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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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

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Prepared by
ICF Kaiser Hanford Company
Richland, Washington

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LETTER REPORT

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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

<table>
<thead>
<tr>
<th>Unit</th>
<th>Prime Mover</th>
<th>Fuel</th>
<th>BHP</th>
<th>Manufacturer</th>
<th>Volt (Delta)</th>
<th>KVA</th>
<th>Rotor</th>
<th>RPM</th>
<th>Type</th>
<th>Fault Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Diesel</td>
<td>900</td>
<td></td>
<td>Westinghouse</td>
<td>2400</td>
<td>750 kVA*</td>
<td>0.8 pf</td>
<td>720</td>
<td>3-Phase</td>
<td>** None</td>
</tr>
<tr>
<td>2</td>
<td>Diesel</td>
<td>900</td>
<td></td>
<td>Westinghouse</td>
<td>2400</td>
<td>750 kVA*</td>
<td>0.8 pf</td>
<td>720</td>
<td>3-Phase</td>
<td>** None</td>
</tr>
<tr>
<td>3</td>
<td>Diesel</td>
<td>900</td>
<td></td>
<td>Westinghouse</td>
<td>2400</td>
<td>750 kVA*</td>
<td>0.8 pf</td>
<td>720</td>
<td>3-Phase</td>
<td>** None</td>
</tr>
<tr>
<td>4</td>
<td>Diesel</td>
<td>1620</td>
<td></td>
<td>Caterpillar</td>
<td>2400</td>
<td>1250 kVA</td>
<td>0.8 pf</td>
<td>1800</td>
<td>PMG Brushless</td>
<td>300% at 10 sec</td>
</tr>
</tbody>
</table>

*Derated from 937.5 nameplate kVA.

**Separately Excited Belt-driven at time of original observation.

### TABLE 2

<table>
<thead>
<tr>
<th>Protective Device</th>
<th>Generator 1</th>
<th>Generator 2</th>
<th>Generator 3</th>
<th>Generator 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>50/51 Instantaneous/Time Overcurrent</td>
<td>GE 121AC538B06A Trip</td>
<td>GE 121AC538B06A Trip</td>
<td>GE 121AC538B06A Trip</td>
<td>ABB 511</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>443P2294 Voltage Controlled by 47</td>
</tr>
<tr>
<td>27/47 Undervoltage/ Negative Sequence</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>ABB 47D</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>412N0195</td>
</tr>
<tr>
<td>32 Reverse Power</td>
<td>GE 12PJV11AH1A Single-Phase Trip</td>
<td>GE 12PJV11AH1A Single-Phase Trip</td>
<td>GE 12PJV11AH1A Single-Phase Trip</td>
<td>ABB 328</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>43TP4691</td>
</tr>
<tr>
<td>46 Current Balance</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>ABB 460</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>427F1591</td>
</tr>
<tr>
<td>47 Undervoltage</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>ABB 47H</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>412N0195 Control for 50/51</td>
</tr>
<tr>
<td>59 Overvoltage</td>
<td>Trip</td>
<td>Trip</td>
<td>Trip</td>
<td>ABB 59D</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>411C4195</td>
</tr>
<tr>
<td>40 Loss of Field</td>
<td>Field Current Relay Trip</td>
<td>Field Current Relay Trip</td>
<td>Field Current Relay Trip</td>
<td>Output Impedance</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ABB 40</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>425E170</td>
</tr>
<tr>
<td>81/12 Frequency/Overspeed</td>
<td>GE 12IJF1A1A Alarm</td>
<td>GE 12IJF1A1A Alarm</td>
<td>GE 12IJF1A1A Alarm</td>
<td>ABB 81</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>428B1295</td>
</tr>
<tr>
<td>81 Frequency</td>
<td>GE 2CFP12831A (Dead Bus) Close Permissive</td>
<td>GE 2CFP12831A (Dead Bus) Close Permissive</td>
<td>GE 2CFP12831A (Dead Bus) Close Permissive</td>
<td>Crompton</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>253-990 Close Permissive</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>256-PLL Close Permissive</td>
</tr>
</tbody>
</table>
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:

E59052LR.TD.553 - 5 - 09/27/96
• **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 offline. 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-OB6-22, 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-I, the contacts for device 25G and contacts for the BR-I 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

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INSTALLATION OF DIFFERENTIAL RELAYING, SELF-BALANCING TYPE FOR GENERATORS 1, 2, 3, AND 4</strong></td>
<td></td>
</tr>
<tr>
<td>Engineering</td>
<td>$3 k</td>
</tr>
<tr>
<td>Bassler BE-50, 3-phase Current Transformer, 50:5A</td>
<td>4 at $1 k = $4 k</td>
</tr>
<tr>
<td>Installation Labor, Miscellaneous Material, and Administration</td>
<td>$11 k</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>$19 k</td>
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</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
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</thead>
<tbody>
<tr>
<td><strong>REPLACEMENT OF TIME OVERCURRENT RELAYS WITH VOLTAGE RESTRAINED TYPE</strong></td>
<td></td>
</tr>
<tr>
<td>Engineering</td>
<td>$3 k</td>
</tr>
<tr>
<td>Bassler BE1-51/27R, 3-phase Voltage Time Overcurrent Relay</td>
<td>3 at $1 k each = $3 k</td>
</tr>
<tr>
<td>Installation Labor, Miscellaneous Material, and Administration</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td>$9 k</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
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</thead>
<tbody>
<tr>
<td><strong>SYNCHRONISM CHECK RELAY REWIRING, GENERATORS 1, 2, 3, AND 4</strong></td>
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</tr>
<tr>
<td>Engineering</td>
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<tr>
<td>Installation Labor, Miscellaneous Material, and Administration</td>
<td>$3 k</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>$6 k</td>
</tr>
</tbody>
</table>

*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."


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)
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 ±2%.
- Timing repeatability ±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.
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 ± 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 C37.90.1-199X for fast transient;
  - IEC 255-5 for impulse.
- UL Recognized under Standard 508, UL File #E97033.
- Two-year warranty.
APPENDIX B

Estimate and Related Drawings
** 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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CHECK
1. DOCUMENTS AND DRAWINGS

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 is not included in this estimate.

6. ROUNING

U.S. DEPARTMENT OF ENERGY - DOE ORDER 5100.4 PAGE 1-32 SUBPARAGRAPH (M), REQUIRES ROUNING 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 % 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.
## Site Electrical Assessment - 300 Area Powerhouse & Emergency System - Rough Order of Magnitude

**Kaiser Engineers Hanford**

**Vestibule Hanford Company**

### JOB NO. F9F0H9

#### DATE 09/20/96 12:38:17

**BY** JJM

---

### IEST - INTERACTIVE ESTIMATING

**PAGE 3 of 5**

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**SUBTOTAL Electrical**

| 5 SUBTOTAL Electrical | 110 | 0 | 0 | 1,227 |

**GENERAL FOREMAN 10.00 %**

| GENERAL FOREMAN 10.00 % | 11 | 388 | 1,019 | 0 | 6,132 |

**SALES TAX 8.00 %**

| SALES TAX 8.00 % | 81 | 0 | 388 |

**OH&P (ON MARKUPS ONLY)**

| OH&P (ON MARKUPS ONLY) | 117 | 117 |

**TOTAL**

| TOTAL COST CODE 70616 | 121 | 4,274 | 0 | 1,100 | 0 | 1,344 | 6,719 |

**(ESCALATION 0.00% - CONTINGENCY 20.00%)**

<p>| TOTAL WBS 320424 Installation of Differential Relays | 121 | 4,274 | 0 | 1,100 | 0 | 1,344 | 6,719 |</p>
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TOTAL WBS 320433 Replcmnt of Time Overcurrent Relays
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ESCALATION 0.00% - CONTINGENCY 20.00%
DISTRIBUTION SHEET

To
Distribution

From
E&TSS/Elect. Eng. 57300

Page 1 of 1
Date 9/30/96

Project Title/Work Order
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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EDT No. na
ECN No. na

A-6000-135 (01/93) WEF067