Emergency System - Rough Order of Magnitude
DOE_R08 - ESTIMATE DETAIL BY WBS / COST CODE

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BY JJM

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB- CONTRACT	EQUIP- MENT	OH&P / 8 & 1	TOTAL DOLLARS
320424	Installation of Differential Relays										
320424.16	Electrical										
320424.1612001	1/2" EMT Conduit	7060	200 lf	4	141	0	28	0	0	42	211
320424.1612201	1/2" EMT Stl InsComp Conn	7060	8 ea	3	106	0	4	0	0	28	138
320424.1612221	1/2" EMT Stl Comp Coupl	7060	20 ea	1	35	0	11	0	0	12	58
320424.1612981	1/2" EMT Support - with Unistrut hanger	7060	20 ea	8	283	0	517	0	0	200	1000
320424.1616503	1" Sealtite Flex	7060	40 lf	3	106	0	62	0	0	42	210
320424.1616703	1" Str ST Conn	7060	24 ea	10	353	0	105	0	0	115	573
320424.1617203	6x6x4 Pullbox W1 SC W/10 pt Term Strip	7060	4 ea	9	318	0	115	0	0	108	541
320424.1621209	#12 THHN 1/C Copper 600V	7060	1500 lf	8	283	0	77	0	0	90	450
320424.1622011	#8 EPR Unshld 1/C Cu 5KV	7060	100 lf	4	141	0	40	0	0	45	226
320424.1660001	Install new 3 ph overcurrent relay	7060	4 ea	24	848	0	60	0	0	227	1135
320424.1660011	Install new C/Is at each generator	7060	12 ea	36	1272	0	0	0	0	318	1500
B-3	SUBTOTAL Electrical			110		0		0		1,227	
	GENERAL FOREMAN 10.00 %			11	3,886		1,019		0		6,132
	SALES TAX 8.00 %				388				0		388
	OH&P (ON MARKUPS ONLY)						81			117	81
											117
TOTAL	COST CODE 70616 WBS 320424			121		0		0		1,344	
	(ESCALATION 0.00% - CONTINGENCY 20.00 %)				4,274		1,100		0		6,719
TOTAL WBS 320424	Installation of Differential Relays			121		0		0		1,344	
					4,274		1,100		0		6,719

KAISER ENGINEERS HANFORD
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DOE_R08 - ESTIMATE DETAIL BY WBS / COST CODE

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB- CONTRACT	EQUIP- MENT	OH&P / B & I	TOTAL DOLLARS
320433	Replcmnt of Time Overcurrent Relays										
320433.16	Electrical										
320433.1660019	Remove existing relays	7060	3 ea	24	108	0	0	0	0	278	1153
320433.1660021	Install new 3 ph overcurrent relay in exist control panel	7060	3 ea	24	848	0	75	0	0	231	1154
SUBTOTAL	Electrical			2733		0	75	0	0	258	1553
	GENERAL FOREMAN 10.00 %			23	254					320	1287
	SALES TAX 8.00 %				29		6		0		6
	OH&P (ON MARKUPS ONLY)									2532	2532
TOTAL	COST CODE 70616			29		0		0		283	
	WBS 320433			36	1048		81		0	352	1743
	(ESCALATION 0.00% - CONTINGENCY 20.00 %)				1283						1708
B-4 TOTAL WBS 320433	Replcmnt of Time Overcurrent Relays			29		0		0		283	
				36	1048		81		0	352	1743
					1283						1708

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB- CONTRACT	EQUIP- MENT	OH&P / B & I	TOTAL DOLLARS
320442	Synchronism Check Relay Rewiring										
320442.16	Electrical										
320442.1660031	Rewire existing Synch-Check Relays	7060	4 ea	32	1130	0	100	0	0	308	1538
SUBTOTAL	Electrical			32	1,130	0	100	0	0	308	1,538
	GENERAL FOREMAN 10.00 %			3	113		8		0		113
	SALES TAX 8.00 %										8
	OH&P (ON MARKUPS ONLY)									30	30
TOTAL	COST CODE 70616			35	1,243	0	108	0	0	338	1,689
	WBS 320442										
	(ESCALATION 0.00% - CONTINGENCY 20.00 %)										
B-5 TOTAL WBS 320442	Synchronism Check Relay Rewiring			35	1,243	0	108	0	0	338	1,689

GENERATOR #4 SWGR

DISTRIBUTION SHEET

To	From	Page 1 of 1
Distribution	E&TSS/Elect. Eng. 57300	Date 9/30/96
Project Title/Work Order		EDT No. <i>na</i>
Evaluation/Disposition of Observations No. 6-17, 6-18, and 6-22 from Site Electrical Assessment Report, 300 Area Powerhouse and Emergency System		ECN No. na

Name	MSIN	Text With All Attach.	Text Only	Attach./Appendix Only	EDT/ECN Only
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EL Ahola	E6-27	1			
Nat Harden	L6-79	1			
Central Files	A3-88	1			