TURBO STEAM

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Steam Turbine Cogeneration System

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SYSTEM OVERVIEW AND OPERATING PROCEDURES

Table of Contents

I TURBINE GENERATOR CONTROLS

The turbine generator control panel contains the process control logic and the turbine starting and stopping controls.

The turbine generator control system consists of the following components:

- Allen Bradley SLC500 series process controller with operator interface and a remote operator interface.
- Airpax Staktach 2 dual speed switches

The following pushbuttons, switches, and lights are included on the turbine generator control panel:

- Mechanical Overspeed test button
- Keyed control power switch (key removable in OFF position)
- Emergency stop pushbutton (push to Trip)
- Control power available light

Mounted on the front of the turbine control panel is an Allen Bradley Panelview plus, serving as the Operator Interface Terminal (OIT). For screen shots of the OIT, please refer to section III of this document.

The following indications are included on the OIT:

- Turbine Tripped, Ready to Start, Speed Ramp
- Generator Circuit Breaker Closed/Open
- Controlling Parameter (Speed, kW, exhaust pressure, or valve limiter)
- Status of relays

The following values can be monitored on the OIT:

- Steam pressure (exhaust, inlet, nozzle)
- Throttle Valve Position
- Turbine generator power output
- MWH
- Lube Oil pressure
- All Temperature indications

The Turbosteam Operator Interface displays a list of system alarms and trips with first-out indication on trips.

The lube oil system is started and stopped using power switch located just above lube oil reservoir.

System protection trips will not allow system reset, startup, circuit breaker closure, or will cause a trip if the breaker is closed.

II OPERATING PROCEDURE FOR TURBINE GENERATOR

****Notify proper personnel that system will be started:**

- **Control Room**

Note: These locations must be contacted when either starting system or system shutdown.

SYSTEM PRE-START PREPARATION

1. Confirm air supply is available to the turbine control valve.
2. Confirm Line up of cooling water to Lube Oil Cooler.

3. Attend to steam stop and drain valves as necessary to prepare turbine for starting.
   - 3.1. All turbine drain valves should already be open from the previous shutdown. Close valves so they are just cracked.
   - 3.2. Start Lube Oil System Using the On / Off Switch located above Lube Oil Skid. Check to ensure pressure increases above alarm and trip point settings.
   - 3.3. Drain warm-up line then crack open slowly to admit steam to the turbine and exhaust piping. These will help equalize pressure across the main exhaust isolation valve for ease of opening. open turbine casing drain valve (located on skid next to turbine)
   - 3.4. Drain Inlets steam line-using bypass though the moisture separator and out the bottom drain. Line-up high-pressure steam up to trip valve. Slowly throttle drain valve shut to build pressure and equalize across inlet valve. Ensure condensate trap located on moisture separator just before the trip valve is functional.
   - 3.5. Allow Turbine casing and piping to warm-up:
     - 3.5.1. Cold Start – Turbine casing needs to be warmed up for 30 minutes.
     - 3.5.2. Hot Start – Ensure that all condensate is clear.

4. Full open Exhaust valve, then full open Inlet valve and shut the warm up line to exhaust and shut bypass around inlet valve.
5. Verify there are no leaks on utilities. If leaks are found, have them fixed before proceeding.

SYSTEM START

1. The operator RESETS system.
   - 1.1. Go to the OIT Trip page. Press on the button labeled System reset located on bottom center of screen.
     - 1.1.1. If all faults are clear, the controls will reset and turbine trip valve can be reset.
     - 1.1.2. If the system does not reset, notice which trip is illuminated and take the necessary action to clear the fault.
   - 1.2. Reset the Turbine as follows:
     - 1.2.1. Lift the trip plunger up till it engages and stays in the up position.
     - 1.2.2. Lift the turbine combo valve lever till it engages and opens the trip valve.

2. ***The operator can now initiate a START command. Automatic governor control incorporates PID control algorithms within the PLC. The PID control will send a signal to the turbine governor valve. The control signal will modulate the valve as necessary to maintain a specific setpoint. Depending on operation mode this control signal may be derived by speed, pressure, or kilowatt control loops.***

   During the initial starting of the system, the control objective is to increase the turbine speed to rated (synchronous speed) in a controlled manner by increasing the speed setpoint.

   2.1. *START*

   - 2.1.1. The operator ensures exhaust and inlet block valves are opened completely.
   - 2.1.2. The operator initiates a START with Automatic Speed Setpoint Ramp.

2.1.3. Steam turbine will ramp to slow roll speed and hold for the specified slow roll hold time. Slow roll allows the turbine shaft to become true (remove any bow that may develop during shutdown).
Slow roll: 5 minutes @ 1000 rpm

2.1.4. After 5 minutes at slow roll, close all steam drains (leaving steam traps functional).

2.1.5. When the slow roll is complete, press the "Ramp to Rated" push button. Press this button to enable auto ramp to rated speed.
Rated speed: 3610 rpm

2.1.6. When the turbine speed is at or near rated, the system is ready for breaker closure.
2.1.6.1. If the breaker control is set for "AUTO" once system has reached rated speed and speed is maintained between lowest allowable and highest allowable speeds the breaker will Automatically shut.
2.1.6.2. If the breaker control is in "MANUAL" once the unit has settled out at rated speed the operator can press the "MANUAL" pushbutton to close the breaker

PROCESS CONTROL

3. Process control incorporates two PID controls:

3.1. Exhaust pressure control - Exhaust pressure control utilizes a PID control to maintain exhaust pressure (process variable) at a designated value (setpoint). The PID controller will modulate the signal to the valve in response to the magnitude and duration of difference between the process variable and setpoint. This signal then changes the valve position allowing more or less steam into the exhaust steam header, thereby maintaining the desired pressure. Exhaust pressure setpoint can be changed as necessary. Typically this setpoint will be at least 2 psi higher than that of the pressure reducing station pressure controller.

3.2. Generator kW limiting control - Generator kW control utilizes a PID control to limit the generator kW production to a desired kW setpoint. The PID controller will modulate the signal to the valve as required to maintain the setpoint. The generator kW limiting setpoint can be changed at any time. This control mode can also be used to base load the generator at some value less than maximum.

[THESE TWO CONTROLS WORK CONCURRENTLY, BUT ONLY ONE LOOP CAN CONTROL THE TURBINE THROTTLE VALVE AT ANY GIVEN TIME. THE CONTROLLER WITH THE LOWER OUTPUT WILL CONTROL THE VALVE.]

3.3

HANDVALVE CONTROLS

4. Handvalves supplied with turbine package can be operated in automatic and manual. The operator selects the operating mode by pressing pushbutton on start up page or overview page.

4.1. Automatic handvalve operations
4.1.1. The handvalves in Automatic mode will be controlled by a differential pressure between inlet pressure and nozzle pressure. As the differential pressure approaches minimum setpoint this is an indication that turbine is passing as much steam as it is capable thus a handvalve must be open to allow for more steam to flow. In reverses as the differential press increases and reaches a maximum setpoint. The controls will shut a handvalve in order to maximize efficiency of the turbine.
4.1.2. Handvalve optimizer looks at the differential pressure that controls the handvalves and the position of the bypass PRV. Once we reach minimal differential pressure where a handvalve would open the controls delay opening until PRV reaches a certain open position. This ensures there is enough steam demand to warrant opening a handvalve and minimizes the chances the controls cycle opening and shutting of the handvalve.
4.1.2.1. In the event that the valve limiter becomes controlling parameter and exhaust pressure is more then 3 PSIG below setpoint the handvalve will open

Note: when the turbine trips both handvalves will open up and upon resetting and pressing the start button both handvalves will shut.

Note: when a handvalve operates the control valve position will change rapidly to compensate for rapid changes in steam flow this is to prevent over pressurization of system.

4.2. Manual handvalve operation

4.2.1. In manual mode of operation the handvalve position is controlled by the operator pressing the open or shut handvalve pushbuttons handvalve operate in sequential order so that #1 handvalve opens and remains open before #2 can be opened. In reverse #2 must shut first before #1 can shut.

REVERSE POWER

5. Power output of the generator is directly related to the steam flow through the turbine. Likewise, steam flow through the turbine is a function of steam demand on the steam header. If the steam load decreases to the point where the generator acts like a motor, the generator will consume rather than generate power. This condition is referred to as Reverse Power. After a reverse power time period expires (30 seconds), a reverse power trip will be issued. The unit will open the breaker and ramp down in speed to 1000 RPM and remain there until operator takes action.

5.1. If steam load returns, the operator can put the system back on-line as follows:
5.2. Reset system. Using the reset button located on trip page.
5.3. Increase turbine speed to rated.
5.4. Close breaker

5.5. Immediately after the system is shutdown (if turbine is going to be shutdown longer than 3 hours),

5.6. Close the steam inlet block valve completely.
5.7. Close the steam exhaust block valve completely.
5.8. Open all turbine drains completely.

OVERSPEED TESTING

6. There are three (3) separate overspeed devices on the system. Two (2) are Airpax speed switches which also provide a speed signal to the PLC used for speed control. The third is a mechanical overspeed trip device. The electronic overspeed trip devices can be tested without actually overspeeding the system. This is described as follows:
6.1. Testing the Airpax overspeed devices:
6.1.1. Reset the system.
6.1.2. Go to OIT Turbine page
6.1.3. Using the OIT push buttons press "Test overpseed channel #1". The system should detect an overspeed as overspeed channel 1 and the system should trip. Notice the peak speed recorded on OIT Turbine page. Record the value.
6.1.4. Repeat above procedure with push button "Test Overspeed channel #2".
6.1.5. This concludes testing of the Airpax overspeed devices.

7. Test the Turbine mechanical Overspeed
7.1. Start the turbine up as normal and bring to rated speed with breaker control in manual mode.
7.2. Press and hold the **"MECHANICAL OVERSPEED TEST"** pushbutton. This will automatically raise the speed reference setpoint. Increasing speed up to a point above the Turbine mechanical overspeed trip level (4205 rpm). Continue to press and hold the **"MECHANICAL OVERSPEED TEST"** pushbutton until system trips

CAUTION

Max allowable speed is 4205 RPM. If system does not trip immediately, release the "MECHANICAL OVERSPEED TEST" pushbutton, this will enable electronic overspeed devices, which should trip the system. In the unlikely event the system does not trip immediately, press the red "EMERGENCY STOP" push button.

The system should trip. OIT Trip page should indicate a Trip Valve trip. Record the peak speed shown on OIT Turbine page. This completes the Turbine mechanical overspeed test.

SHUTTING DOWN SYSTEM:

8. Shutting system down has two methods preferred and emergency.

8.1. Normal shutdown: **(Preferred *method)***

8.1.1. From the Start-up page or the Overview Page Press and hold for 3sec, the button in the upper right hand corner labeled Control Shut down.

Note: Pressing the pushbutton displayed as shutdown in progress will terminate shut down and the unit will remain running at current conditions.

8.1.2. Once control shut down has been initiated this button will change to indicate that a control shut down is in progress.

8.1.3. The control shut down will slowly lower valve limiter setpoint down to zero. If the unit was online making power the KW will begin to lower until a reverse power state occurs in which breaker will open and speed will be the controlling parameter. After breaker opens the valve limiter setpoint will continue to be lowered until valve limiter reaches 3% at which time a trip will be intiated to trip turbine.

8.1.4. Verify on Trip page the first out is Control shut down.

8.1.5. If the unit is to be shut down for greater then 3 hours shut steam inlet and exhaust isolation valves and open drains slowly.

8.2. Emergency Shutdown:

8.2.1. In any situation where operator feels damage to equipment or personal is possible the unit may be shut down using the Emergency stop button located on control panel, bolier control room, or switch gear. This will immediately trip turbine offline and open breaker.

Emergency trip should be used in any emergency that the operator deems necessary.

➢ OPERATOR INTERFACE:

The main control panel serves as the primary operator interface point. It is typically located within eyesight of the turbine generator. There are several components mounted on the control panel door providing visual monitoring and operator control of system parameters. These devices are summarized below:

Touch Screen operator interface (Allen Bradley Panelview Plus)

- *Controls (PB – pushbutton) (VE – Value Entry)*

  Start options:

  1. PB – Start

  Speed Ramp Options:

  1. PB – Ramp to Rated
  2. PB – Ramp to Slow roll
  3. PB – Manual Speed UP
  4. PB – Manual Speed DOWN

  Breaker:

  1. PB – Breaker Close AUTO/MANUAL
  2. PB – Manual Close breaker.

  Other:

  1. PB - Controlled Stop
  2. PB - Controlled Stop Cancel (displayed only while Controlled stop is in progress)
  3. VE – Speed Setpoint
  4. VE – Exhaust Pressure Setpoint
  5. VE – Generator kW Setpoint
  6. VE – Valve limiter Setpoint
  7. PB – Handvalve Mode Automatic/Manual
  8. PB – Handvalve Optimizer on/off
  9. PB – Open handvalve
  10. PB – Close handvalve
  11. PB – Page Dir ***Note: appears on all pages***

- *Monitored Parameters*

Startup Page

1. Turbine Generator Status: (tripped, ramping, at slow roll,...etc.) ***Note: appears on all operations pages***
2. Actual Speed.
3. Speed setpoint & target
4. Actual Exhaust pressure
5. Exhaust pressure setpoint & target
6. Actual Generator kW output
7. Generator kW setpoint & target
8. % Valve command
9. Valve limiter setpoint & target
10. Breaker Controls & status
11. Handvalve controls & status
12. Alarm Status ***Note: appears on all operations pages***
13. PRV position %
14. Lube Oil Pressure

Overview Page

1. Items all items from start up page

2. Temperature
3. Runtime counters

Power page

1. Voltage
2. Current
3. Power: Real, Reactive, Factor
4. Frequency

Turbine page

1. Electronic Overspeed channel #1
2. Electronic Overspeed channel #2
3. Peak Speed Reached
4. Speed (Actual, setpoint, target)
5. % Valve command
6. Temperature turbine bearings (inlet, exhaust)
7. Temperature Alarm & trip setpoint

Generator Page

1. Temperature Generator Bearings and Stator.
2. Temperature Alarm & Trip setpoints
3. Total MWH counter
4. MWH counter that automatically resets (20,000KWH) *this is adjustable fro the OIT*
5. PB – Reset MWH counter
6. KW (actual, setpoint, target)

Alarm List

1. See ALARM PAGE in Section III

Trip List

1. See TRIP PAGE in Section III

All other pages in Section III

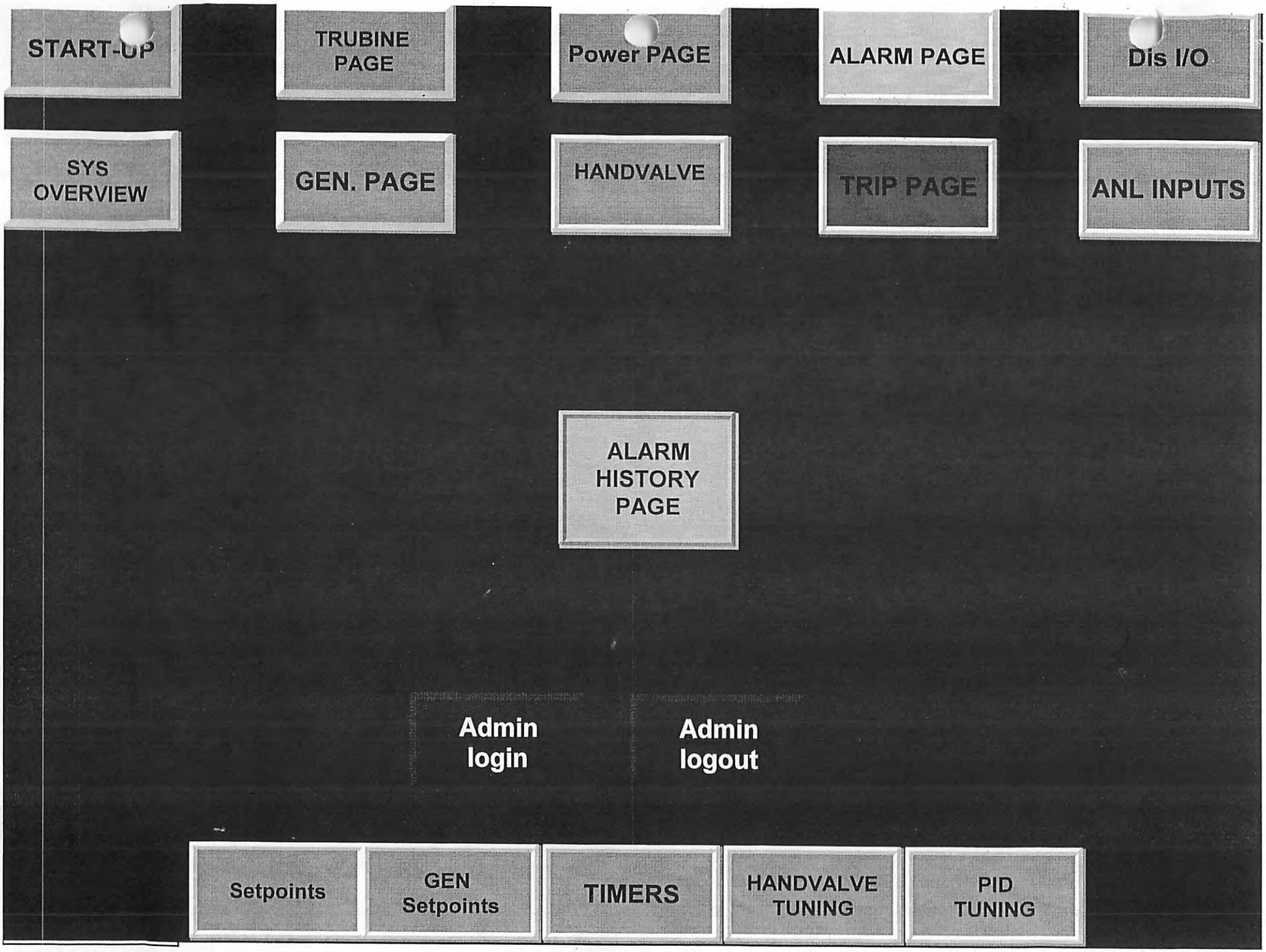
Controls located on Control Panel Door

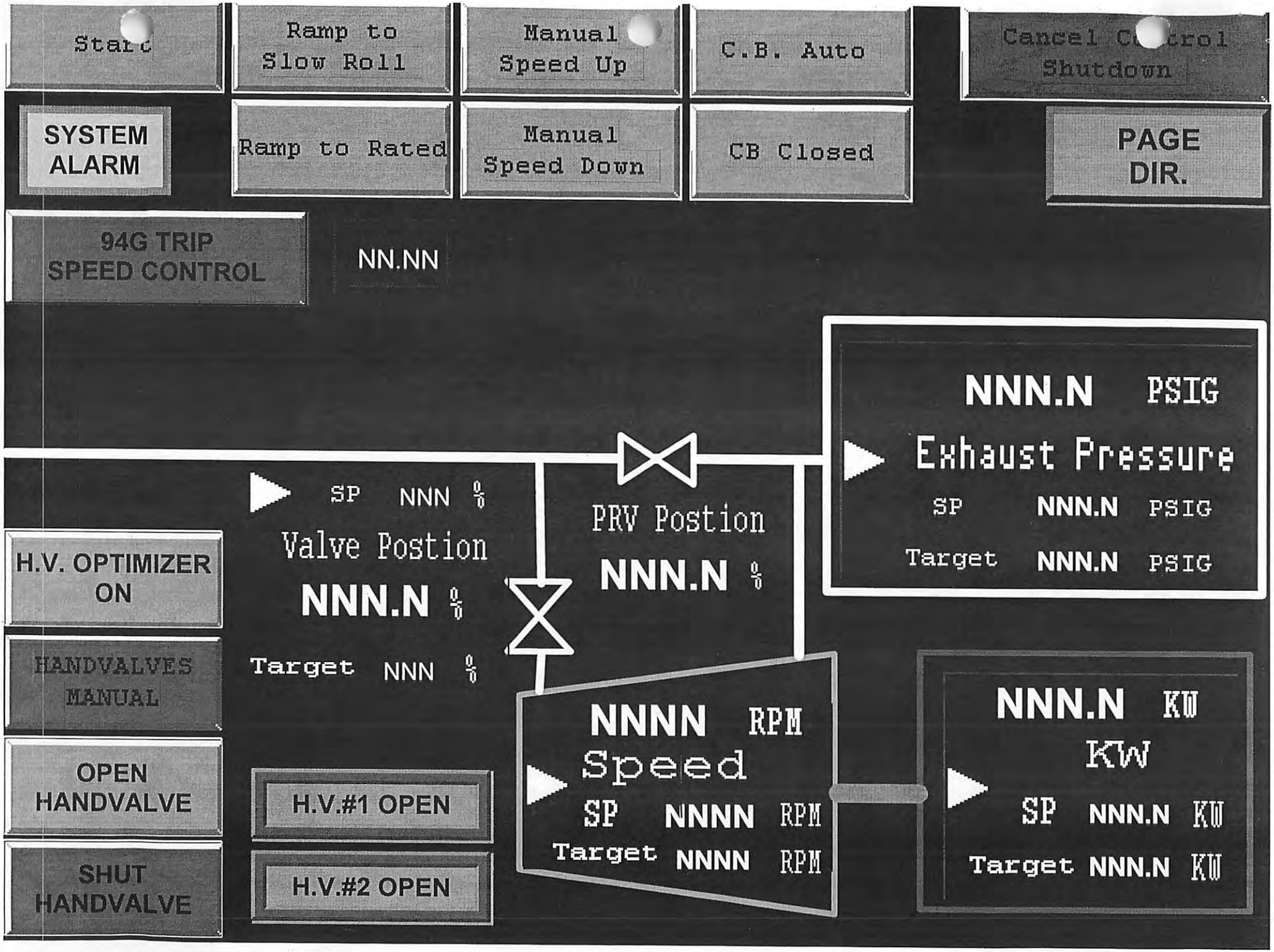
1. Control power switch
2. Mechanical Overspeed test Pushbutton.
3. Emergency Stop pushbutton

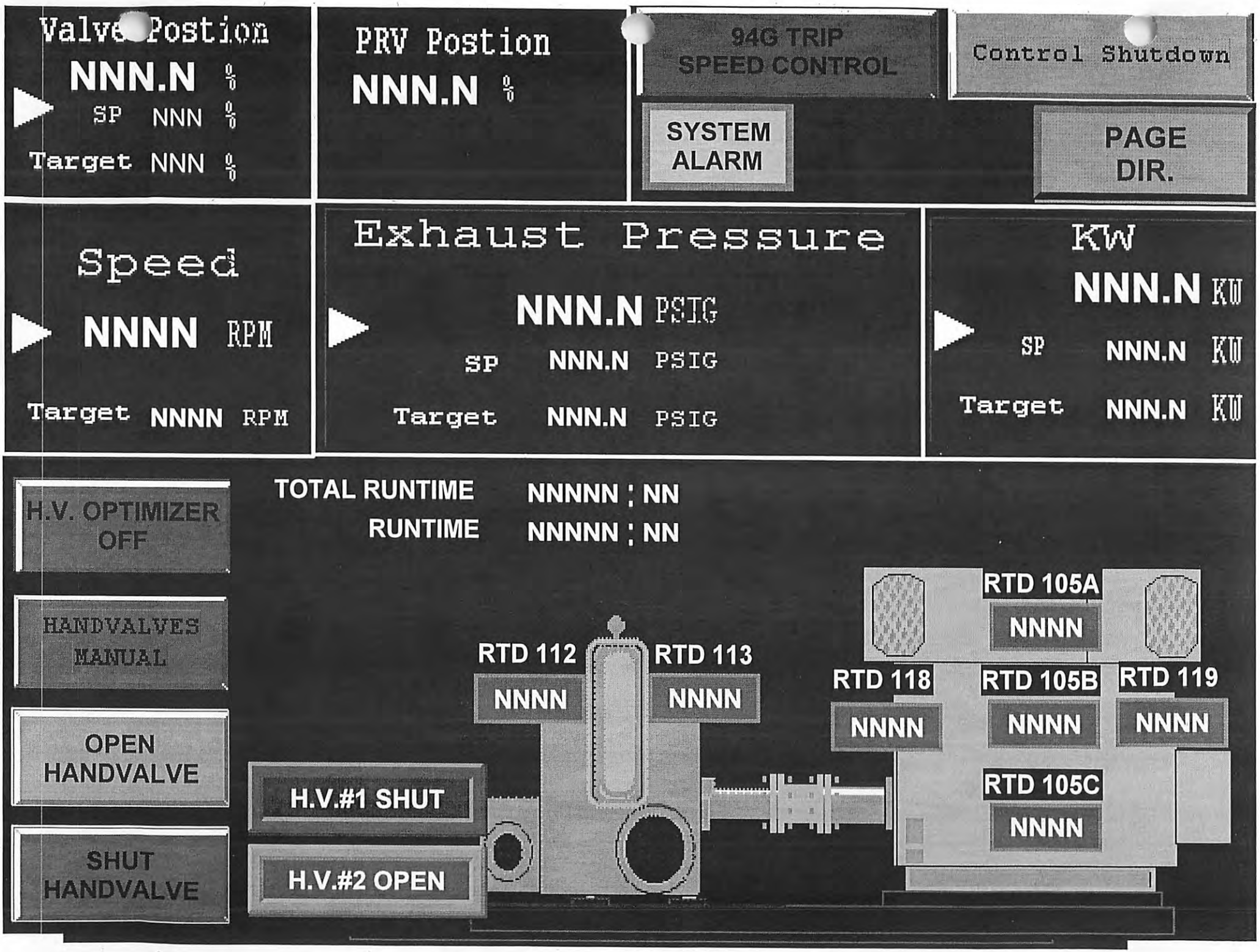
Remote Operator Interface (Allen Bradley Panel 550)

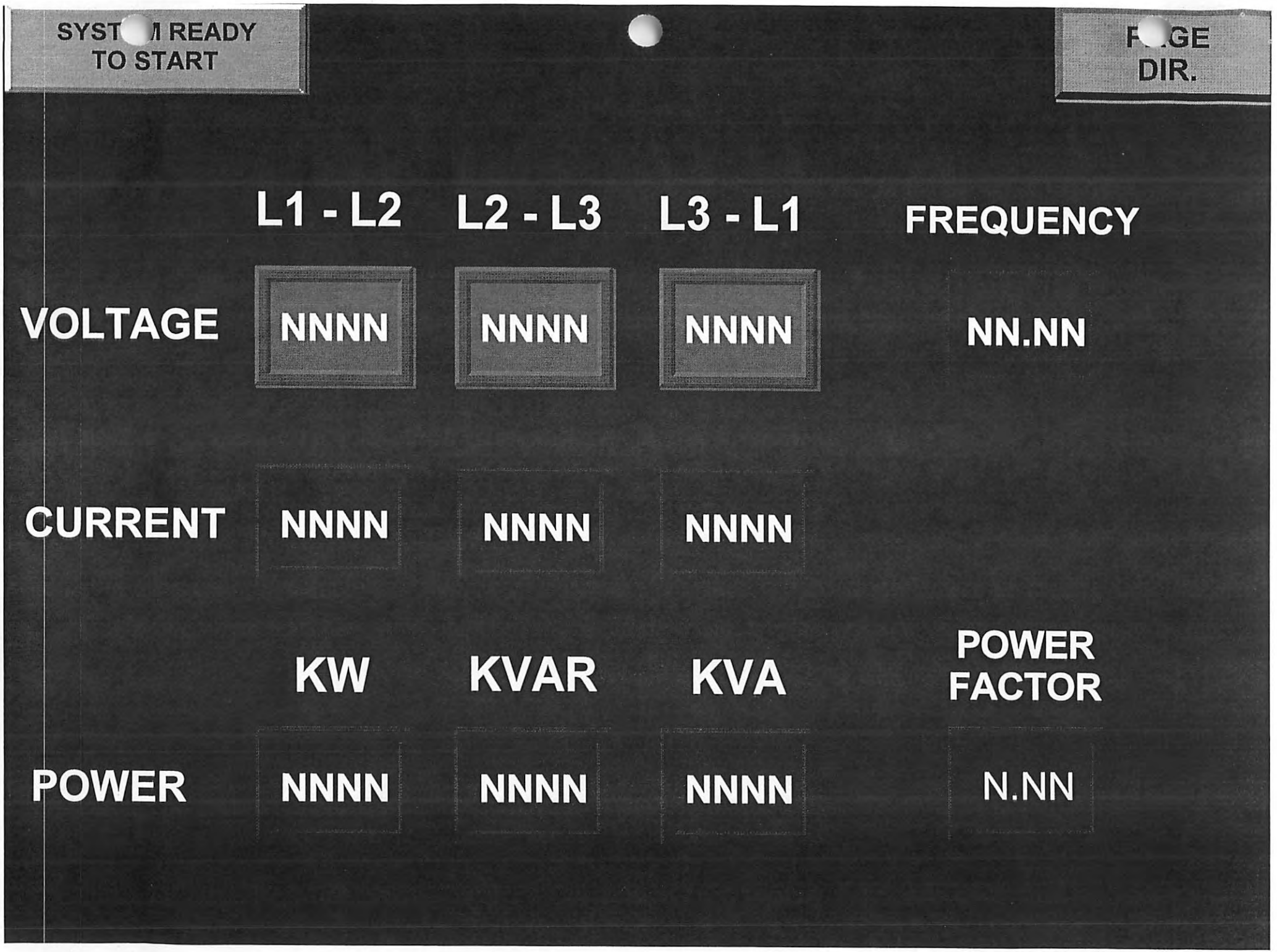
1. Displays Exhaust pressure (actual, setpoint, target)
2. VE-F1 Button Exhaust pressure target.
3. F5- Alarm silencer.
4. F12- Display configuration page.
5. Handvalve status.
6. PRV % open.

III
OPERATOR INTERFACE TERMINAL (OIT) SCREENS


START-UP
TRUBINE PAGE
Power PAGE
ALARM PAGE
Dis I/O
SYS OVERVIEW
GEN. PAGE
HANDVALVE
TRIP PAGE
ANL INPUTS
ALARM HISTORY PAGE
Admin login
Admin logout
Setpoints
GEN Setpoints
TIMERS
HANDVALVE TUNING
PID TUNING


Start
Ramp to Slow Roll
Manual Speed Up
C.B. Auto
Cancel Control Shutdown
SYSTEM ALARM
Ramp to Rated
Manual Speed Down
CB Closed
PAGE DIR.
94G TRIP SPEED CONTROL
NN.NN
NNN.N PSIG
Exhaust Pressure
SP NNN.N PSIG
Target NNN.N PSIG
SP NNN %
Valve Postion
NNN.N %
Target NNN %
PRV Postion
NNN.N %
H.V. OPTIMIZER ON
HANDVALVES MANUAL
OPEN HANDVALVE
SHUT HANDVALVE
H.V.#1 OPEN
H.V.#2 OPEN
NNNN RPM
Speed
SP NNNN RPM
Target NNNN RPM
NNN.N KW
KW
SP NNN.N KW
Target NNN.N KW


Valve Postion
NNN.N %
SP NNN %
Target NNN %
PRV Postion
NNN.N %
94G TRIP
SPEED CONTROL
Control Shutdown
SYSTEM
ALARM
PAGE
DIR.
Speed
NNNN RPM
Target NNNN RPM
Exhaust Pressure
NNN.N PSIG
SP NNN.N PSIG
Target NNN.N PSIG
KW
NNN.N KW
SP NNN.N KW
Target NNN.N KW
H.V. OPTIMIZER
OFF
TOTAL RUNTIME NNNNN : NN
RUNTIME NNNNN : NN
HANDVALVES
MANUAL
OPEN
HANDVALVE
SHUT
HANDVALVE
H.V.#1 SHUT
H.V.#2 OPEN
RTD 112
NNNN
RTD 113
NNNN
RTD 105A
NNNN
RTD 118
NNNN
RTD 105B
NNNN
RTD 119
NNNN
RTD 105C
NNNN


SYST M READY
TO START
F GE
DIR.
L1 - L2
L2 - L3
L3 - L1
FREQUENCY
VOLTAGE
NNNN
NNNN
NNNN
NN.NN
CURRENT
NNNN
NNNN
NNNN
KW
KVAR
KVA
POWER
FACTOR
POWER
NNNN
NNNN
NNNN
N.NN

ELECTRONIC OS1

NNNNN

TEST OVERSPEED CHANNEL #1

PAGE DIR.

ELECTRONIC OS2

NNNNN

TEST OVERSPEED CHANNEL #2

SP NNN %

Target NNN %

PEAK SPEED

NNNNN

RESET PEAK SPEED

Valve Postion

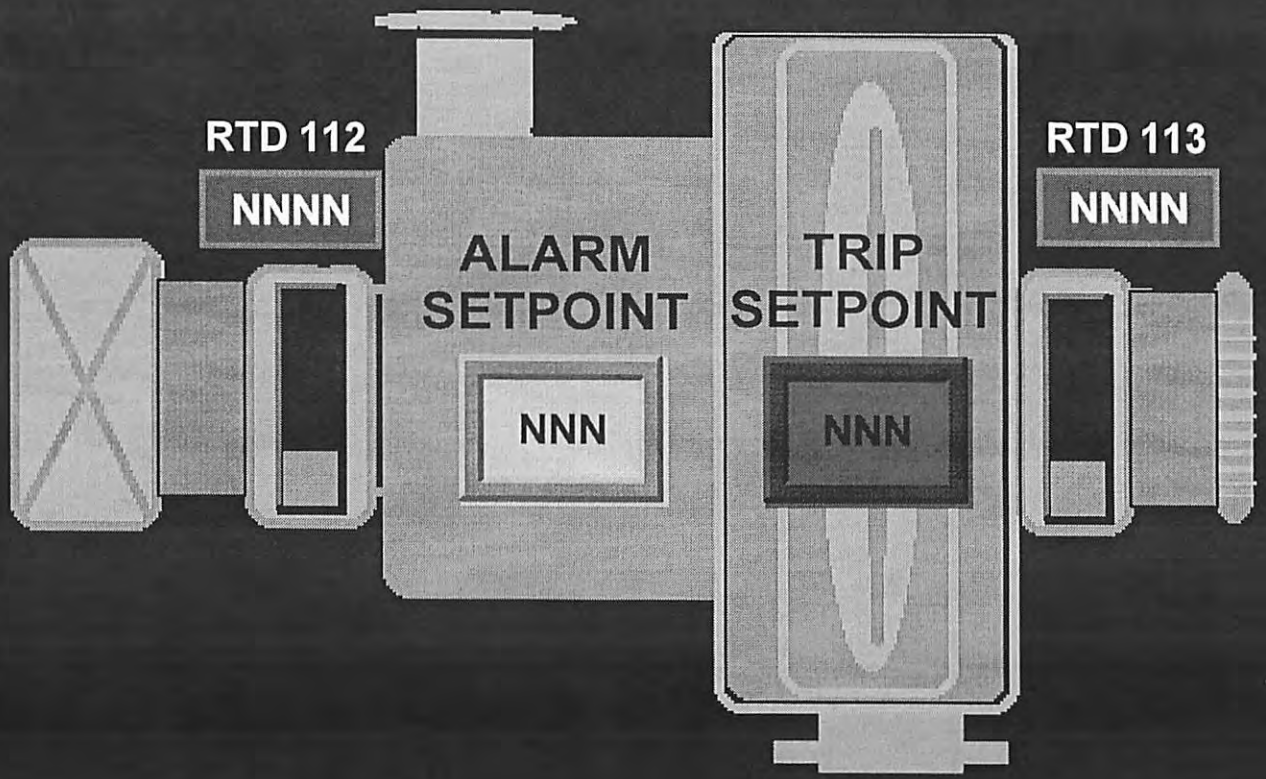
NNN.N %

Speed

NNNN RPM

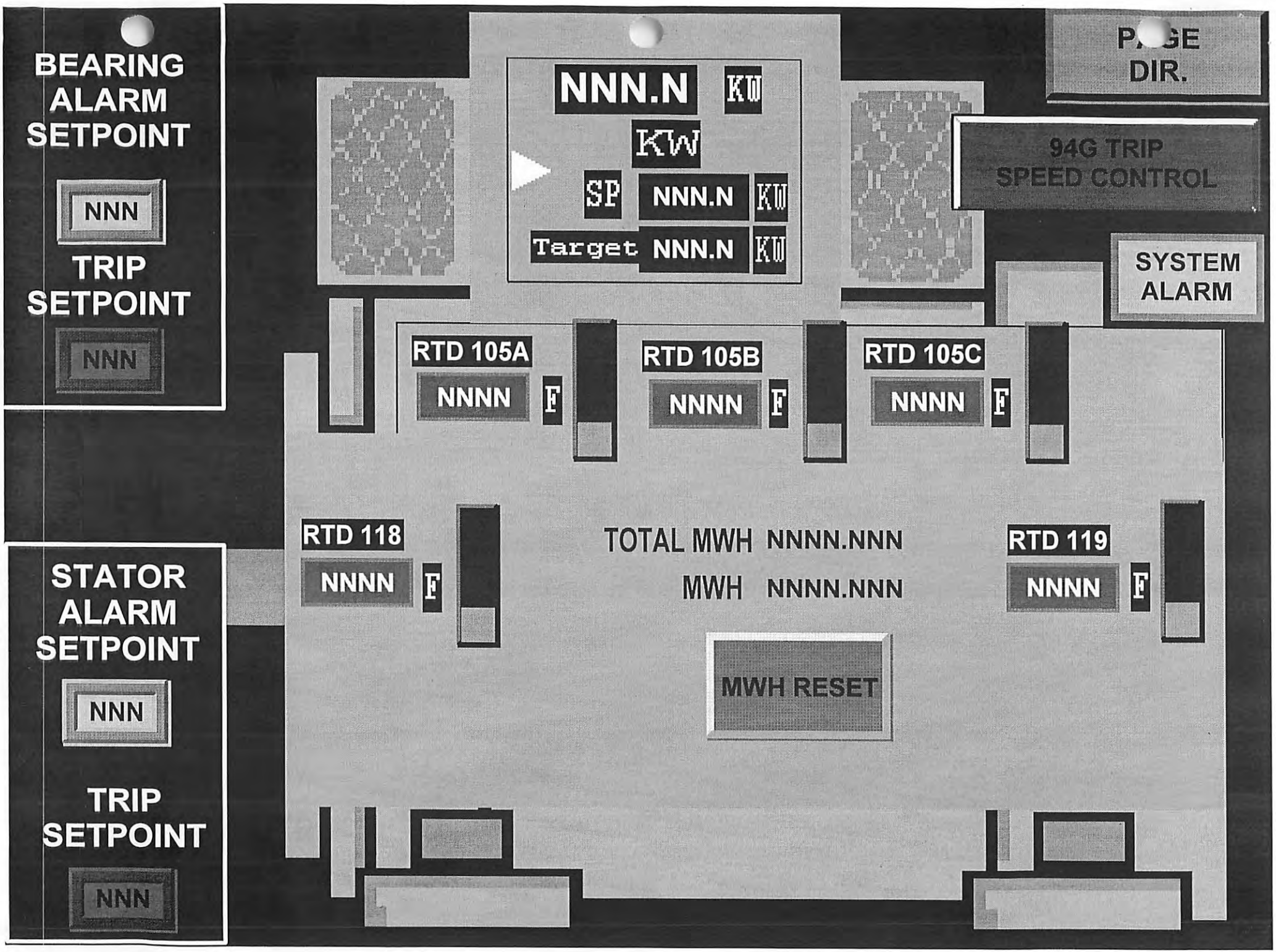
SP NNNN RPM

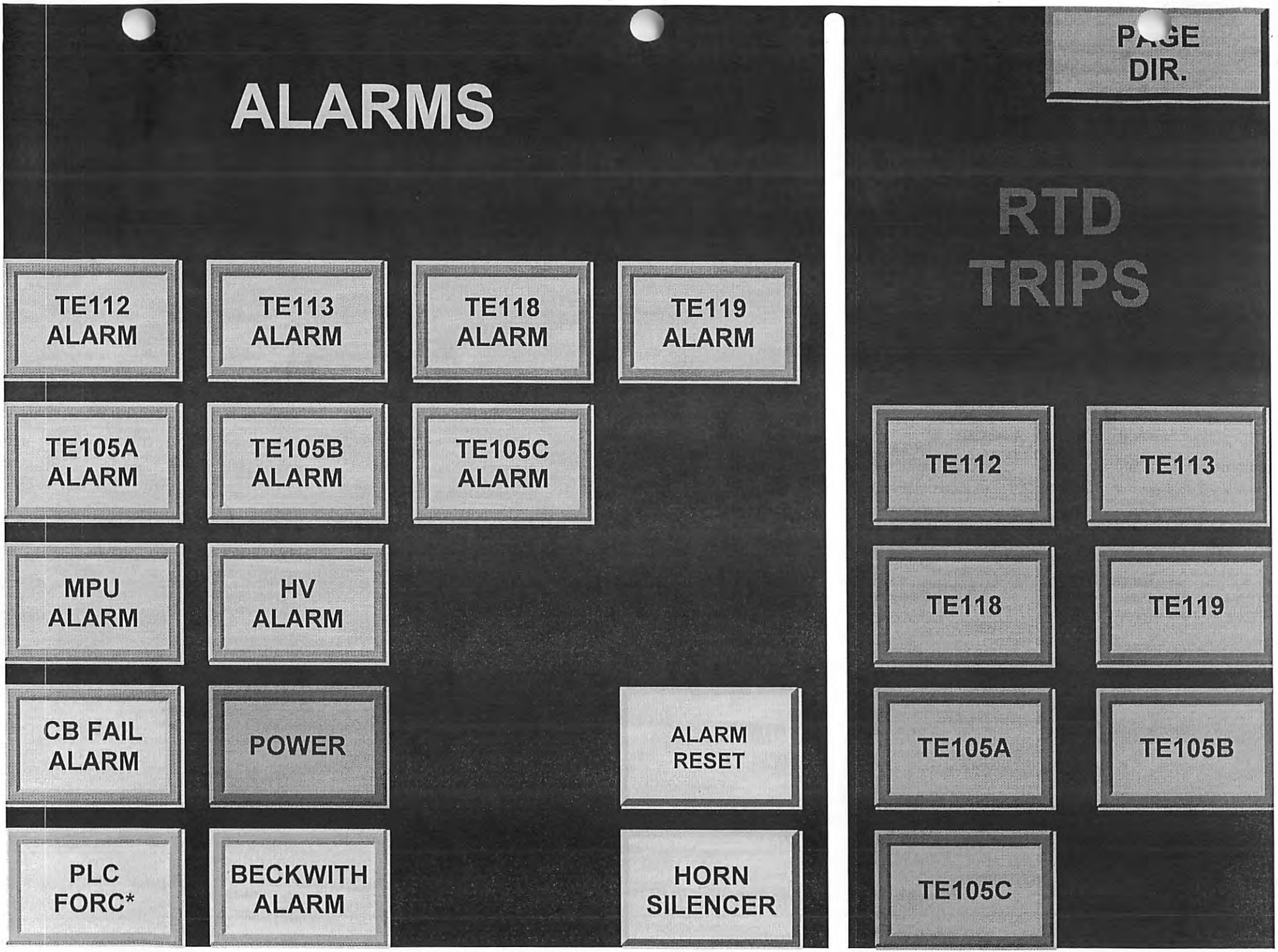
Target NNNN RPM

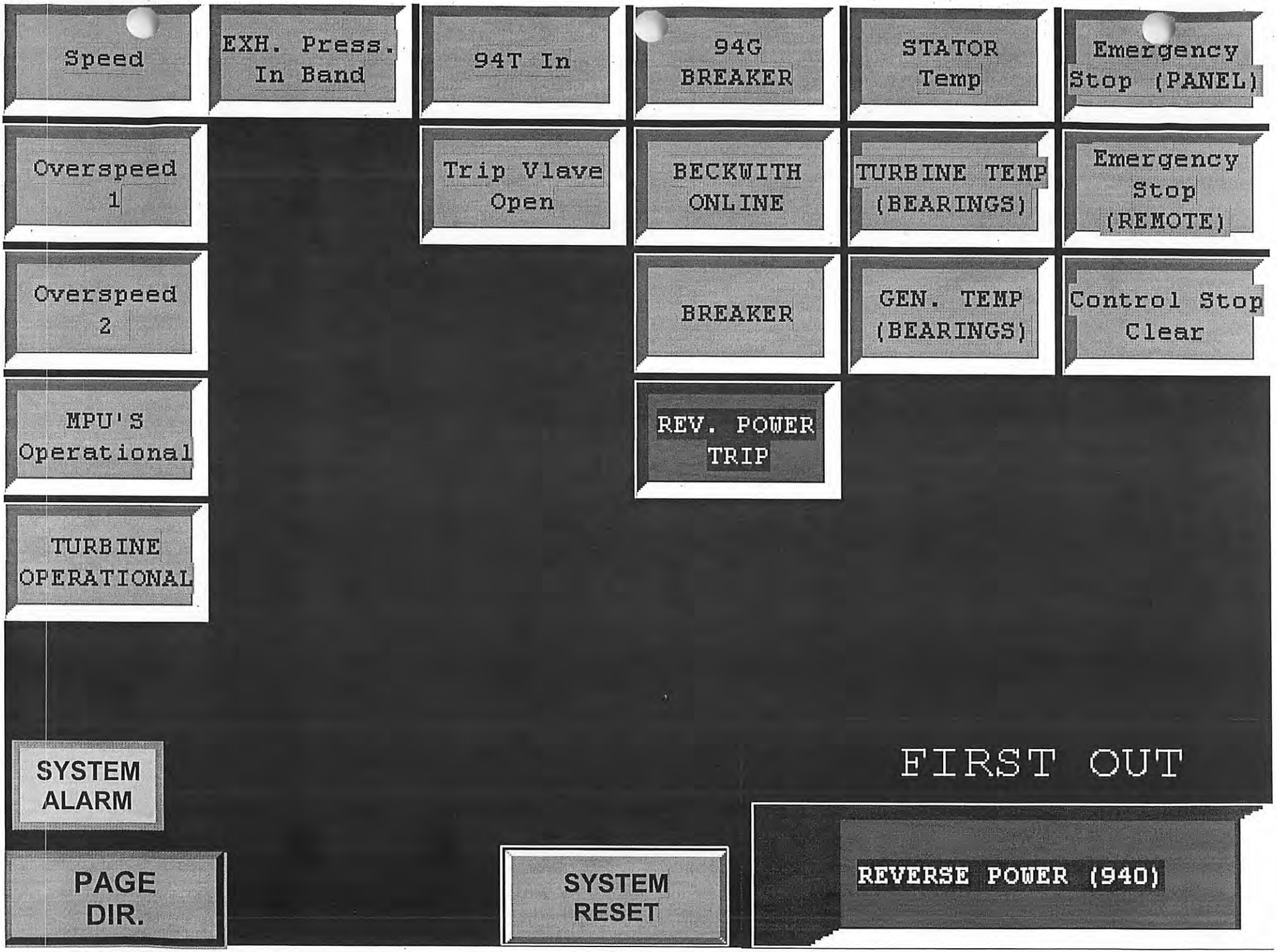


SYSTEM ALARM

94G TRIP SPEED CONTROL


BEARING ALARM SETPOINT
NNN
TRIP SETPOINT
NNN
STATOR ALARM SETPOINT
NNN
TRIP SETPOINT
NNN
NNN.N KW
KW
SP NNN.N KW
Target NNN.N KW
PAGE DIR.
94G TRIP SPEED CONTROL
SYSTEM ALARM
RTD 105A
NNNN F
RTD 105B
NNNN F
RTD 105C
NNNN F
RTD 118
NNNN F
TOTAL MWH NNNN.NNN
MWH NNNN.NNN
RTD 119
NNNN F
MWH RESET


ALARMS
PAGE DIR.
RTD TRIPS
TE112 ALARM
TE113 ALARM
TE118 ALARM
TE119 ALARM
TE105A ALARM
TE105B ALARM
TE105C ALARM
MPU ALARM
HV ALARM
CB FAIL ALARM
POWER
ALARM RESET
PLC FORC*
BECKWITH ALARM
HORN SILENCER
TE112
TE113
TE118
TE119
TE105A
TE105B
TE105C


Speed
EXH. Press. In Band
94T In
94G BREAKER
STATOR Temp
Emergency Stop (PANEL)
Overspeed 1
Trip Vlave Open
BECKWITH ONLINE
TURBINE TEMP (BEARINGS)
Emergency Stop (REMOTE)
Overspeed 2
BREAKER
GEN. TEMP (BEARINGS)
Control Stop Clear
MPU'S Operational
REV. POWER TRIP
TURBINE OPERATIONAL
FIRST OUT
SYSTEM ALARM
REVERSE POWER (940)
PAGE DIR.
SYSTEM RESET

DISCRETE INPUTS

94G- Breaker Reset

194TX- Turbine Reset

OS1-TRIPPED

OS2-TRIPPED

OST- MECH OS TEST ENABLED

LOCAL-Estop

REMOTE Estop

ZS/TT-1 TRIP VALVE OPEN

HV #1 OPEN SW 1

HV #1 OPEN SW 2

HV #2 OPEN SW 1

HV #2 OPEN SW 2

52A Breaker Closed

P[illegible]GE DIR.

DISCRETE OUTPUTS

CB CLOSED CIRCUIT ENERGIZED

PLC 94GX DE-ENERGIZED

PLC 94TX ENERGIZED

OS1 TEST ENABLED

OS2 TEST ENABLED

ALARM HORN

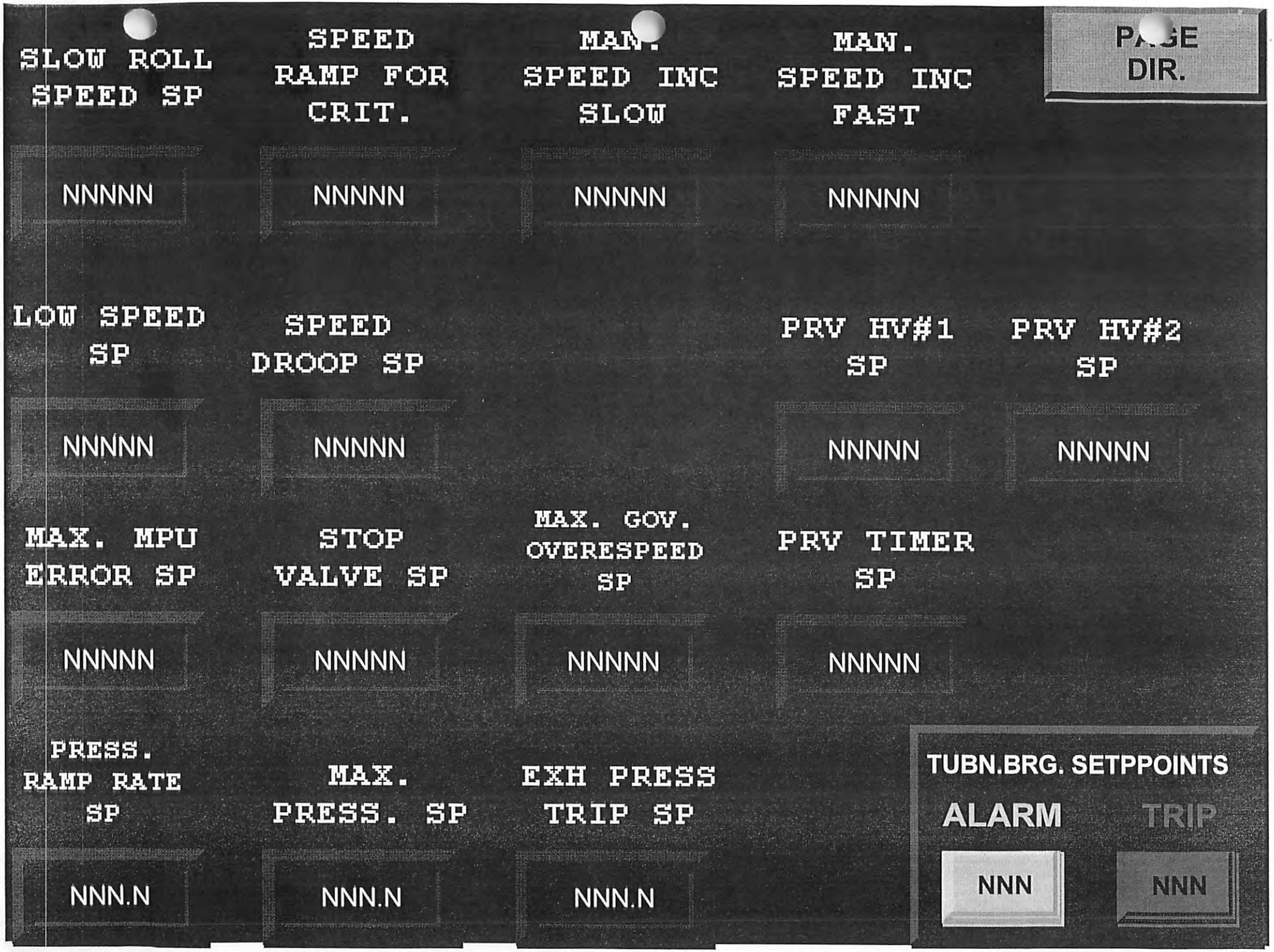
AUTO HANDVALVE 1 OPEN

AUTO HANDVALVE 2 OPEN

ANALOG INPUTS

PAGE DIR.

NNNNN	EXHAUST PRESSURE
NNNNN	INLET PRESSURE
NNNNN	CHEST PRESSURE
NNNNN	MPU CHANNEL 1
NNNNN	MPU CHANNEL 2


SLOW ROLL SPEED SP
SPEED RAMP FOR CRIT.
MAN. SPEED INC SLOW
MAN. SPEED INC FAST
PAGE DIR.
NNNNN
NNNNN
NNNNN
NNNNN
LOW SPEED SP
SPEED DROOP SP
PRV HV#1 SP
PRV HV#2 SP
NNNNN
NNNNN
NNNNN
NNNNN
MAX. MPU ERROR SP
STOP VALVE SP
MAX. GOV. OVERESPEED SP
PRV TIMER SP
NNNNN
NNNNN
NNNNN
NNNNN
PRESS. RAMP RATE SP
MAX. PRESS. SP
EXH PRESS TRIP SP
NNN.N
NNN.N
NNN.N
TUBN.BRG. SETPPOINTS
ALARM
TRIP
NNN
NNN

SPEED P OFFLINE	SPEED I OFFLINE	SPEED DERIVATIVE	SPEED PID DEADBAND	PAGE DIR.
NN.NN	NN.NN	NN.NN	NNNNN	
SPEED P ONLINE	SPEED I ONLINE		SPEED PID MAX	
NN.NN	NN.NN		NNNNN	
EXH PRESS P	EXH PRESS I	EXH PRESS DEADBAND	EXH PRESS PID MAX	INLET PRESS PID MAX
NN.NN	NN.NN	NNN.N	NNN.N	NNN.N
KW GEN P	KW GEN I	KW GEN DEADBAND	KW GEN PID MAX	NZZL PRESS PID MAX
NN.NN	NN.NN	NNNNN	NNNNN	NNN.N

TIMERS

PAGE DIR.

NO RESPONSE TRIP TIMER

NNNNN

TIMER HOLD AT SLOW ROLL

NNNNN

SETPOINT RAMP TIMER

NNNNN

REVERSE POWER TIMER

NNNNN

TURBINE TEMP TRIP DELAY

NNNNN

HANDVALVE DELAY AT SETPOINT

NNNNN

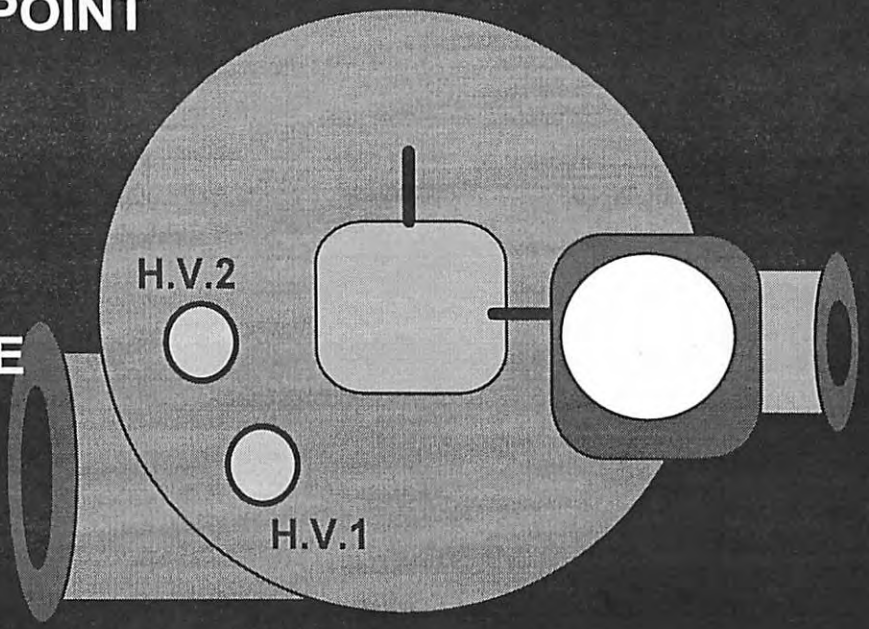
HANDVALVE SEQUENCE DELAY

NNNNN

PAGE DIR.

94G TRIP SPEED CONTROL

NNN.N	HANDVALVE 1 OPEN SETPOINT
NNN.N	HANDVALVE 1 SHUT SETPOINT
NNN.N	HANDVALVE 2 OPEN SETPOINT
NNN.N	HANDVALVE 2 SHUT SETPOINT
NNN.N	INLET PRESSURE
NNN.N	DIFFERENTIAL PRESSURE
NNN.N	CHEST PRESSURE
NNN.N	EXHAUST PRESSURE



PAGE DIR.

94G TRIP SPEED CONTROL

NNN.N HANDVALVE 1 OPEN SETPOINT

NNN.N HANDVALVE 1 SHUT SETPOINT

NNN.N HANDVALVE 2 OPEN SETPOINT

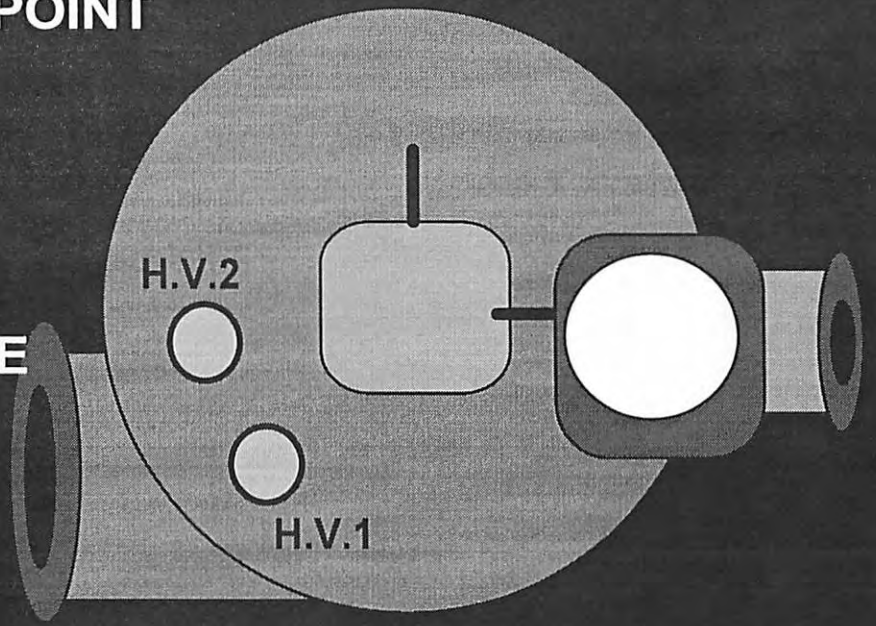
NNN.N HANDVALVE 2 SHUT SETPOINT

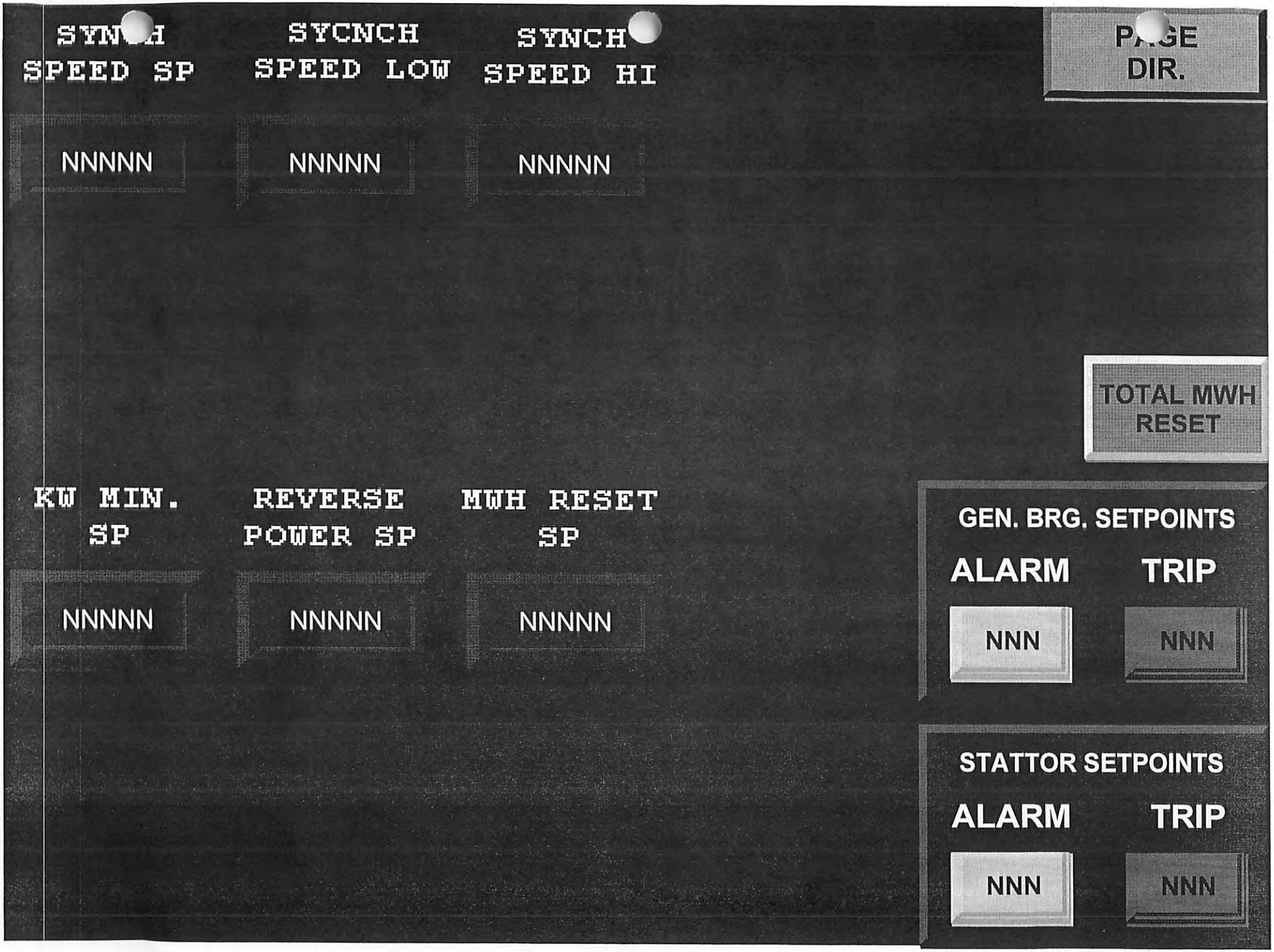
NNN.N INLET PRESSURE

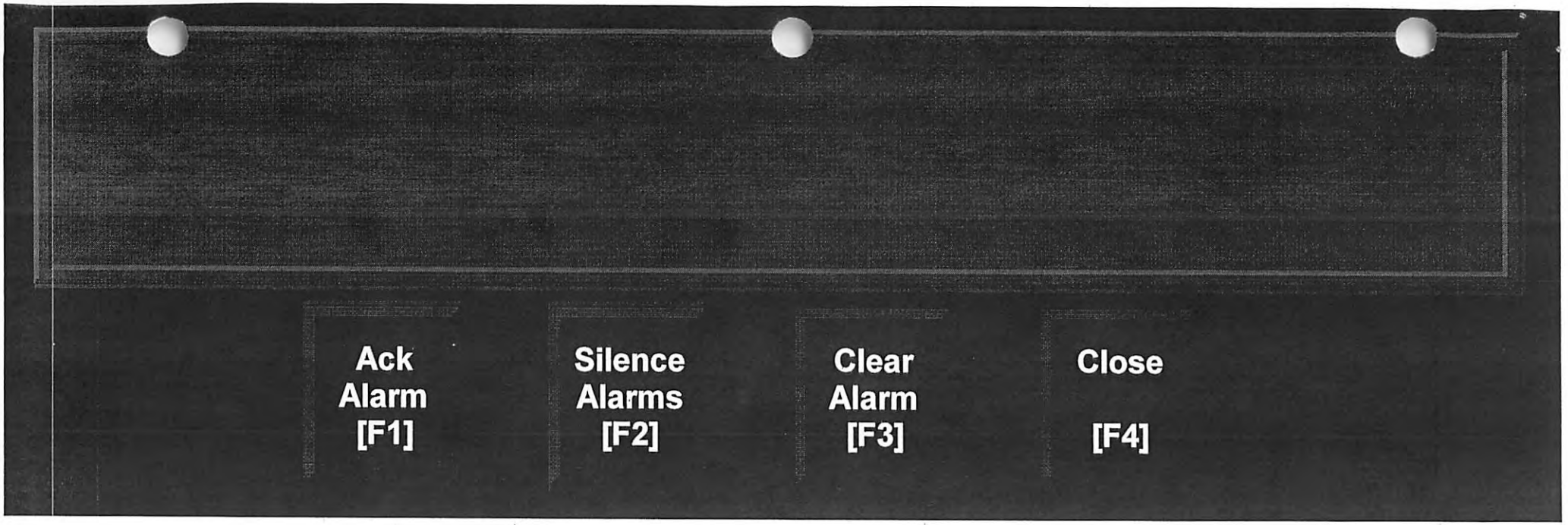
NNN.N DIFFERENTIAL PRESSURE

NNN.N CHEST PRESSURE

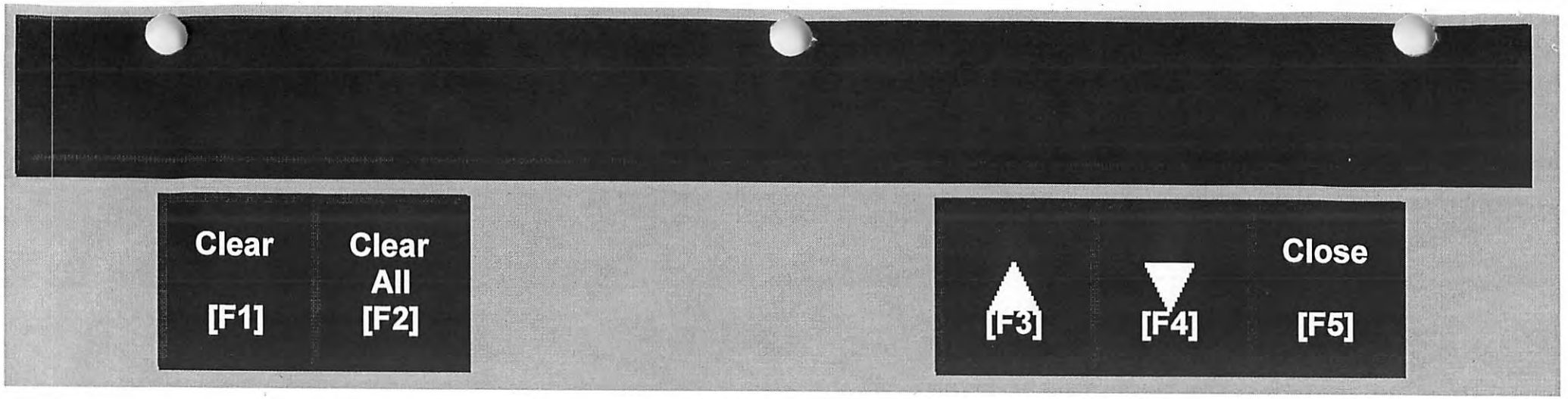
NNN.N EXHAUST PRESSURE




SYNCH SPEED SP
SYCNCH SPEED LOW
SYNCH SPEED HI
PAGE DIR.
NNNNN
NNNNN
NNNNN
TOTAL MWH RESET
KW MIN. SP
REVERSE POWER SP
MWH RESET SP
NNNNN
NNNNN
NNNNN
GEN. BRG. SETPOINTS
ALARM
TRIP
NNN
NNN
STATTOR SETPOINTS
ALARM
TRIP
NNN
NNN


Ack
Alarm
[F1]
Silence
Alarms
[F2]
Clear
Alarm
[F3]
Close
[F4]


Alarm History
Alarm time
Acknowledge time
Message
* 9:19:06 PM
9:19:06 PM
12345678901234567890123456789012345678901234567890
Ack Alarm
ALARM RESET
Home
Page Up
Move Up
Ack All
SILENCE HORN
Clear All
End
Page Down
Move Down
Close


Clear
[F1]
Clear
All
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Close
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