07-500-91

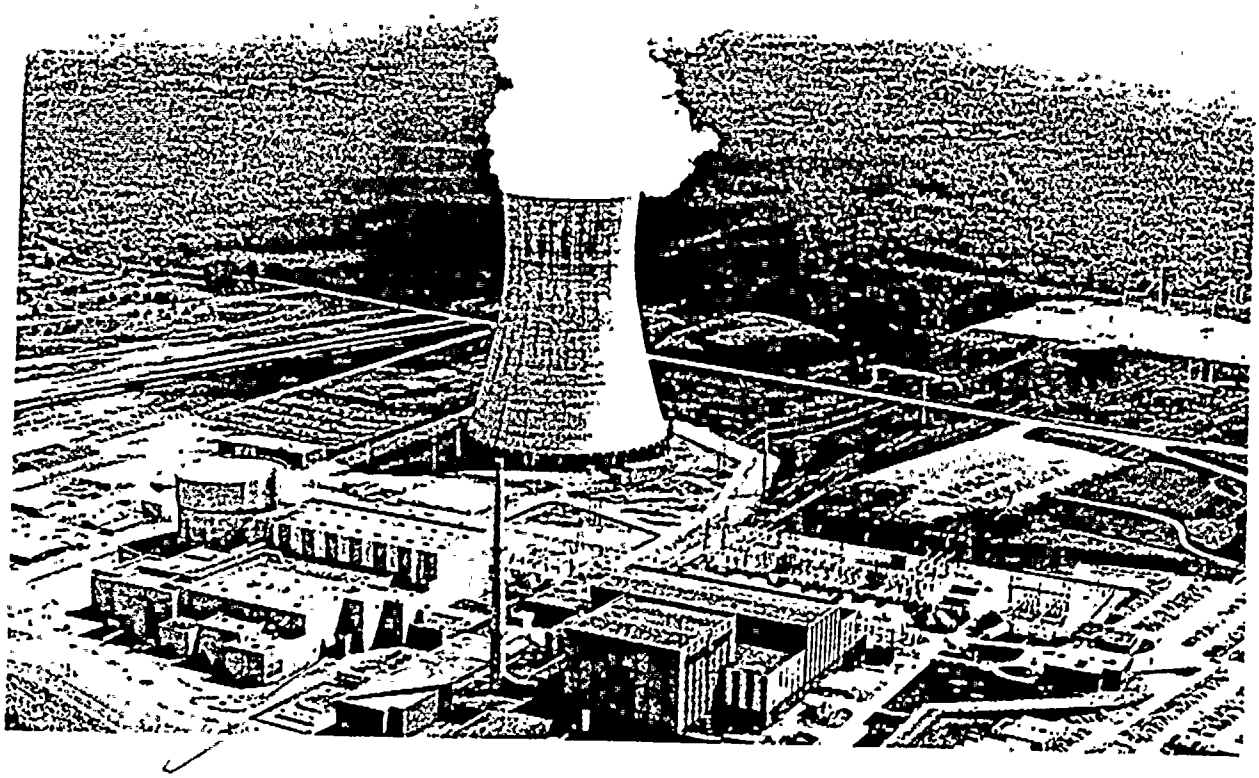
# NIAGARA MOHAWK POWER CORPORATION

## NINE MILE POINT UNIT 2

## NUCLEAR STATION

## NRC UPS MEETING

## SEPTEMBER 4, 1991



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# AGENDA

| | |
|---|---|
| OPENING REMARKS/PURPOSE | B. R. Sylvia |
| UPS OVERVIEW | R. J. Crandall |
| ROOT CAUSE OF UPS FAILURE | J. T. Conway |
| UPS LOAD EVALUATION | A. K. Julka/<br>R. B. Abbott |
| CLOSING REMARKS | B. R. Sylvia |

# UPS OVERVIEW

# UPS - FUNCTIONS

- 3 - PHASE INPUT
- CHARGER SECTION - AC to DC
- INVERTER SECTION - DC to AC
- STATION BATTERIES
- LOSS OF NORMAL AC
- TRIPS - 10 (INVERTER ONLY)

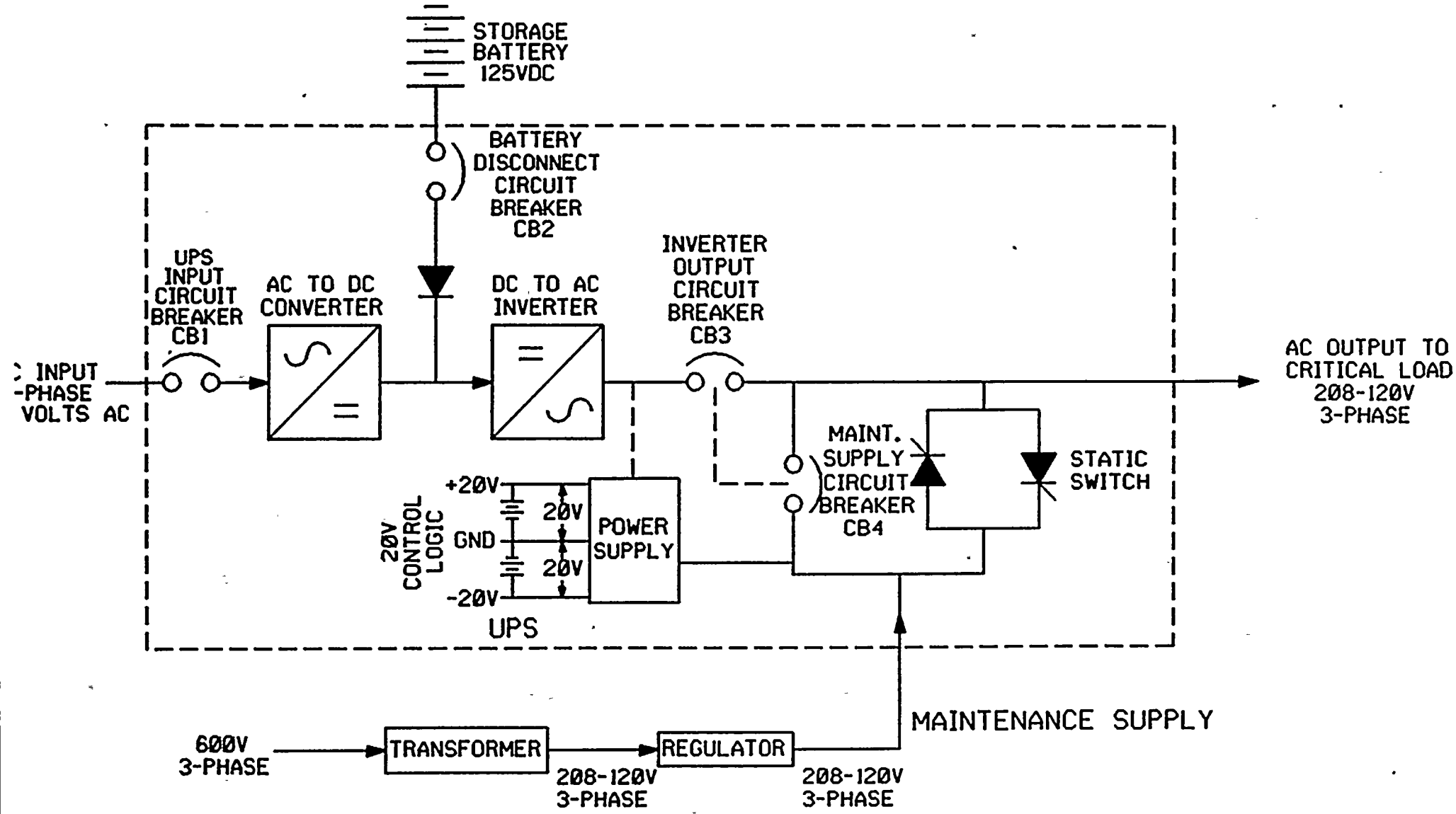
# UPS FUNCTIONS (CONT'D)

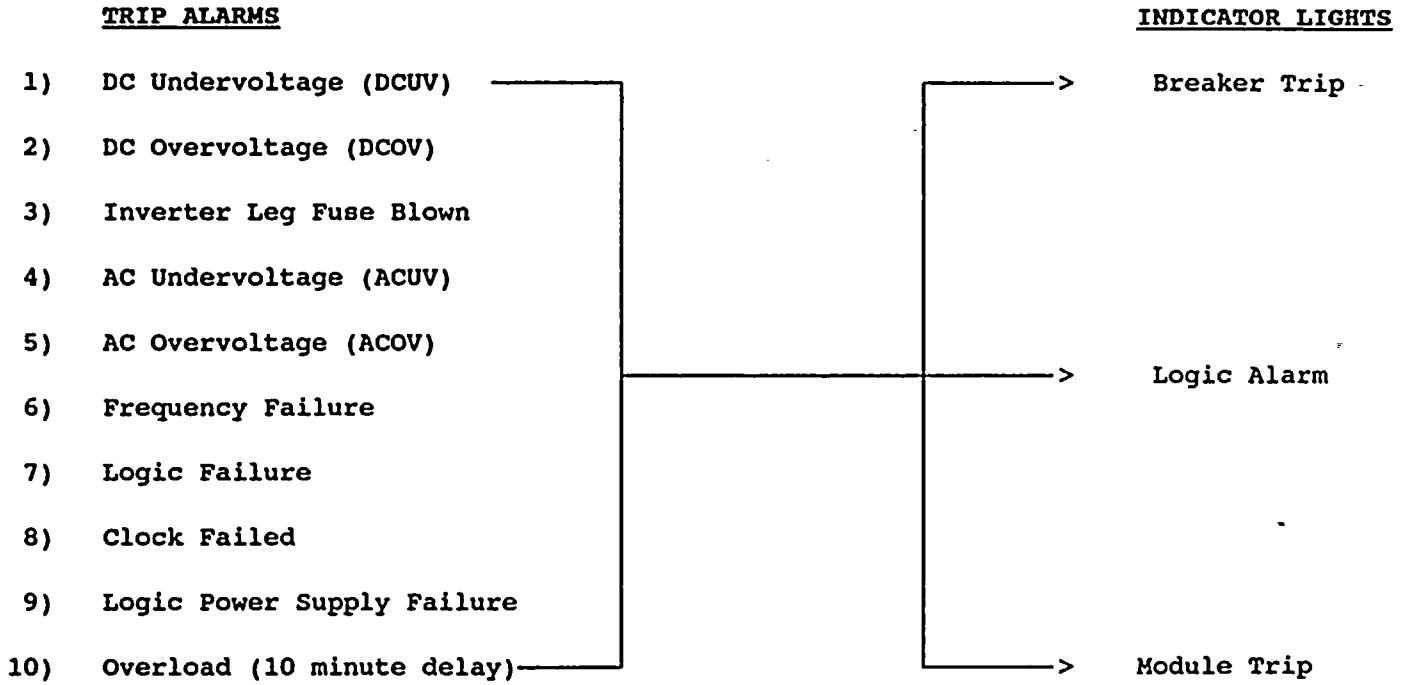
- MAINTENANCE SUPPLY (3-Phase)

- TRANSFERS
  - MANUAL
  - AUTOMATIC

- INVERTER TO MAINTENANCE MONITOR

# NINE MILE POINT UNIT 2
# UNINTERRUPTIBLE POWER SUPPLY
# TYPICAL SERIES (1A, 1B, 1C, 1D, 1G)




TRIP ALARMS
1) DC Undervoltage (DCUV)
2) DC Overvoltage (DCOV)
3) Inverter Leg Fuse Blown
4) AC Undervoltage (ACUV)
5) AC Overvoltage (ACOV)
6) Frequency Failure
7) Logic Failure
8) Clock Failed
9) Logic Power Supply Failure
10) Overload (10 minute delay)
INDICATOR LIGHTS
Breaker Trip
Logic Alarm
Module Trip

# LOGIC POWER

| | | |
|---|---|---|
| EXIDE - | UPS1A<br>UPS1B<br>UPS1C<br>UPS1D<br>UPS1G | B-PHASE MAINT. DC |
| ELGAR - | UPS2A<br>UPS2B | DC to DC |
| ELGAR - | UPS3A<br>UPS3B | DC to DC |
| EXIDE - | UPS1H | DC to DC |

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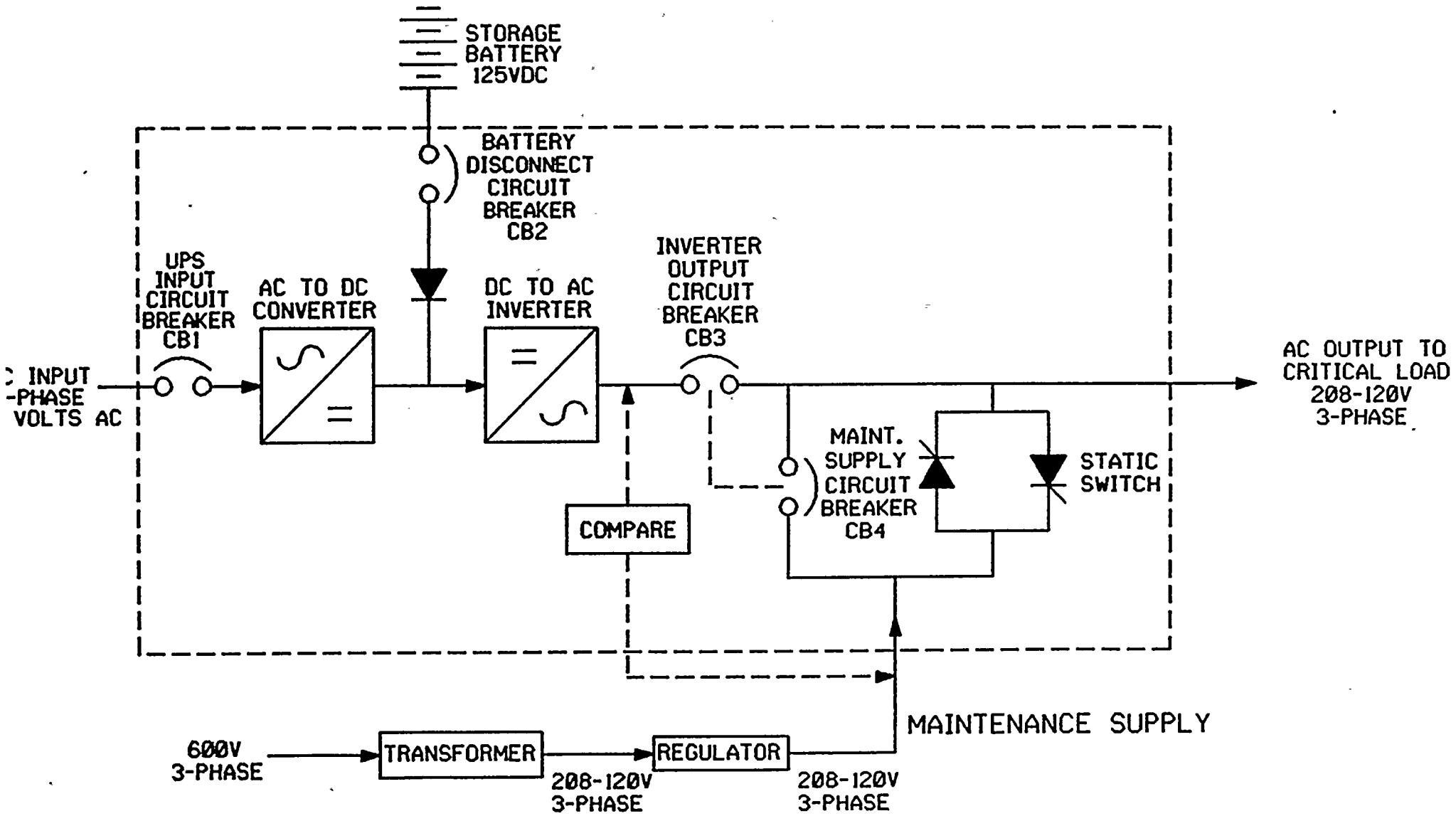


# UPS PREVENTIVE MAINTENANCE

- SHIFT ROUNDS
- FILTERS
- CLEANING
- SCR HEAT SINK GREASE
- ZERO CROSSING, SETPOINTS
- LOADS TRENDED
- AMBIENT TEMPERATURE (32-104°F)
- ROOM TEMPERATURE 93-97°F MAX (WITHOUT HVAC)

# UPS PREVENTIVE MAINTENANCE (CONT'D)

- DEVIATION/EVENT REPORT (4/3/91)

- BATTERIES
  - NOT RELIABILITY
  - INDICATION
  - WEIGH PERSONNEL RISK VS BENEFIT

## 2.3 INVERTER

The rectifier/charger or battery DC output is the inverter input power. This DC voltage is filtered by shunt capacitors contained in DC capacitor assemblies. The quantity of capacitor assemblies required varies with the KW rating of the UPS module, as listed here:

| KW Rating | Capacitor Assemblies |
|---|---|
| 30 | A15 |
| 60 | A15, A16 |
| 100, 180 | A15 |
| 250 | A15, A16 |
| 330 | A15, A16, A17 |
| 400, 450 | A15, A16, A17, A18 |

DC is converted to AC by SCR switching action of the inverter legs, A1, etc. Each adjacent pair of legs (i.e., A1 and A2, etc.) constitutes a bridge circuit which supplies quasi-square-wave AC to one of the primary windings of the power transformers, T1 or T2. The 30 and 60 KW modules have only one power transformer, T1. Component designators for 300 KW and larger inverters are preceded by the numeral 2; e.g., 2T2. Refer to Figure 2-2.

Secondary windings of T1 and T2 are connected so that the resultant output is a balanced 3-phase voltage. Each line-to-line and line-to-neutral voltage would appear as a near sine wave consisting of 12 steps. This wave form is filtered to provide a good sine wave at the output terminals by the filtering action of AC output filters, A21 (if used, A22 through A24), and by reactors, L3 through L8, connected between adjacent pairs of inverter legs.

The inverter senses its output voltage and regulates within 1% tolerance for a wide variation in load and DC input voltage. Various other sensing circuits provide protection alarm indications. See Tables 2-1 and 2-2 for alarm descriptions.

A redundant logic supply, powered by the inverter output, a separate 120 VAC bypass source, and/or internal rechargeable sealed batteries, allows logic testing with no input power applied and keeps alarms indicating for as long as any source of AC control power is available.

A static interrupter is part of the inverter sensing circuits. Whenever an UPS module trips, it must be disconnected automatically and immediately from the critical load bus. Not providing immediate disconnection could result in out-of-tolerance disturbance of the sensitive critical load. The UPS module provides instantaneous output isolation via internal logic responding to any one of a number of control or protection signals that "programs off" all of the inverter legs. This produces a force-commutated interruption of the inverter output, assuming power continuity at the load.

The following is a list of major inverter components and brief description of their functions.

b. A primary function is the storage, via R-S flip-flops, of most alarms and all trip functions and the display of these conditions on card-mounted LEDs.

2.3.2.10 Static Switch Control, A13A34.

This control determines the condition of the inverter, bypass source, and critical load. It then logically determines whether or not the critical load should be transferred to the bypass source. It also determines whether the UPS can or should be restarted depending on the UPS condition and the critical load bus.

2.3.3 Control Panel, A14

This panel contains control and status display components for the entire UPS module. See Figure 2-3 & Table 2-3 for location and description of each.

2.3.4 DC Capacitor Module, A15 (some modules up to A18, see paragraph 2.3)

Each slide-in module contains DC filter capacitors that are fused in groups of seven capacitors.

2.3.5 AC Output Filter Panel, A21

These Ac capacitors are connected in delta across the inverter output to filter output waveform. The capacitors have integral interrupt overcurrent protection.

2.3.6 Load Division and Interface Panel, A26.

This panel provides interface between the card cage, A13, and the following:

a. Load-division current transformer loop (contains burden resistors and loop-shorting relays.

b. Commutation-limit current transformers (contains burden resistors).

c. Inverter voltage sensing (potential transformers, 3-phase).

d. Signal synchronizing node (mounts sync node transformer).

e. Blown leg fuse sensing (contains optocoupled electrical blown fuse sensing).

2.3.7 Logic Power and Relay Panel, A27.

This panel contains positive and negative 20 VDC power supplies (PS1 and PS2). These power supplies are powered through relay A27K1, which selects inverter output (preferred) or bypass (alternate) source. Positive and negative 18-V sealed batteries (A27BT1-BT6) are mounted on this panel and are kept charged by the power supplies. Circuit breaker A27CB1 disconnects the battery from

the logic power bus, and logic power supply switch A27S1 disconnects the power supply's 120 VAC input power. The panel also contains card-mounted (A27A1) relays which interface the A13 controls with external items such as circuit breaker motor operators, shunt trip coils, and remote monitor panel functions. Control battery discharge sensing is located on the A27A1 card. (These batteries should be replaced at 4-year intervals.)

2.3.8 System Terminal Board Panel, A30.

This panel contains terminal boards for all external control connections.

2.3.9 Remote Alarm, A30A1.

The remote alarm panel provides indications of the UPS module status and has no control function. Alarms initiated by the UPS module are as follows:

a. TRANSFERRED TO BYPASS

b. BATTERY DISCHARGE

c. UPS MINOR ALARM

d. UPS MAJOR ALARM

e. DC UNDERVOLTAGE WARNING.

Dry contact relay closure indicates alarm condition. Contact rating is 10 VA max., 100 V max., 0.1 A max., resistive.

2.3.10 Static Switch Leg, A33.

The static switch leg contains static switch power SCRs, SCR gate drivers, and overtemperature sensing circuits. The static switch leg provides an uninterrupted transfer of critical load between the inverter source and the utility bypass source.

2.3.11 Static Switch Control Panel, A34.

This control panel senses critical load and bypass source busses for feeding static switch control card A13A34. Power supplies (PS1 and PS2) produce positive and negative 20 VDC for static switch leg (A33) and remote monitor.

2.3.12 AC Output Filter Reactor, L3-L8.

Each reactor filters the AC output of each inverter leg to power transformer T1 (and T2 when used).

2.3.13 AC Output Filter Harmonic Reactors, L9 through L11.

These reactors (in combination with A21) filter the output waveform.

SECTION 3

MAINTENANCE AND TROUBLESHOOTING 08508 2420

## 3.1 PREVENTIVE MAINTENANCE.

### 3.1.1 General.

A record log should be kept which should include periodic meter readings, maintenance, and any alarms and subsequent actions taken. Early recognition of deteriorating performance is important

> DANGER
> HIGH VOLTAGE
>
> ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THIS EQUIPMENT.
>
> IF INJURY DOES OCCUR, APPLY STANDARD TREATMENT FOR ELECTRICAL SHOCK.

### 3.1.2 Air Filters.

The air filters should be changed every 2 months(even more frequently if they are dirty). The filters are commercially available. Filters may be safely replaced while the UPS is operating and without opening the doors. Front filters (if so equipped) are accessible by loosening the two screws at the top corners of the hinged filter housing. The retainer chain allows the filter housing to tilt forward approximately 15 cm (6 inches) for filter removal. Bottom filters are accessible by loosening the wing bolts (two per filter) located on the front channel below the cabinet access doors. When the bolts are loosened (approximately 1.5 cm (½ inch), it may be necessary to reach under and pull the hinged filter door down from the front (there are three magnetic clasps). The filter can now be easily replaced.

### 3.1.3 Lamp Test.

A lamp test may be performed with UPS operating.

### 3.1.4 Physical Inspection.

It is recommended that the UPS be inspected annually for tightness of connections and for evidence of component damage or overheating.

# ROOT CAUSE FAILURE OF UPS

# ROOT CAUSE INVESTIGATION

- COMMON MODE FOR EXIDE UNITS

- ASSOCIATION WITH TRANSFORMER FAULT

- INITIAL INSPECTION INDICATED LOGIC TRIPPED WITH SOME ALARM LIGHT ANOMALIES

- INITIAL INSPECTION INDICATED MAINTENANCE SUPPLY BREAKERS OPEN

- 3 POTENTIAL CAUSES EVALUATED

    1. Voltage Transient on Normal AC Distribution System

    2. Propagation of High Frequency Noise From Transformer Fault

    3. Voltage Transient On Station Ground System

# PROPAGATION OF HIGH FREQUENCY NOISE

## UNLIKELY DUE TO

- PREOPERATIONAL RADIO FREQUENCY TESTING

- RADIO FREQUENCY ATTENUATION THROUGH STATION TRANSFORMERS

- LABORATORY TESTING TO DATE

# VOLTAGE TRANSIENT ON STATION GROUND SYSTEM

## UNLIKELY DUE TO

- COMMON BEHAVIOR OF ALL 5 EXIDE UNITS

- BEHAVIOR OF OTHER STATION EQUIPMENT

- LABORATORY DESTRUCTIVE TESTING

# VOLTAGE TRANSIENT ON NORMAL AC DISTRIBUTION

- MAGNITUDE OF TRANSIENT IS WELL UNDERSTOOD

- COMMON TO ALL FIVE UNITS

- TRANSFORMER FAULT ON B PHASE

- B PHASE SUPPLY TO UPS LOGIC

- MAINTENANCE TRANSFER PREVENTED

# IN PLANT TROUBLESHOOTING RESULTS

- LOGIC TRIPS AT 17 VDC CORRESPONDING TO 85 VAC

- LOGIC SUPPLY TRANSFER AT 45 VAC

- LOGIC BACKUP BATTERIES WERE DEGRADED

- AC SUPPLY TRANSIENTS (100 - 200 MSEC) TRIP UNITS WITH DEGRADED BATTERIES

- AC SUPPLY LOSS DOES NOT TRIP UNITS

- LOGIC BATTERY IMPACT

# LABORATORY TESTING RESULTS

- LOGIC BATTERY FAILURE

- GROUND VOLTAGE TRANSIENTS

- EXTENSIVE LOGIC BOARD TESTING

- NO COMMON MODE FAILURES IDENTIFIED

# CONCLUSIONS

- IMPROPER LOGIC POWER SUPPLY DESIGN
  - MAINTENANCE SUPPLY VS. INVERTER OUTPUT
  - LOGIC SUPPLY SWITCHING CIRCUIT
  - LOGIC BATTERY INSTALLATION
- TRANSFORMER FAULT CAUSED MAINT. SUPPLY VOLTAGE TRANSIENT
- UPS LOADS DEENERGIZED DUE TO
  - TRIP OF ALL FIVE UNITS
  - TRANSFER TO MAINT. PREVENTED (BY DESIGN)
- CAUSE OF UPS TRIPS DETERMINED TO BE
  - MAINT. SUPPLY VOLTAGE TRANSIENT

    AND
  - SWITCHING CIRCUIT CHARACTERISTIC

    AND
  - DEGRADED BATTERY CONDITION

# CONCLUSIONS (CONT'D)

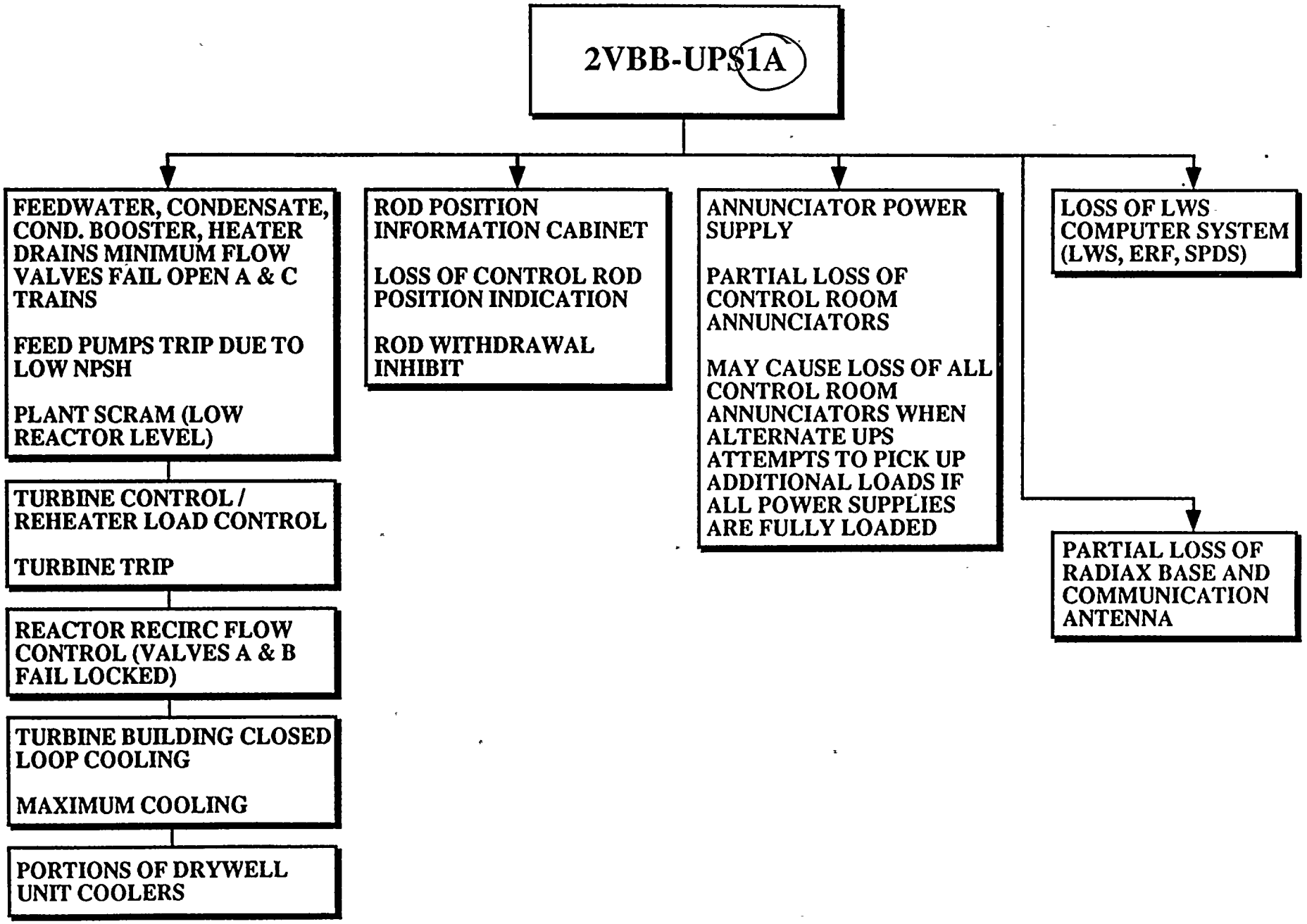
- VENDOR MANUAL IS DEFICIENT
  - PREVENTATIVE MAINT. SECTION NEGLECTS BATTERIES
  - FOUR YEAR REPLACEMENT FREQUENCY STATEMENT
  - FUNCTION OF BATTERIES NOT CLEAR

# CORRECTIVE ACTIONS

- PRIOR TO RESTART
  - MODIFY UPS LOGIC POWER SUPPLY TO MAKE INVERTER OUTPUT PRIMARY, MAINT. SUPPLY BACKUP (COMPLETE)
  - REPLACE ALL LOGIC BATTERIES AND DETERMINE APPROPRIATE SERVICE LIFE/REPLACEMENT SCHEDULE (COMPLETE)
- POST RESTART
  - EVALUATE FURTHER MODIFICATIONS FOR
    - o IMPROVED ACCESS TO BATTERIES
    - o SWITCHING CIRCUIT CHARACTERISTICS
- ALARM LIGHT ANOMALIES

# UPS LOAD EVALUATION

# UPS LOADS – PLANT IMPACT



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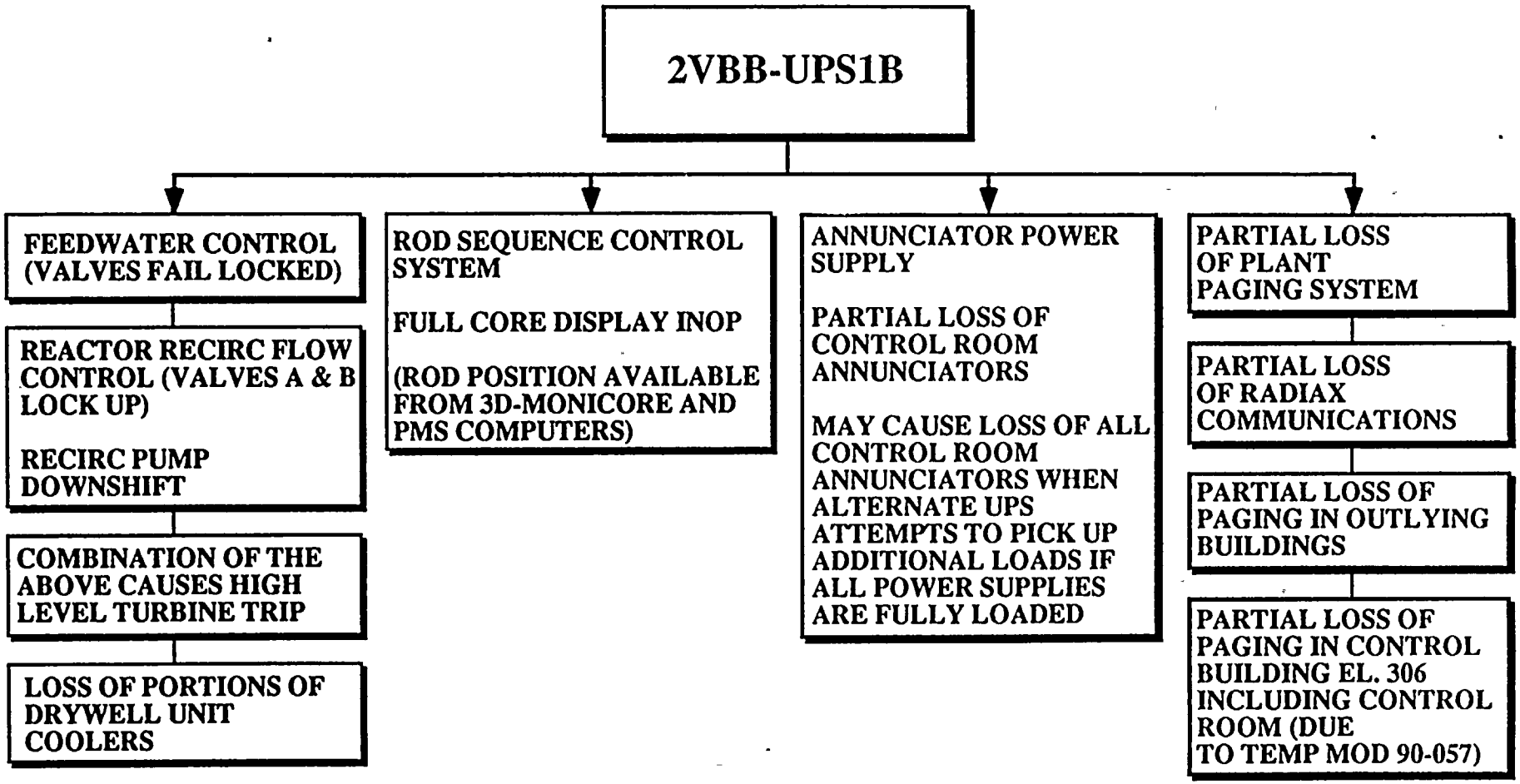

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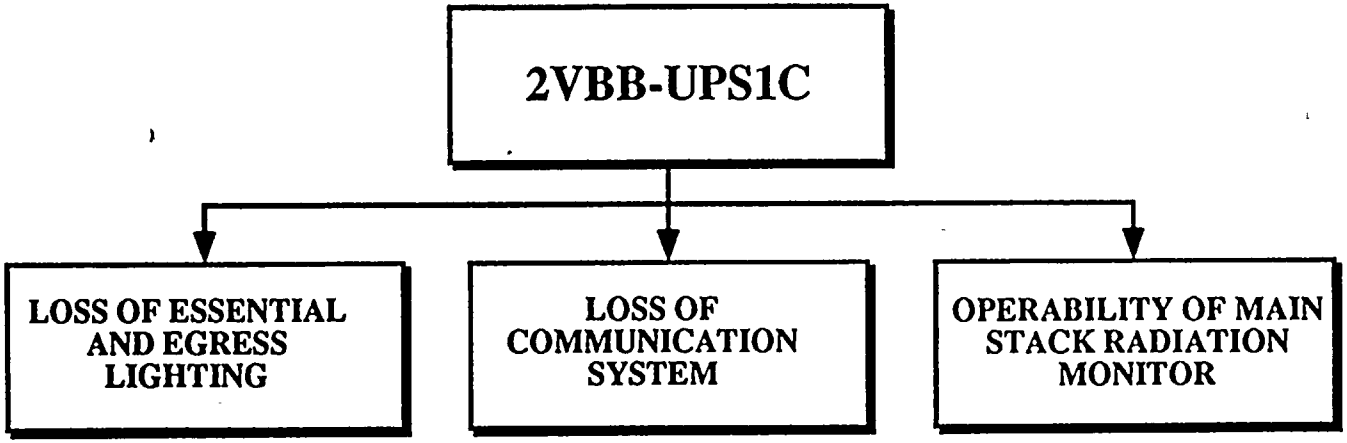

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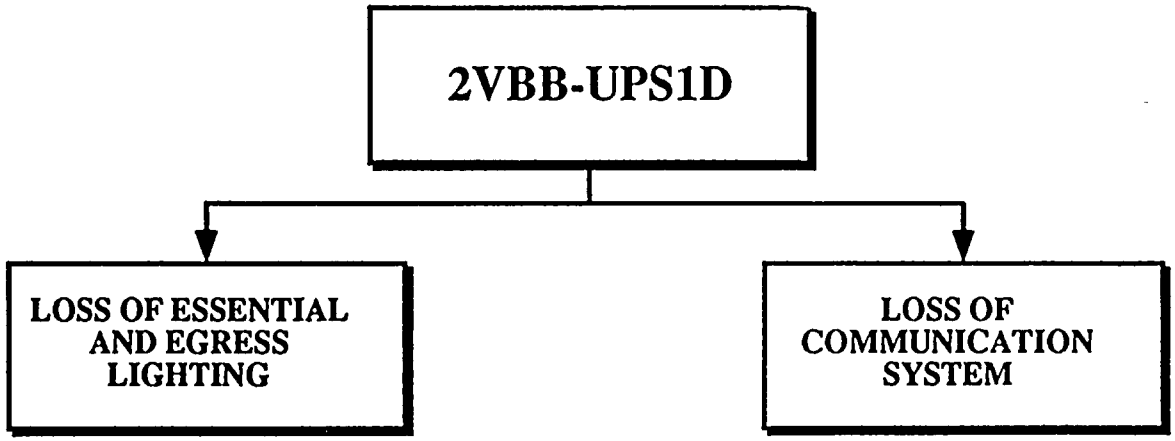

# UPS LOADS – PLANT IMPACT