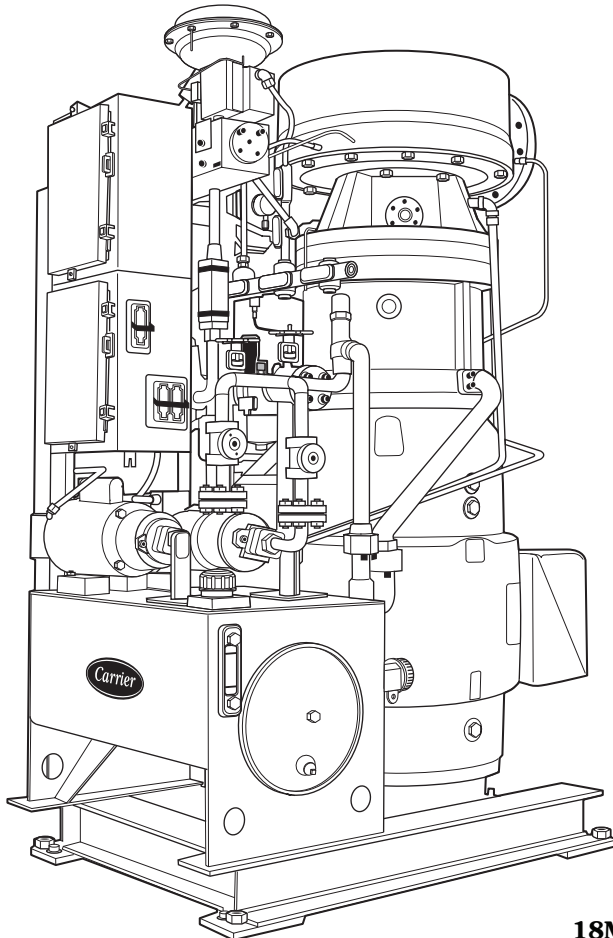




Product Data

MICROSTEAM® 18MS Power System

Up to 275 kWe



18MS

State of California
Air Resources Board
DG-017 Certification
for Zero-Emission Technology

The Microsteam 18MS power system offers:

- Energy generation from the steam that was previously wasted
- Peak shaving
- High efficiency operation
- Small footprint
- Environmentally sound solution
- Pre-wired configuration for all necessary controls

Features/Benefits

The Microsteam 18MS power system is a complete, compact self-contained power system designed to generate electric power from available steam energy.

Unique application

The Microsteam® power system is a unique product. It creates savings through energy generation from a source that is often available but not used. Steam that is usually routed through a pressure reducing valve (PRV) and wasted can be utilized by the Microsteam power system to generate energy.

Each 4 lb/hr of steam is now capable of generating 1 kWe of electricity that can be used to offset peak demand.

Features/Benefits (cont)



A new opportunity for sustainable energy recovery

Many steam users do not take advantage of the available steam until it reaches the final point of use. Before that stage is reached, there is an enormous potential to utilize the energy and generate valuable power for the plant or building. The vertical packaging concept applied to a steam turbine generator now allows progressive minded facility engineers the opportunity to integrate a wasted steam energy recovery strategy into their energy reduction programs.

The Microsteam® power system solution can be applied under any of these applications:

- typical PRV stations with 4-in. pipe diameters or larger
- high pressure boiler plants over 300 bhp
- district steam
- co-generation exhaust
- low pressure absorption cooling from 300 to 400 tons
- domestic hot water preheat
- electric chiller fuel switch
- turbine drive cooling replacement

These types of applications are normally found in the following locations:

- chemical industry
- colleges/universities
- food processing
- hotels
- hospitals
- petro-chemical plants
- pulp and paper industries
- pharmaceutical manufacturing
- other general manufacturing facilities

→ High efficiency

The key component for the system is the patented radial outflow turbine design. This style of turbine provides two stages of pressure reduction along with high efficiency performance. With a turbine efficiency of approximately 75%, the Microsteam power system can efficiently generate up to 275 kWe. For installations with a high amount of available steam, multiple units can be installed and even more energy can be produced.

Environmentally sound solution

With today's need for new environmentally sound solutions, the

Microsteam power system is a perfect fit. The Microsteam power system generates zero emissions and creates minimum disposal requirements (only oil from gear box).

The Microsteam power system also has the potential to contribute to extra LEED points for city buildings by providing a more efficient operation.

There are no rejections or contaminants from the Microsteam power system. The system uses an existing installation and causes zero additional impact to the environment.

Small footprint

With overall dimensions of 34 (W) x 42 (L) x 78 (H) in., the Microsteam power system is the smallest turbine system available in the market due to its vertical construction concept. For application inside buildings, the unit can be transported inside small elevators and will require minimum floor space for installation. The modular construction allows the turbine to be installed with the control panel or, if required by space limitations, the control panel may be installed separately in a remote location from the turbine.

System integration

The Microsteam power system can be easily integrated with an absorption chiller and provide even more efficiency and higher kWe levels from the steam energy available.

The steam being exhausted by the turbine has a pressure of approximately 15 psig which is ideal for operating an absorption chiller. Installing the Microsteam power system in series with an absorption chiller will make the

overall operation efficiency even higher.

Peak shaving

In many areas, the kWh price at 6:00 PM to 8:00 PM is typically more expensive than during regular hours. Electrical consumption beyond that allowed by contract can generate very costly fines and penalties. The need to reduce the overall kW consumption inside a plant or building becomes crucial during this time of the day. Replacing the regular electrical consumption with a steam supply can bring significant benefits to the cost of operation and avoid unexpected expenses on the electric bill.

Rugged construction

The Microsteam power system has a solid titanium alloy rotor with the blades machined into the disc. This method of construction is very rugged compared to the usual steam turbine with sheet metal blades of stainless steel pressed into a disc. The Microsteam radial outflow steam passages clear out any debris without causing erosion. This concept allows the operation of the Microsteam power system within an environment of less than perfect steam. This design will work in applications that are not possible with stainless steel turbines.

Low noise/vibration

With noise levels of 85 dBA, the operation of the steam turbine is suitable for most environments. The vibration level is less than 1 mil which eliminates the need for a special foundation in most applications. As long as the floor of the application is able to support a

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weight of 6,500 lb with a 34 x 42-in. area, the steam turbine can be installed easily.

Minimum maintenance

The radial outflow design disperses contaminants which improves maintenance characteristics. The titanium construction improves durability. Routine maintenance is limited to checking that operating parameters are in range, inspecting for oil and steam leakage, and inspecting the lubrication

oil reservoir level. No major overall maintenance procedures are expected.

Advanced controls

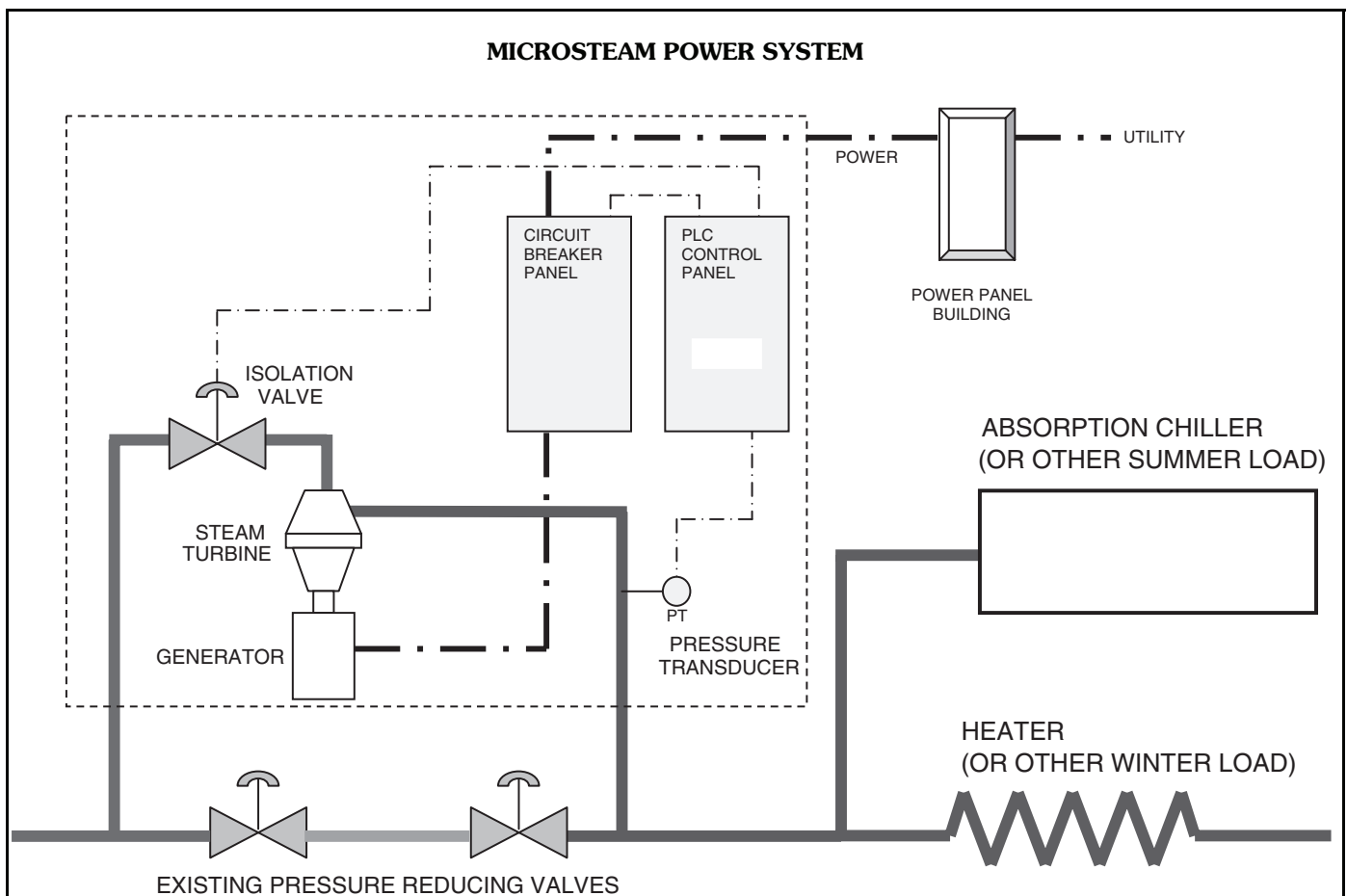
The PLC (programmable logic controller) based control system, with a single start/stop button, allows for easy operation.

Several features make the control system a major advantage of the Microsteam package:

- PID (proportional, integral, derivative) loop for ramp up to synchronous speed

- automatic connection to grid
- automatic control of steam demand by load
- fail safe design with default to PRV
- remote monitoring capability.

With a simple touch screen panel, the Microsteam power system control panel can easily meet the requirements of demanding customers and operations, including robust trending and metering capabilities.



The diagram above shows a typical installation with a Microsteam power system. Most applications utilizing steam normally have only pressure reducing valves (PRV) to reduce the steam pressure from its source. The pressure must be reduced so it can be used. This reduction on pressure generates no benefits to the customer and wastes valuable energy.

When the Microsteam power system is installed parallel to the PRVs, the same pressure reduction happens, but now, the Microsteam power system will utilize the energy released by the steam during the pressure reduction and generate power from it. The steam rotates the steam

turbine which drives a gear box. This powers the generator. With this configuration, the generator is able to produce up to 275 kWe of electricity (depending on the steam conditions and flow).

The control panel assures reliable operation and the circuit breaker panel makes the link between the Microsteam power system and the electrical system.

The steam being exhausted by the Microsteam power system will be at the same pressure that is used for the normal operation of the system. The difference is that the efficiency of the whole system is now optimized.

→ Model number nomenclature



18MS - 275 35 6 1 1 1 1 -

18MS – Microsteam Power System

Nominal Rating (kWe)

Blade Height (mm)
(30 – 50)

Voltage

- 5 – 208-3-60
- 6 – 460-3-60
- 9 – 380-3-50

Temperature Rating

- 1 – Standard (400 F)
- 2 – High Temperature (500 F)

Special

- – No Special Orders
- S – Special Order

Instrumentation

- 1 – Standard
- 2 – Additional

Skid Design

- 1 – Standard Packaging
(Generator/Oil System on One Skid)
- 2 – Complete Package
(Generator/Oil System/
Control Panel/Breaker Panel)

Outlet Separator

- 1 – No Outlet Separator
- 2 – 8 inch 150 lb
- 3 – 8 inch 300 lb
- 4 – 6 inch 150 lb
- 5 – 6 inch 300 lb

State of California
Air Resources Board
DG-017 Certification
for Zero-Emission Technology

Physical data



STANDARD 3-PIECE MICROSTEAM® POWER SYSTEM

ITEM	LENGTH in. (mm)	WIDTH in. (mm)	HEIGHT in. (mm)	WEIGHT lb (kg)
Turbine Package	45 (1131)	34 (864)	78 (1981)	5200 (2363)
Control Panel	24 (607)	18 (457)	72 (1829)	350 (159)
Breaker Panel	28 (711)	18 (457)	72 (1829)	800 (364)

OPTIONAL SINGLE-SKID MICROSTEAM POWER SYSTEM

ITEM	LENGTH in. (mm)	WIDTH in. (mm)	HEIGHT in. (mm)	WEIGHT lb (kg)
Turbine Package (Includes Control Panel and Breaker Panel)	112.5 (2858)	46 (1168)	85 (2159)	7300 (3318)

CONNECTION SIZES

ITEM	SIZE (in.)
Steam Inlet	4 – 300 lb
Steam Outlet	6 – 300 lb
Trip Valve	3 – 300 lb
Control Valve	3 – 300 lb
Cooling Water Inlet	¾ NPT
Cooling Water Outlet	¾ NPT
Seal Air Inlet	3/8 NPT
Case Drain	½ NPT

SKID MOUNTED FACTORY-SUPPLIED ITEMS

Generator
Gearbox
Steam Turbine
Lube Oil System with all Required Instrumentation

FACTORY-SUPPLIED ITEMS SHIPPED LOOSE

Inlet Steam Separator (with Level Switch)
Steam Trap and Isolation Valve
Steam Inlet Pressure Gage
Steam Outlet Pressure Gage
Control and Trip Valves (3-in., 300 lb)
Vacuum Breaker
Steam Inlet RTD (Resistance Temperature Detector) Temperature Sensor
Steam Outlet RTD Temperature Sensor
Pressure Transmitter
Level Switch

→ Options and accessories

ITEM	OPTION*	ACCESSORY†
250 psig, 500 F, Inlet Steam Pressure and Temperature, Upgraded System and Components	X	
Complete Packaging (Generator, Lube Oil System, Control Panel and Breaker Panel on Single Skid)	X	
Additional Instrumentation (inlet flow conditioner/meter, inlet RTD and PT, outlet PT)	X	
Special Options††	X	
208-3-60 Output Voltage		X
6 or 8-in. 150 lb Outlet Separator**		X
6 or 8-in. 300 lb Outlet Separator**		X
Pneumatic Air Compressor (7 SCFM)		X

LEGEND

PT — Pressure Transducer
 RTD — Resistance Temperature Detector
 SCFM — Standard Cubic Feet per Minute

*Factory Installed.

†Field Installed.

** If the customer does not select an accessory outlet separator, a field-supplied outlet separator must be purchased and installed. The turbine system will not operate without an outlet separator.

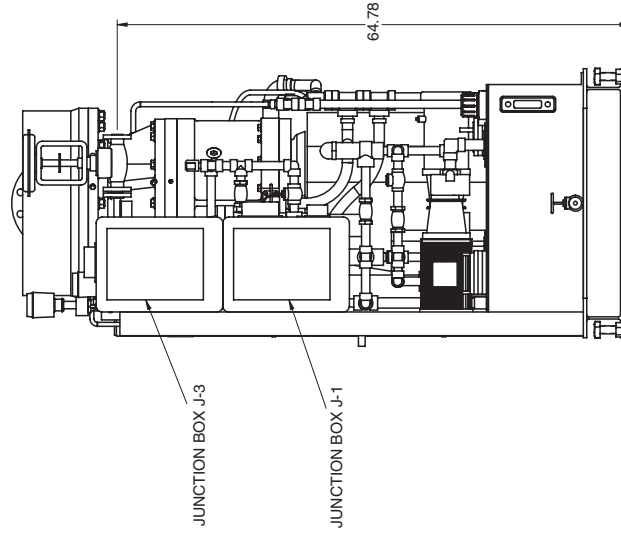
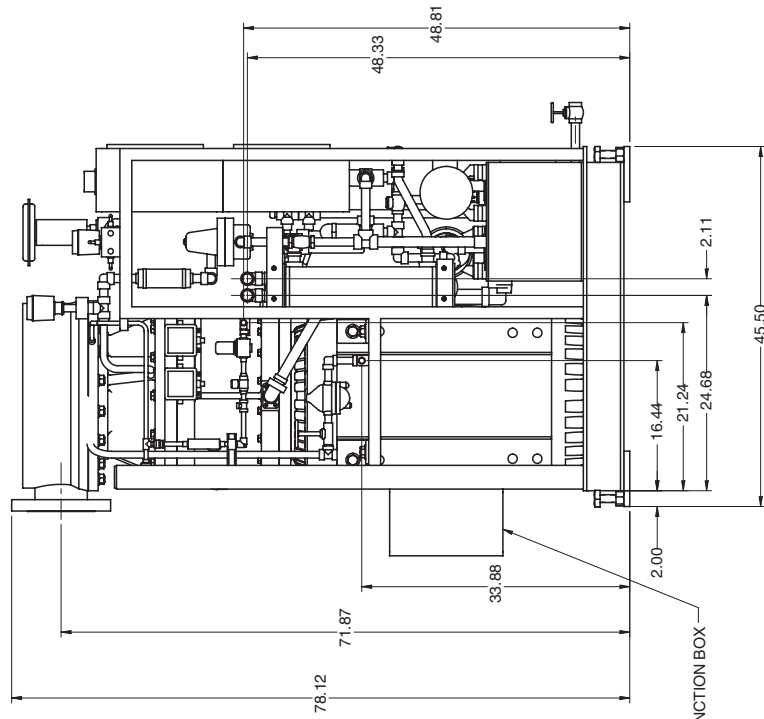
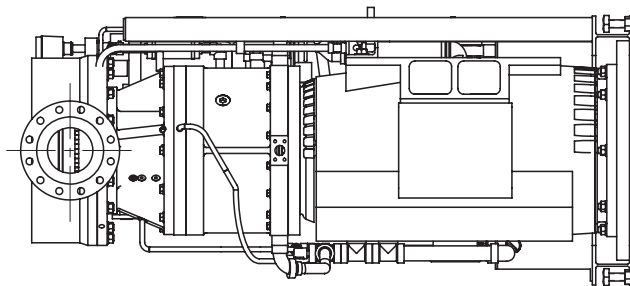
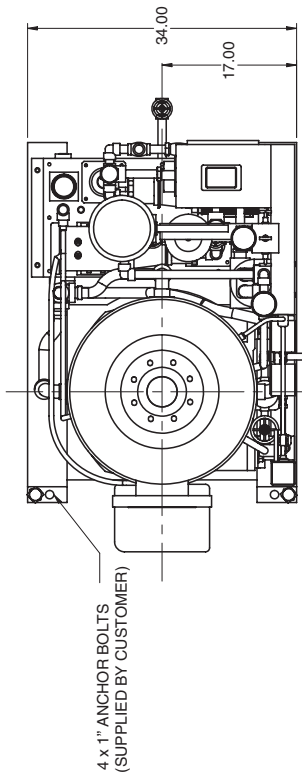
†† Contact application engineering for any special application options or needs.

Dimensions



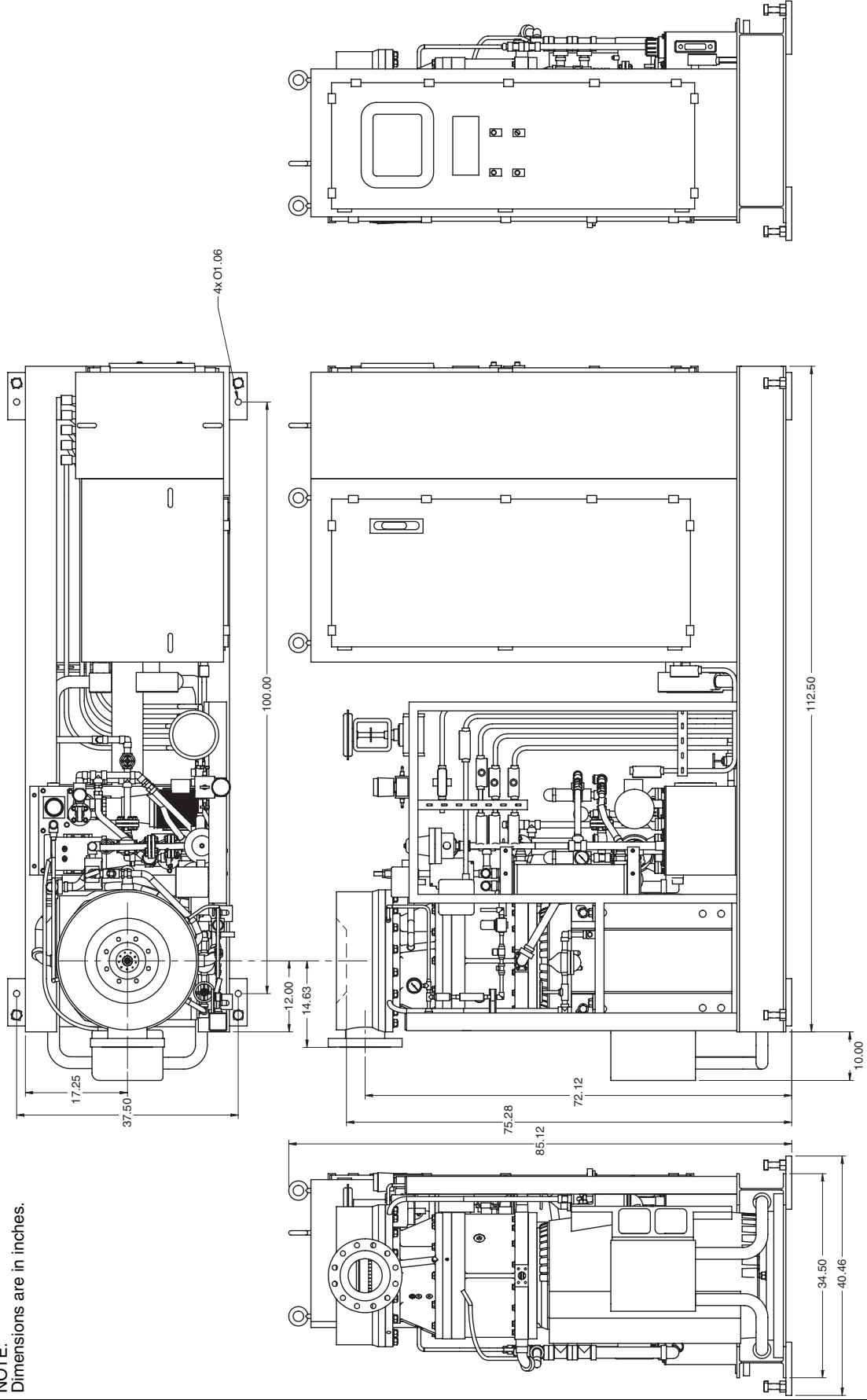
STANDARD MICROSTEAM® POWER SYSTEM (Control and Breaker Panels Separate)

NOTE:
Dimensions are in inches.

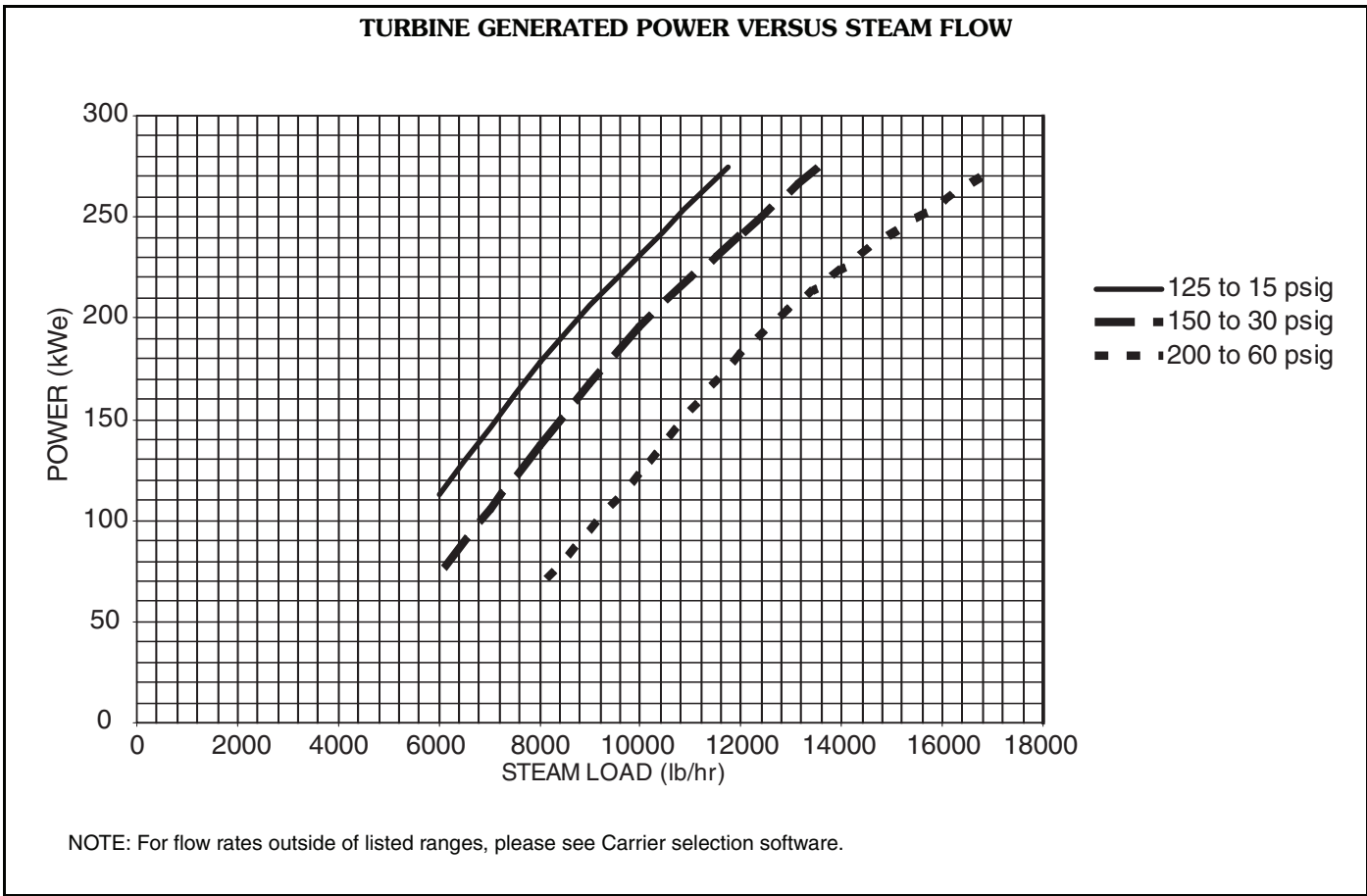


SINGLE SKID MICROSTEAM® POWER SYSTEM WITH CONTROL AND BREAKER PANELS

NOTE:
Dimensions are in inches.



Performance data



TURBINE PERFORMANCE

INLET STEAM PRESSURE (PSIG)	INLET STEAM TEMPERATURE (F)	SUPERHEAT (F)	EXHAUST STEAM PRESSURE					
			15 psig		30 psig		60 psig	
			Steam Required (lb/hr)	kWe Generated	Steam Required (lb/hr)	kWe Generated	Steam Required (lb/hr)	kWe Generated
125	353.2	0.0	12,828	275	13,502	241	13,972	118
	400.0	46.8	11,021	275	13,063	249	13,550	122
	450.0	96.8	10,294	275	12,587	257	13,091	126
	500.0	146.8	9,608	275	12,108	265	12,626	130
150	366.3	0.0	11,150	275	13,532	275	16,212	154
	400.0	33.7	10,661	275	12,942	275	15,856	193
	450.0	83.7	9,967	275	12,106	275	15,319	199
	500.0	133.7	9,312	275	11,315	275	14,773	206
200	387.9	0.0	10,779	275	12,041	275	16,759	275
	400.0	12.1	10,618	275	11,866	275	16,502	275
	450.0	62.1	9,973	275	11,166	275	15,470	275
	500.0	112.1	9,364	275	10,506	275	14,490	275

NOTE: Super-heated steam has a temperature higher than the evaporating temperature at a given pressure. For example, steam at 100 psig has a evaporating or saturation temperature of 337.9 F (170 C). A superheat of 50° F (27.8° C) means that the steam temperature is 50° F (27.8° C) above the saturation temperature or 337.9 + 50 = 387.9 F (197.8° C).

Electrical data



→ GENERATOR ELECTRICAL DATA

UNIT VOLTAGE V-Ph-Hz	GENERATOR OUTPUT (kWe)	GENERATOR ROTATION SPEED (RPM)	FLA
208-3-60	150	3575	475
	200	3575	634
	250	3575	792
	275	3575	871
480-3-60	150	3575	206
	200	3575	275
	250	3575	343
	275	3575	378

→ PUMP ELECTRIC DATA - PRIMARY OIL PUMP

PUMP SIZE	PUMP RPM	PUMP VOLTAGE (V-Ph-Hz)	FLA
1 HP (0.75 kW)	3575	230-3-60	2.9

PUMP ELECTRIC DATA - AUXILIARY OIL PUMP

PUMP SIZE	PUMP RPM	PUMP VOLTAGE
0.5 HP (0.37 kW)	3575	24 VDC

Microprocessor controls

Microprocessor controls provide safety, interlock and indications necessary to operate the Microsteam® power system in a safe and efficient manner.

Control system

The microprocessor control on each Microsteam power system is factory supplied (shipped loose or mounted and wired in the skid as an option) and tested to ensure machine protection and efficient operation. The control consists of a NEMA type 12 panel and includes a programmable logic controller (PLC).

Control system screens

AC output screen

- kilowatts
- power factor
- volts
- amps
- hertz
- bus volts

Analog I/O summary no. 1 screen

- steam inlet pressure
- steam outlet pressure
- steam inlet temperature
- steam outlet temperature
- steam valve position
- steam flow
- control system voltage

Analog I/O summary no. 2 screen

- steam inlet pressure (after control valve)
- lube oil pressure
- lube oil temperature
- high speed bearing temperature
- turbine casing temperature
- speed signal SE-1
- speed signal SE-2

Analog I/O summary no. 3 screen

- turbine wheel outlet pressure
- turbine nozzle inlet pressure
- turbine wheel differential pressure
- lube oil "out" temperature
- turbine wheel DP control valve position
- steam separator inlet pressure
- turbine radial vibration
- lube oil flow

Trend screen groups

Provide real time trending group screens.

Turbine performance trend screen

- steam inlet pressure
- steam inlet temperature
- steam valve position

- steam outlet pressure
- steam outlet temperature

AC output trend screen

- generator kilowatts (kWe)
- generator volts
- generator volt-amps (VA)
- generator amps (current)
- bus voltage

Flow, vibration and speed trend screen

- turbine steam flow
- velocity vibration
- radial vibration
- turbine speed signal SE-1
- turbine speed signal SE-2

Gearbox and casing trend screen

- steam turbine inlet pressure
- steam turbine casing pressure
- steam turbine casing (inlet nozzle)
- gearbox lube oil temperature
- gearbox lube oil flow
- radial vibration

Miscellaneous trend screen

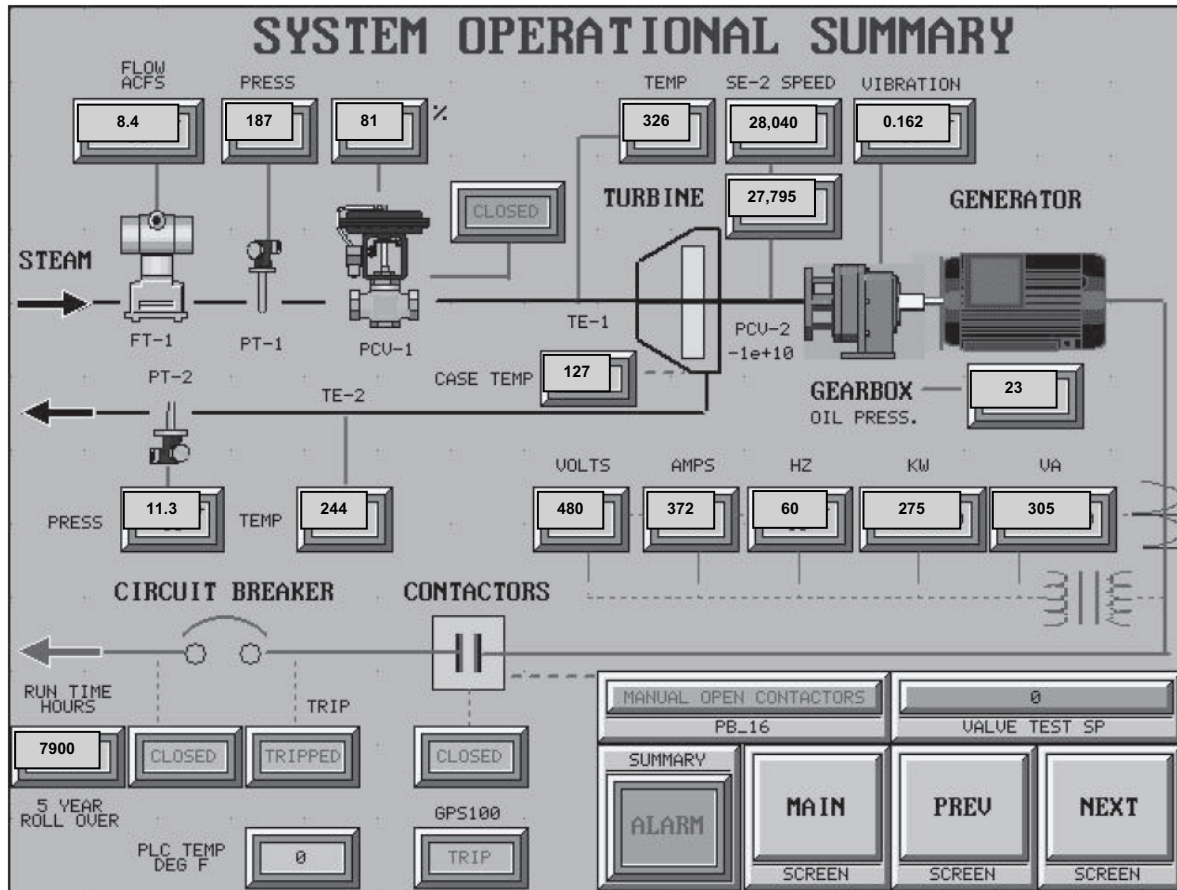
- casing temperature
- high speed bearing temperature
- generator kilowatts

Speed and pressure start-up trend screen

Safety cutouts

- steam inlet pressure high – high trip
- steam inlet pressure high alarm
- steam outlet pressure high – high trip
- steam outlet pressure low alarm
- steam inlet temperature high alarm
- steam outlet temperature low alarm
- steam inlet pressure low alarm
- steam outlet pressure low alarm
- steam inlet temperature low alarm
- steam turbine overspeed
- vibration high radial trip
- steam outlet pressure switch trip
- low power trip
- trip valve problem
- AC lube oil pump on – off (status only)
- DC lube oil pump on – off
- lube oil pressure low – low trip
- lube oil pressure high –high trip
- lube oil temperature high – high trip
- high speed bearing over temperature trip
- turbine casing over temperature trip
- DC lube oil contactor failure
- oil reservoir low alarm

SYSTEM OPERATIONAL SUMMARY DISPLAY SCREEN



The control panel of the Microsteam® power system has simple start-stop button sequences.

During the start-up, after pushing the start button (considering all requirements to start the machine have been satisfied and the machine is "ready to start"), the control panel will be in charge of opening the trip and control valves, putting the turbine up to the nominal speed and closing the contacts of the breaker panel. No action is needed from the user.

After achieving the nominal speed and closing the contacts in the breaker panel, the customer's electrical grid will supply a small amount of kW's (approximately 10 to 15 kW) to prime the generator so it can start supplying energy back to the customer's installation.

The screen above shows the different parameters the user can have access to during the normal operation of the machine. The following can be accessed from the screen:

INPUTS

- kW's
- voltage
- current

STEAM INFORMATION

- inlet pressure
- inlet temperature
- inlet flow
- exhaust pressure
- exhaust temperature

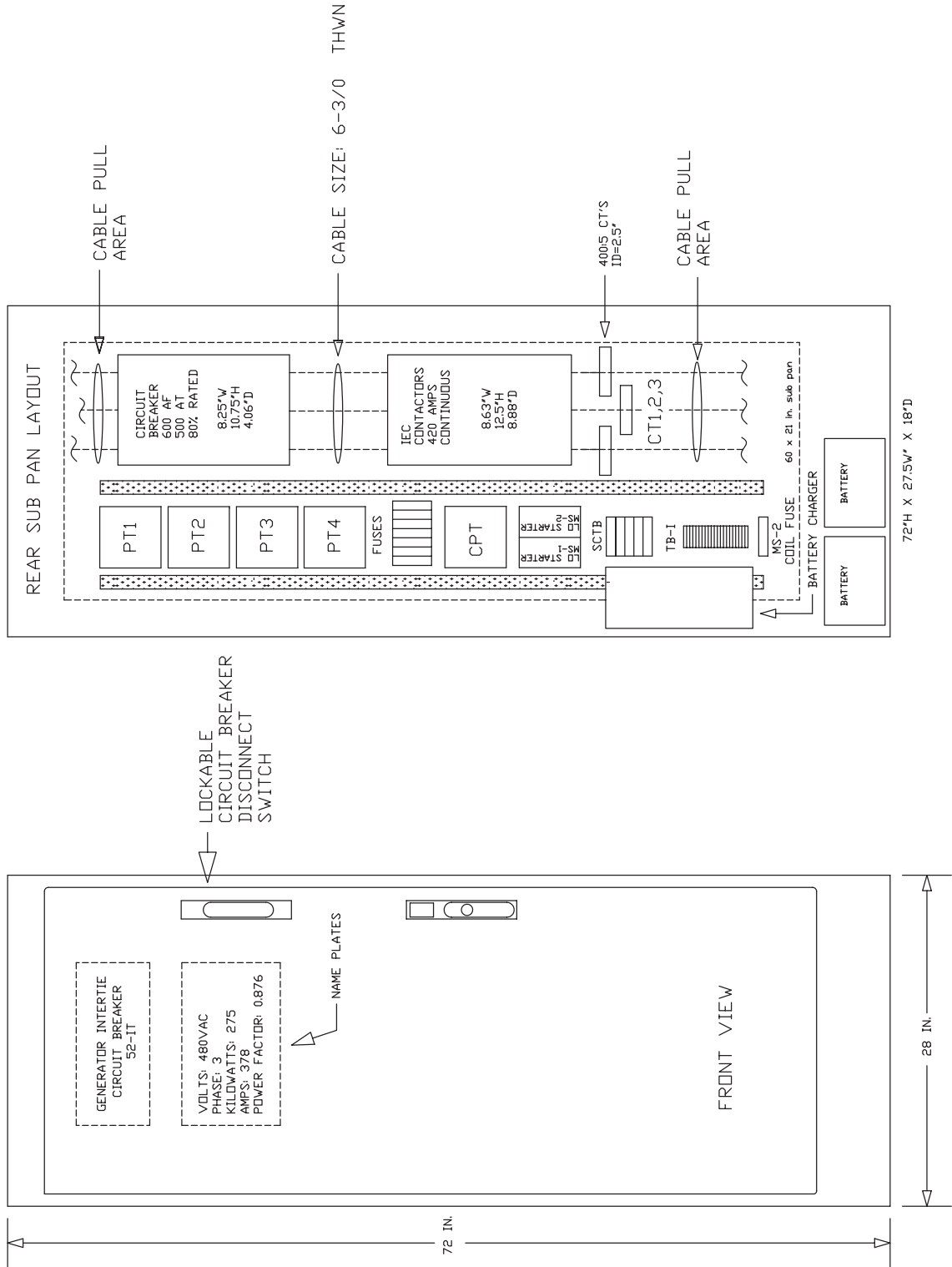
ADDITIONAL MONITORING INFORMATION

- vibration
- temperatures
- pressures

The stop sequence will also be fully automatic. After pushing the stop button, the control panel will disengage the breaker, close the control and trip valves and keep the oil pump running to cool down the internal components.

For more detailed information on the control panel operation, please refer to the control panel manual.

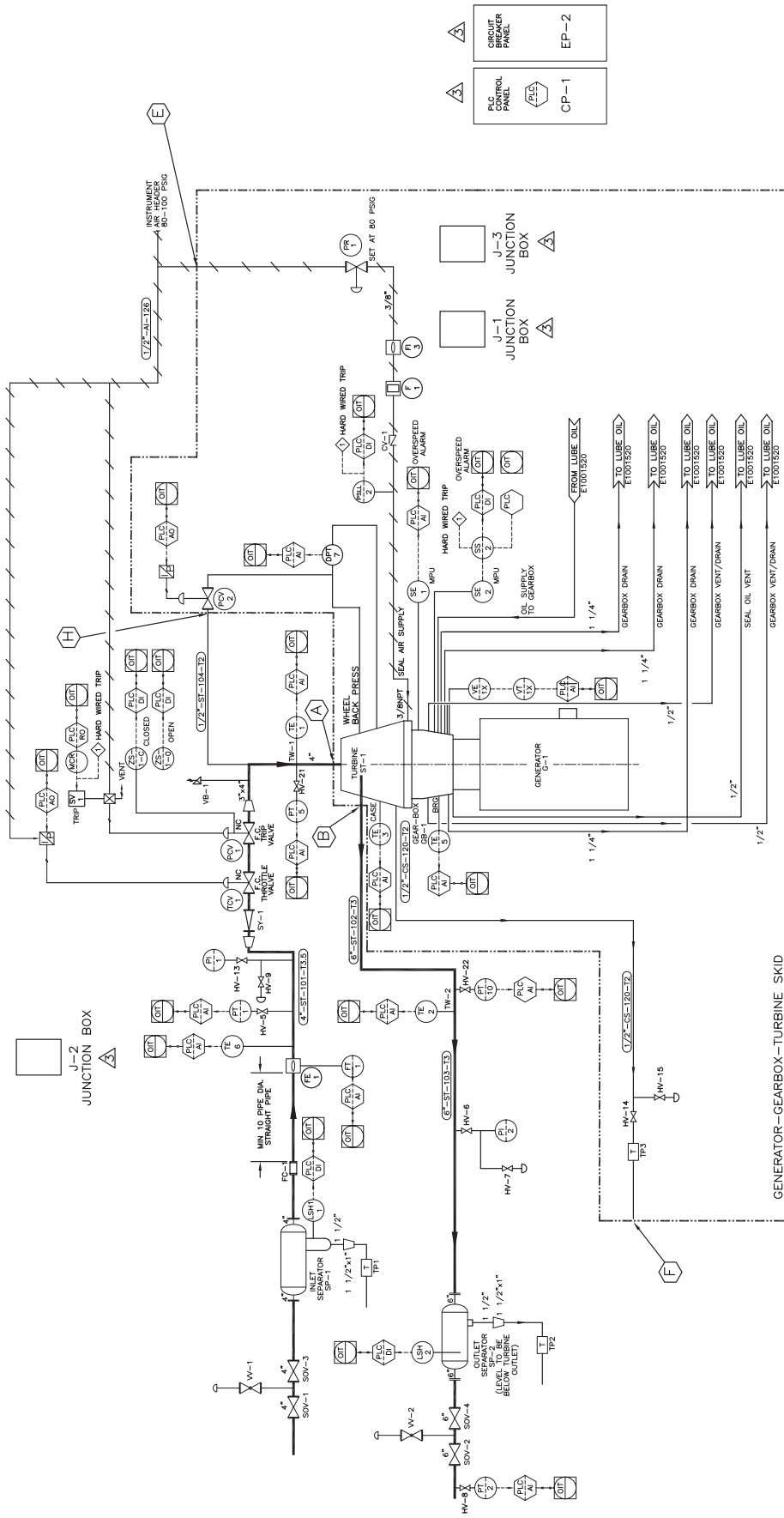
CONTROL PANEL WIRING DIAGRAM



Typical piping and wiring



TYPICAL PRESSURE AND INSTRUMENTATION DIAGRAM



1. LUBE OIL SYSTEM IS SUPPLIED FULLY ASSEMBLED AND CONNECTED (WITH GENERATOR-TURBINE SKID). SEE SKID ASSEMBLY DWG E1001523 OR E1001555 FOR SINGLE SKID OPTION
 2. FOR SKID CONNECTING POINTS, COMPONENTS SUPPLIED BY CARRIER AND GENERAL ARRANGEMENT/INSTALLATION NOTES SEE MICROTEAM TURBINE SYSTEM DRAWING E1001540 OR E1001556 FOR SINGLE SKID OPTION
- NOTE: OUTLET SEPARATOR SP-2, SAFETY VALVES SV-1, SV-2, SV-3, SV-4 AND VENT VALVES WV-1, WV-2 ARE NOT SUPPLIED BY CARRIER (CUSTOMER TO SUPPLY)

FOR SINGLE SKID OPTION, CONTROL AND BREAKER-CONTACTOR PANEL ARE MOUNTED ON THE TURBINE SKID AND JUNCTION BOXES J-1, J-2 AND J-3 ARE NOT REQUIRED

Application data



Unit preparation

To ensure proper operation of the unit, the following installation and start-up guidelines must be followed.

It should be determined prior to installation if any special arrangement must be made to meet the requirements below. Prior to proceeding with the installation, a Carrier service team must be contacted in case there is any doubt or uncertainty.

Installation requirements

The following are requirements for installation of the Microsteam® power system in a facility having an existing PRV station and new or existing steam load. The requirements are to be met and certified by Carrier prior to start-up.

1. A cement pad or floor is required that can support 5200 lb weight (520 lb per sq ft), not considering control and breaker panels. For the single skid option, the total weight is 7200 lb.
2. A steam piping design is required to minimize loads on turbine flanges. The sum of forces and moments must be less than 1000 ft/lb. The piping diameter depends on the steam conditions.
3. Verify correct installation of all components shown in the Installation Instructions. The inlet piping leg must be no more than 3 ft from the control valve. The inlet piping leg must be manually and chemically cleaned and free of weld slag prior to installation. The inlet strainer must be installed immediately upstream of trip valve.
4. Steam traps should be installed at all low points of piping system.
5. A trip valve must be installed very close to the Microsteam power system (2 to 3 feet is the ideal distance) so whenever a trip occurs, the turbine shuts down immediately. Having the trip valve far from the turbine will enable the turbine to operate after a trip command is issued and this can be dangerous.
6. Steam trap condensate lines must be run separately to the flash tank with a steam vent. The flash tank must be piped to the condensate tank.
7. An exhaust separator suitable for 10 micron droplets must be provided. The exhaust separator is installed below turbine exhaust port with a 5-degree minimum slope away from the turbine.
8. The seal air supply is to be piped separately from compressed air header with a minimum of 3/8-in. tubing. The tubing must be dry air only. Water removal to be verified before start-up.
9. Loop check all of the installation wiring before start-up. Perform a rotation verification of the generator with multimeter.
10. Leak test all piping before start-up.
11. A steam blow of high pressure steam piping before start-up is required. There is a minimum of 1 hour at dynamic head twice maximum during operation. Blow until 50 mesh start-up screen has zero particles.
12. A calibration of the protective relay by independent test company before start-up must be completed.
13. Utility company approval of interconnection before start-up is also required.

Start-up requirements

1. Final loop check.
2. Check start-up sequence and permissives.
3. Adjust pressure control PID and power clamp PID for system response.
4. Adjust thrust balance valve setting for to maintain pressure difference less than 40 inches.
5. Troubleshoot anomalies.
6. Verify performance.
7. Verify stable operation and trips.

Condensate generation

About 4 pounds per hour of steam (i.e., water) are consumed for every kWe generated. This will be slightly less for superheated steam. Steam traps (separators) must be installed before and after the turbine. The inlet separator is used to prevent water and solid particles from entering the turbine, especially if the turbine has been idle for some time. The outlet separator collects the 4 pounds of condensate per hour that the turbine generates. The inlet separator can also help collect particulate matter before it enters the turbine, which can be harmful to wheel operation.

Electrical installation

1. Make sure utility approval of interconnection is granted prior to start-up.
2. All electrical installation must be executed and approved by a certified company. Carrier is responsible for the Microsteam power system, but can not be responsible for the electrical installation the customer chooses.
3. An 86G lockout relay is a safety feature and is required in the U.S.A. and many other countries. The lockout relay is triggered by any one of several other relays that would trip the generator and cause an alarm. The relay prevents restarts of the unit without a MANUAL reset. This means that any system that has a lockout relay cannot be automatically or remotely restarted and in fact cannot be restarted until an authorized person who is physically located at the generator hits the reset button. The person would look over the unit and determine what caused the trip in the first place before trying to restart. This relay is used to prevent control schemes where an automatic or remote system continually restarts the unit in a situation that is unsafe or where repetitive cycling can damage equipment.

Guide specifications



Microsteam® Power System

Size Range:

Up to 275 kWe

Carrier Model Number:

18MS

Part 1 — General

1.01 SYSTEM DESCRIPTION

- A. Microprocessor-controlled steam turbine power system skid shall be packaged for installation through standard (34-in. width x 78-in. height) door.
- B. System shall have start-up and shutdown with single push button activation and allow for unattended operation with automatic safety trips.
- C. System shall have power production of 24.5 kWe per 1000 lb/hr of steam at a supply pressure of 125 psig and load pressure of 15 psig (steam conditions of 125/15), including control valve loss.
- D. Noise level shall be less than 85 dBA at 1 meter.
- E. Turbine shall have erosion-resistant radial outflow design with corrosion resistant titanium alloy rotor and stainless steel nozzles.
- F. System shall have hard-wired, separate, fail safe trip valve.
- G. System shall have zero steam leakage dual seal with pressurized air buffer.
- H. A separable control console shall have quick disconnect pre-wired cables.
 - I. System shall have utility approved interconnection design and digital multifunction protective relay.

1.02 PROPOSAL REQUIREMENTS

- A. If a manufacturer proposes a steam power system which requires disassembly and reassembly or site assembly for installation, then the additional cost shall be included by the installing contractor.
- B. If a manufacturer proposes a steam power system which requires operator labor during start-up or shutdown or which requires operator attendance during operation, then the installing contractor shall provide this manpower at no additional cost to the owner.
- C. If a manufacturer proposes a steam power system with a noise level greater than 85 dBA, then the cost to provide acoustic treatment to reduce the noise level to 85 dBA shall be included by the installing contractor.
- D. If a manufacturer proposes a steam turbine with a rotor of ferrous alloy, then the cost of a new rotor or of re-blading shall be included in the offer together with the installation costs and the cost of lost electric generation.
- E. A hard wired, separate, fail safe trip valve shall be included in the offer.
- F. If a steam seal without buffer gas is offered, the manufacturer shall include in the proposal a sensor and alarm to alert personnel. This shall be located in

the room in which the steam power system is installed and warn of any steam leakage through the seal. This shall be provided by the installing contractor.

- G. If a manufacturer proposes a steam power system with the control console attached to the steam turbine skid, the labor hours to separate the console and wire the skid instruments to the separated console shall be included in the offer for evaluating purposes.

1.03 QUALITY ASSURANCE

- A. Steam turbine performance shall conform to ASME short form test PC 6.
- B. Equipment and installation shall be designed in compliance with the ASME Piping Code B31.3, ASME Boiler Code, Section 8, Div. 1 and NEMA SM23.
- C. Steam turbine casing shall be hydrostatically tested at 150% of the design working pressure.
- D. Steam power system electrical system components shall be designed and constructed to meet UL and UL of Canada requirements and have labels appropriately affixed.
- E. Steam turbine rotor shall be dynamically balanced and over-speed tested by the manufacturer at a minimum of 115% design operating speed.
- F. Each complete steam power system with controls and switchgear shall undergo a mechanical and electrical run-in test at the manufacturer's factory to verify vibration levels, oil pressures, and temperatures are within acceptable limits and that controls and interconnection contactors function successfully. Interconnection and parallel operation with a utility grid shall be demonstrated and documented before shipment.
- G. Each steam turbine assembly shall be proof tested at a minimum of 150% of the design working pressure.

1.04 DELIVERY, STORAGE AND HANDLING

- A. Unit shall be stored in a clean dry location and handled in accordance with manufacturer's instructions.
- B. Unit shall be shipped with all control wiring factory installed.
- C. Unit shall be shipped without oil.
- D. Unit shall be shipped with firmly attached labels that indicate name of manufacturer, system model number and system serial number.
- E. If the power system is to be exported, the unit shall be sufficiently protected at the factory against sea water corrosion to be suitable for shipment in a standard open top, ocean shipping container.

1.05 WARRANTY

Warranty shall include parts and labor for one year after start-up or 18 months from shipment, whichever occurs first.



Part 2 — Products

2.01 EQUIPMENT

A. General:

Factory assembled, complete power system shall consist of:

1. Microsteam power system, epicyclic gearbox, high-efficiency induction generator, lubrication system, and cooler shall be installed on one skid.
2. Microprocessor control system with digital multifunction protective relay shall be installed in console.
3. Electric switchgear shall be required for automatic interconnection.
4. Prewired interconnecting cables shall be used for the first three components or assembled on a common skid.
5. An inlet separator, trip valve, control valve, pressure balancing valve, and steam piping instrumentation shall be shipped loose.

B. Microsteam Turbine Skid:

1. Steam Turbine:

- a. Steam turbine shall be of the high performance, radial outflow type with a titanium alloy rotor and stainless steel nozzles.
- b. Steam turbine shall be installed in a casing which is removable for service without disengaging any rotating components.
- c. Steam turbine rotor shall have active thrust balancing.
- d. Steam turbine seal replacement may be performed with no realignment required.
- e. Steam turbine sensors shall have quick disconnects to allow replacement of the sensor without replacement of the entire sensor wire. Pressure transducers shall be capable of field calibration to ensure accurate readings and to avoid unnecessary transducer replacement. Transducers shall be serviceable without the need for purging.

2. Transmission:

- a. Transmission shall be single ratio, epicyclic type with parallel shaft speed decriaser.
 - b. Gears shall conform to AGMA Standards, Quality II or better.
 - c. Transmission bearings for the high speed shaft shall be tilting pad type with tapered land thrust bearings.
 - d. Planet bearings shall be deep groove ball bearings.
 - e. Transmission sun and planet gears shall be nitrided. Annulus shall be through hardened. All gears shall be high precision.
3. Two magnetic speed sensors and target shall be provided on high speed shaft.

4. Metrix vibration transducer or equal shall be provided on high speed bearing.

5. Induction Generator:

- a. Induction generator shall be a high-efficiency type with an efficiency no less than 95.4% at full load. Operation shall be in a vertical shaft position to minimize footprint.
- b. Generator shall be direct to transmission so that no field alignment is required.
- c. Generator casing shall be designed to support the full weight of the turbine and transmission for a vertical mounted configuration.

6. Lubrication System:

- a. Lubrication system shall have an electrical AC motor driven pump with an electrical DC motor driven backup pump.
- b. Lubrication system shall have a reservoir with a submerged filter, readily accessible fill and drain connections, a visual level indication and a low level switch.
- c. Lubrication system cooler shall be shell and tube construction with rolled tubes and water cooling. The unit shall be rated for the maximum water pressure of the utility water system.

C. Control System:

1. The control system shall control and protect the steam turbine generator. The control system shall be housed within a NEMA type 12 panel and shall include a programmable logic controller (PLC) based architecture. Additionally, manufacturer shall provide auxiliary PLC input-output modules as required to meet final element control and sensing devices.
2. The electrical and control system shall meet or exceed the utility industry electrical grid connection requirements for Dispersed Generation Customers as defined, as a minimum, by the Consolidated Edison Company of New York, specifications EO-2115 latest revision, IEEE 1547, and California rule 21.
3. An operator touch screen shall be provided. The touch screen shall be non-PC based (no hard-drives), 10-in. TFT (thin film transistor), bright, high-resolution with multiple color graphic screens for ease of use. Features shall include graphic “mimic bus” like system representative screens to simplify operator understanding of system operation. The operator screen shall provide features for operator setup and control of system. The provided touch screen displays shall include: all alarm, shutdown conditions, operating conditions, real time historical parameter trending of all analog parameters.
4. A programmable logic controller (PLC) shall be provided for start-up sequencing which consists of the PLC verifying all operating conditions are

in working order (interlocks complete) and, upon command, beginning the start-up sequence. An operator shall first turn on the primary gearbox lube oil pump. The operator then presses the start button on the touch screen and the turbine controls shall begin opening the steam valve. The control shall then bring the turbine up to rated speed, close the contactors, and switch to pressure control mode, at which time the turbine generator produces electrical energy based on the steam loads.

5. The PLC shall provide special features that include four ports for communication to multiple devices, the modem, the generator protection relay, the touch screen, and the customer's building management system. All ports shall be configurable to match the protection relay's communication protocol. Ports shall be built-in as an integral part of the main PLC assembly rack and not provided as a separate device module. Additionally, the PLC shall include PLC factory-designed functions for initializing modems, monitoring communication port status, and communicating with the specified generator protection relay using its approved communication protocol.
6. A SCADA quality modem shall be provided that is specifically designed for hostile conditions and for unattended remote applications. Modem shall include automatic reset supervisory processor built into the modem architecture to recover from system faults when they occur.
7. A utility approved, IEEE and IEC certified, multifunction, configurable, generator protection relay with the following functions shall be provided:
 - a. The multifunction generator protection relay shall provide electrical protection for the system relative to the customers load and the utility grid.
 - b. The relay shall be hardwired to trip the turbine, the contactors, and the circuit breaker when electrical faults occur.
 - c. The relay shall also be connected to the PLC, using utilizing utility approved data highway communications protocol, so that all electrical parameters required to operate the system will be available for control within the PLC and to display power parameters on the operator screen.
 - d. The relay shall provide breaker trip coil circuit monitoring and alarming if an open circuit condition should occur. The relay shall be fully integrated in the system utilizing relay class current transformers, voltage transformers, and relay test blocks that satisfy utility relay testing requirements.

e. Protective configuration shall include:

- 1) Over under frequency.
- 2) Over under voltage.
- 3) Time over current.
- 4) Instantaneous over current.
- 5) Negative sequence over voltage.
- 6) Negative sequence over current.
- 7) Fuse loss detection.

f. Connection to a utility grid and operating in parallel with the utility power grid shall require the generator protection system to trip under all fault conditions. Therefore, the control system shall base all of its control architecture on a DC voltage battery based operating system. The PLC shall be used to monitor the system control voltage and if the system control voltage decreases below the specified minimum operational level the PLC shall trip open the contactors and shut the unit down.

g. Hardwired protective circuits shall be provided to trip unit when exceeding critical limits of over-speed, high steam pressure, low seal air pressure, emergency stop circuits, PLC failure, and generator electrical faults. An 86G lockout relay shall be incorporated as specified by utility specifications. The generator protection relay shall directly trip the circuit breaker by energizing the breaker shunt trip. All other trips, such as turbine related conditions, shall open the contactors. The PLC logic shall be provided to trip the circuit breaker if the contactors fail to open when commanded as a backup to the contactors.

h. An 86G lockout relay shall trip the circuit breaker and or the contactors as signaled by either the generator protection relay or the PLC. Tripping the 86G relay shall open the contactors. Relay must then be reset, through the operator screen, before reclosing the contactors.

D. Control System Screens:

1. System Operational Summary Screen:

This graphic screen display shall provide a simplified flow diagram of the system. It shall include primary pressures, temperatures, vibration, speeds, flows, generator power, circuit breaker position, and contactor position. It is to present a summary of system operational status in mimic bus graphical form.

2. Operator Push Button Summary Screen:

This screen shall provide the means to perform system setup, reset alarms, reset the 86G relay, and other discrete operator selections incorporated on one summary screen. Additionally, this screen shall display some basic system status conditions, as outlined below. Some push buttons on this screen are to be assigned engineers

only and are not to be used for normal operations. These push buttons shall be password protected.

- a. Turbine on – off.
- b. 86G Relay tripped: Shall indicate when an electrical fault has occurred and must be reset before starting the turbine generator.
- c. Contactors open – closed.
- d. Breaker open – closed.
- e. System tripped: Shall display a summary reminder that there has been a trip due to an unsafe condition. The user must review all alarm and trip conditions, resolve cause, and then use alarm reset before restart of turbine.
- f. Manually closes contactors: Shall be used only for test by engineers only. Shall be password protected.
- g. Data log sample: After each push of this button, data logger shall record one sample of all data in addition to the automatic timed recording as determined by the data log seconds set point.
- h. Data log seconds (set point): Shall be used to set how often data logger samples and records data.
- i. Trip valve closed – open.
- j. Alarm summary.
- k. Start sequence reset: This shall be used, however rarely, if start sequence fails to follow steps 1 to 7 on start-stop sequence screen.
- l. Alarm acknowledge: Shall silence a remote optional alarm if installed.
- m. MCR reset: Shall be used to reset the master control relay (MCR). This relay shall be tripped on all turbine system faults and any hardwired trip conditions.
- n. Alarm reset: Shall be used to reset all alarm (yellow alarms) and trip (red alarms) conditions.
- o. 86G relay reset: Shall be used to reset generator lockout relay “86G” after an electrical fault occurs.
- p. Fixed ramp mode – speed ramp mode: Shall be used by engineers only and shall be password protected.
- q. Valve exercise: Shall be used to exercise the steam control valve to check that it is not sticking.
- r. Start: Shall be the turbine generator start button.
- s. Stop: Shall be the turbine generator stop button.

- t. System set point summary: Shall be used for tuning by engineers only and shall be password protected.
 - u. Simulation mode: Shall be used for software program control loop testing by engineers only and shall be password protected.
 - v. kW load limit mode on – off: Shall provide choice of start-up mode by engineers only. Shall be password protected.
3. Turbine Steam Pressure Control Screen:
This screen shall be provided to provide features to switch to manual mode for testing.
 4. Turbine Wheel Differential Pressure Control Screen:
This screen shall be provided to observe normal operational characteristics of the turbine wheel differential pressure control loop. Normal operation is in auto mode. Shall be password protected.
 5. Turbine Speed Control Screen:
This screen shall be provided to observe speed control loop characteristics when starting in speed control mode. Switching to manual mode shall be password protected and is for engineering use only.
 6. Turbine Alarm Screen:
Alarm screen shall be provided. Red alarms are shutdowns. Yellow alarms are warnings only. The MCR and alarm reset push button shall also be included. Alarms on this screen shall be as follows:
 - a. Steam inlet pressure high – high trip
 - b. Steam inlet pressure high alarm
 - c. Steam outlet pressure high – high trip
 - d. Steam outlet pressure low alarm
 - e. Steam inlet temperature high alarm
 - f. Steam outlet temperature low alarm
 - g. Steam inlet pressure low alarm
 - h. Steam outlet pressure low alarm
 - i. Steam inlet temperature low alarm
 - j. Steam turbine overspeed
 - k. Vibration high radial trip
 - l. Steam outlet pressure switch trip
 - m. Low power trip
 - n. Trip valve problem.
 7. System Alarms No. 1 Screen:
Alarm screen shall be provided. Red alarms are shutdowns. Yellow alarms are warnings only. The MCR and alarm reset push button shall also be included. Alarms on this screen shall be as follows:
 - a. Circuit breaker thermal trip
 - b. GPS (generator power system) major alarm trip

- c. 86G relay tripped
 - d. MCR (master control relay) trip
 - e. Control under voltage trip
 - f. Generator protective relay alarm
 - g. Battery charger alarm
 - h. Turbine wheel DP high alarm
 - i. PLC fault trip
 - j. PLC battery low alarm
 - k. PLC over temperature alarm remote trip
 - l. Start sequence failure trip
 - m. Start-up interlock incomplete
 - n. Speed signal failure trip
 - o. E-stop (emergency stop push button)
8. System Alarms No. 2 Screen:
- Analog input failure trips in this group shall be critical loops that are used to protect and control the turbine generator system. When an open wire or transmitter failure occurs the loss of the signal will cause the turbine generator to trip and shut down.
- Red alarms are shutdowns. Yellow alarms are warnings only. The MCR and alarm reset push button shall also be included. Alarms on this screen shall be as follows:
- a. Contactors failed to close trip
 - b. Contactors failed to open trip
 - c. Seal air pressure low – low trip
 - d. Seal air pressure low alarm
 - e. Steam separator level high – high trip
 - f. PT-1 analog input failure
 - g. PT-2 analog input failure trip
 - h. PT-3 analog input failure
 - i. VT-1 analog input failure
 - j. VT-1X analog input failure
 - k. SE-2 analog input failure
 - l. Data log error
9. Gearbox and Lube Oil Alarms Screen:
- Alarm screen shall be provided. Red alarms are shutdowns. Yellow alarms are warnings only. The MCR and alarm reset push button shall also be included.
- A DC lube oil pump test button to test and run the backup DC lube oil pump for a short period of time (20 minutes) shall be provided on this screen. Alarms on this screen are as follows:
- a. AC lube oil pump on – off (status only)
 - b. DC lube oil pump on – off
 - c. Lube oil pressure low – low trip (if on, a failure has occurred)
 - d. Lube oil pressure high –high trip
 - e. Lube oil temperature high – high trip
 - f. High speed bearing over temperature trip

- g. Turbine casing over temperature trip
 - h. DC lube oil contactor failure
 - i. Oil reservoir low alarm
10. Start – Stop Sequence Screen:
- This screen shall indicate; using the step – transition method of control, the start-up steps and start-up progress of the turbine generator.
- a. STEP 1: When operator presses the start button, if all interlocks are complete, PLC shall progress to next transition. PLC shall also save current system operating pressure for later use in step 5.
PLC shall wait for auxiliary lube oil pump running signal and pressure signal to be at a safe minimum.
 - b. STEP 2: PLC shall then energize the trip control solenoid, and set steam control valve to warm up position.
 - c. STEP 3: PLC shall set speed ramp starting value to around 500 rpm and ending value to around 28,000 rpm, and begin start ramp.
 - d. STEP 4: PLC shall close the contactors to switch control of pressure control valve PCV-1 switches from the speed control loop to the pressure control loop. The pressure control PID (proportional, integral, derivative) then takes control of pressure.
System is now running, controlling pressure at set point, limiting load based on kWe, and waiting to begin a normal shutdown sequence. An operator pressing the stop button shall initiate normal shutdown.
NOTE: If load decreases to less than 1 kWe, after a mature start-up sequence, and load continues to be below 1 kWe for an extended period of time (15 minutes) the unit shall shut down.
 - e. STEP 5: When operator initiates a stop command, PLC shall lower pressure control loop set point to below the PRV (pressure reducing valve) operating set point. The PLC PID shall begin pressure control let down. A time delay shall provide time for the pressure to decrease below the PRV set point and time for the PRV to take over control of the system.
 - f. STEP 6: When “pressure” control let down is complete, the PLC shall open contactors, switch to the speed control loop, and close the steam control valve.
 - g. STEP 7: The PLC shall deenergize the SV-1 trip solenoid.
11. PLC Digital I/O Summary Screen:
- This screen shall be provided to be used for loop testing digital inputs and output of PLC. This screen is normally not used by operators.

12. Operating Procedures Screen:

This screen shall provide help screens for start-up and shutdown operating procedures as outlined below.

- a. Perform all steam blow-down and steam line clean-out operations.
- b. Confirm all steam related manual valves are properly set.
- c. Manually open steam turbine inlet isolation valve.
- d. Gradually open steam turbine outlet isolation valve.
- e. Wait for back fed steam to warm up system.
- f. Check all disconnect switches are closed.
- g. Check generator circuit breaker – disconnect is on (closed).
- h. Check control power is on. Green breaker light will be on.
- i. Check instrument air and seal air is on.
- j. All PLC related start-up interlocks must be complete.
- k. Main circuit breaker disconnect reset and closed (normally closed).
- l. Emergency stop switch pulled out on front panel.
- m. All shutdown conditions reset.
- n. Any previous trip conditions and alarms are reset.
- o. No trip (red alarms blinking) conditions. Check all alarm screens.
- p. 86G relay reset.
- q. Check bus voltage is available.
- r. Turn on AC lube oil pump.
- s. Go to the ‘start – sequence’ screen and press start.
- t. The turbine will startup in the sequence that is outlined on the “start – sequence” screen.
- u. A normal stop is initiated by pressing “stop” on the screen.
- v. Pressing “stop” before step 4 (system running and waiting for shutdown) will cause an immediate stop.
- w. Pressing “stop” after the “system is running waiting for shutdown” will cause a normal timed shutdown.
- x. After the system completely shuts down, turn the AC lube oil pump off.

E. Analog Screens:

The analog screens shall provide screen groups with data available bar graph and digital format.

1. AC output screen:

Shall display the following:

- a. Kilowatts

- b. Power factor
- c. Volts
- d. Amps
- e. Hertz
- f. Bus Volts

2. Analog I/O Summary No. 1 Screen:

Shall display the following:

- a. Steam inlet pressure
- b. Steam outlet pressure
- c. Steam inlet temperature
- d. Steam outlet temperature
- e. Steam valve position
- f. Steam flow
- g. Control system voltage

3. Analog I/O Summary No. 2 screen:

Shall display the following:

- a. Steam inlet pressure (after control valve)
- b. Lube oil pressure
- c. Lube oil temperature
- d. High speed bearing temperature
- e. Turbine casing temperature
- f. Speed signal SE-1
- g. Speed signal SE-2

4. Analog I/O Summary No. 3 Screen:

- a. Turbine wheel outlet pressure
- b. Turbine nozzle inlet pressure
- c. Turbine wheel differential pressure
- d. Lube oil “out” temperature
- e. Turbine wheel DP control valve position
- f. Steam separator inlet pressure
- g. Turbine radial vibration
- h. Lube oil flow

F. Trend Screen Groups:

Trend screen groups shall provide real time trending screens groups as follows:

1. Turbine Performance Trend Screen:

Shall display the following:

- a. Steam inlet pressure
- b. Steam inlet temperature
- c. Steam valve position
- d. Steam outlet pressure
- e. Steam outlet temperature

2. AC Output Trend Screen:

Shall display the following:

- a. Generator kilowatts (kW)
- b. Generator volts
- c. Generator volt-amps (VA)
- d. Generator amps (current)
- e. Bus voltage

Guide specifications (cont)



3. Flow, Vibration, and Speed Trend Screen:

Shall display the following:

- a. Turbine steam flow
- b. Velocity vibration
- c. Radial vibration
- d. Turbine speed signal SE-1
- e. Turbine speed signal SE-2

4. Gearbox and Casing Trend Screen:

Shall display the following:

- a. Steam turbine inlet pressure
- b. Steam turbine casing pressure
- c. Steam turbine casing (inlet nozzle and wheel outlet)
- d. Gearbox lube oil temperature
- e. Gearbox lube oil flow
- f. Radial vibration

5. Miscellaneous trend screen:

Shall display the following:

- a. Casing temperature
- b. High speed bearing temperature
- c. Generator kilowatts

6. Speed and Pressure Start-Up Trend Screen:

This screen shall be designed to display the start-up sequence progress. Trend characteristics follow a typical pattern and indicate start-up profile both during start ramps and pressure control mode. Trends included on this screen are to be duplicated on other screens, however, not with this same combination. These trends shall indicate how the PID controls loops are performing.

- a. Steam pressure PID set point
- b. Speed PID set point in percent
- c. Steam valve PID algorithm summing point
- d. Pressure PID input
- e. Speed control PID output in percent
- f. Speed PID input

G. Switchgear Panel:

1. The switchgear must be part of the manufacturers' scope of supply.
2. The generator circuit breaker and main contactors shall be housed within a NEMA type 12, floor standing panel, 28 inches wide, 18 inches deep, 72 inches high, with lockable disconnect handle connected to the circuit breaker within.
3. The circuit breaker shall be a 600 amp frame, 500 amp trip, 80% rated breaker. The circuit breaker shall be a thermal-magnetic type with integrated DC shunt trip. Trip clearing time shall be equal to or less than 18 milliseconds (1.2 cycles). The breaker shall be installed within the enclosure and integrated with a lockable disconnect switch located on the outside of

the enclosure. Auxiliary position contacts and bell alarm contacts shall be included to provide the PLC with position and trip information. The circuit breaker shall operate as a redundant overcurrent device to the generator protection relay and the contactors.

4. The contactors shall be IEC rated for 420 amp continuously duty.
5. Metering and relaying class current and voltage transformers shall be provided for sensing the signal to the generator protection relay.

H. Interconnecting Cables:

Pre-wired interconnecting cables shall be provided for all instrument and auxiliary power wiring between the turbine skid, control console and switchgear panel. The cables shall be of the quick disconnect type. The cables shall be loop checked and used to test and operate the power system before shipping.

I. Other Steam System Components:

Installation of loose steam equipment, additional piping, insulation, wiring of loose instruments, conduit, interconnection electrical wiring, steam traps, condensate piping ductwork, and coordination with other trades shall be the responsibility of the mechanical contractor.

1. An inlet separator shall be provided. The separator shall be rated for the steam supply pressure and temperature. Separation efficiency shall be 99.9% or greater. A steam trap rated for the maximum steam supply pressure shall be provided.
2. An inlet trip valve shall be provided. The valve shall be rated for the steam supply pressure and temperature. The trip valve will be air actuated normally closed with a closing time less than 0.5 seconds.
3. An inlet control valve shall be provided. The valve shall be rated for the steam supply pressure and temperature. The control valve shall be air actuated and normally closed with a closing time less than 1 second.
4. A pressure transmitter to measure the steam load pressure shall be provided. The pressure transmitter shall be utility grade, manufactured by E&H or equal. The pressure transmitter shall be capable of field calibration to ensure accurate readings and to avoid unnecessary transducer replacement. Transducers shall be serviceable without the need for purging. Signal shall be 4 to 20 mA.
5. An air actuated control valve to balance the pressure across the steam turbine rotor shall be supplied. High pressure steam shall be supplied to the valve.
6. Temperature sensors shall be provided as required. The temperature sensors shall be of



the RTD (resistance temperature detector) type with 4 to 20 mA output.

7. A vacuum breaker shall be provided.
8. Pressure gages shall be provided as required. The gages shall be 4 ½-in. diameter with a solid front and welded stainless steel sensing element.
9. Pressure transmitters shall be provided as required. The pressure transmitter output signal shall be 4 to 20 mA.
10. Steam flow meters shall be provided as required. The flow meters shall be of the vortex flow meter type with a 4 to 20 mA signal. The flow meters shall be utility grade manufactured by E&H or equal. Manufacturer's recommendations shall be followed for the installation of the flowmeters and accessories required to give accurate readings.

J. Electrical Requirements:

1. Electrical contractor shall supply and install main electrical power line, disconnect switches, circuit breakers, and electrical protection devices per local code requirements and as indicated necessary by the steam power system manufacturer.
2. Electrical contractor shall supply and install electrical wiring and devices required to interface the steam turbine power system controls with the building control system if applicable.
3. Electrical power shall be supplied to the unit at the voltage, phase, and frequency listed in the equipment schedule.

K. Piping Requirements:

1. Mechanical contractor shall install and support steam piping such that NEMA specifications for turbine flange loads are met. Contractor shall

install piping in compliance with the ASME Piping Code B31.3 and the ASME Boiler Code.

2. Mechanical contractor shall supply and install pressure gages in readily accessible locations in piping adjacent to the steam turbine such that they can be easily read from a standing position on the floor.

L. Vibration Isolation:

Steam power system supplier shall furnish neoprene isolator pads for mounting equipment on a level concrete surface.

No special concrete foundation shall be required for vibration isolation.

M. Start-Up:

1. The steam power system manufacturer shall provide a factory-trained representative, employed by the steam power system manufacturer, to perform the start-up procedures as outlined in the Start-up, Operation and Maintenance manual provided by the steam power system manufacturer.
2. Manufacturer shall supply the following literature:
 - a. Start-up, operation and maintenance instructions.
 - b. Installation instructions.
 - c. Field wiring diagrams.
 - d. One complete set of certified drawings.

N. Special Features:

1. Upgraded system and components.
2. Complete packaging on a single skid.
3. Additional instrumentation.
4. Outlet steam separator.
5. 208-3-60 output voltage.
6. Pneumatic air compressor.

