Modular Integrated Energy Systems

Task 5 Prototype Development
Reference Design Documentation

April 27, 2006

Prepared for:

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Oak Ridge, TN 37831

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Section 1. Introduction

This document presents a set of Reference Designs for Modular Integrated Energy Systems (IES). These designs were prepared under a research and development project funded by the U.S. Department of Energy (DOE). This work was administered by Oak Ridge National Laboratory (ORNL) under subcontact number 4000011476 entitled "Research, Development and Demonstration of Packaged Cooling, Heating, and Power Systems for Buildings".

The technical work in developing the Reference Designs was led by I.C. Thomosson, with support from Broad USA and Honeywell. The technical description of the Reference Designs is presented in the following sections.

Development of standardized packaged IES modular systems will provide lower life-cycle costs, and will also speed the acceptance of this technology in the marketplace. Streamlining the up-front design process is needed to produce the greatest benefit from IES technology. The project team's focus is on IES modular systems in the 1- to 5-MW size range, with 900 to 3000 tons of cooling. These systems are typically intended for central plant and district energy applications serving multiple buildings.

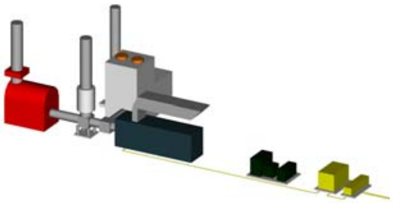
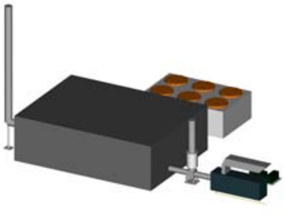
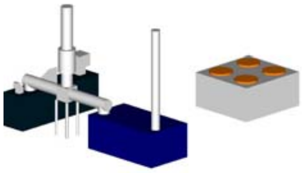
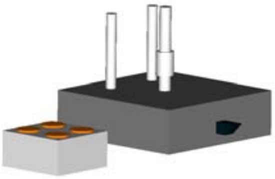
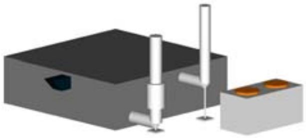
Because large IES systems' (1 to 5MW in size) installation scenarios vary widely, packaging is dependent on modularity, namely, the ability to construct a system by choosing from a selection of compatible components with standardized interfaces. This is especially important for larger IES systems, where the physical size of the equipment prohibits the manufacture and shipment of the entire system in one enclosure. Designing these systems as a number of component modules with each corresponding to a piece of major equipment (i.e. gas turbine-generator, heat recovery steam generator, and absorption chiller or chiller-heater) simplifies the design and installation process by reducing the amount of site-specific engineering and site preparation required. The benefits of applying a "reference" package design are:

- The amount of custom design work for a given site application is greatly reduced. These modular Reference Designs provide IES systems that are more cost-competitive through a reduction in installed cost and optimal matching of equipment to the energy loads.
- These improved economics can serve to validate applications that may have otherwise been difficult to justify (from a purely economic standpoint). For these applications, the other benefits provided by IES technology (e.g., reduced emissions, improved IAQ, and increased energy efficiency) are thus made available to the central plant/building owner and occupants.
- Readily available reference designs can serve to shorten the time required to perform the upfront analysis needed to quantify the economic and other benefits offered in each individual application. This will help speed the process of evaluating candidate IES applications.

Section 2. Reference Design Overview

The Reference Designs are built around a gas turbine as the prime mover, and an exhaust-driven absorption chiller (or chiller-heater). An overview of the designs is shown in Table 2-1.

Table 2-1. Reference Design Overview

Title	Arrangement	Description
R-1		5.7-MW Turbine, 1,000-Ton Chiller, Outdoor Installation with HRSG and Inlet Air Cooler, New Chiller Building, Existing Plant Expansion
R-2		5.3-MW Turbine, 3,300-Ton Chiller-Heater, New Standalone Plant Building
R-4		4.6-MW Turbine, 1,300-Ton Chiller-Heater, Complete Outdoor Installation, Auxiliaries Installed in Existing Space
R-6		3.5-MW Turbine, two 1,000-Ton Chiller-Heaters (2000 Tons total), New Stand-alone Plant Building, Dual Chiller-Heaters
R-8		1.2-MW Turbine, 900-Ton Chiller-Heater, Existing Plant Expansion, All Contained in Existing Space

The system arrangement Reference Design R-1 is shown in Figure 2-1. (Note: This system was installed at Ft. Bragg, NC.)

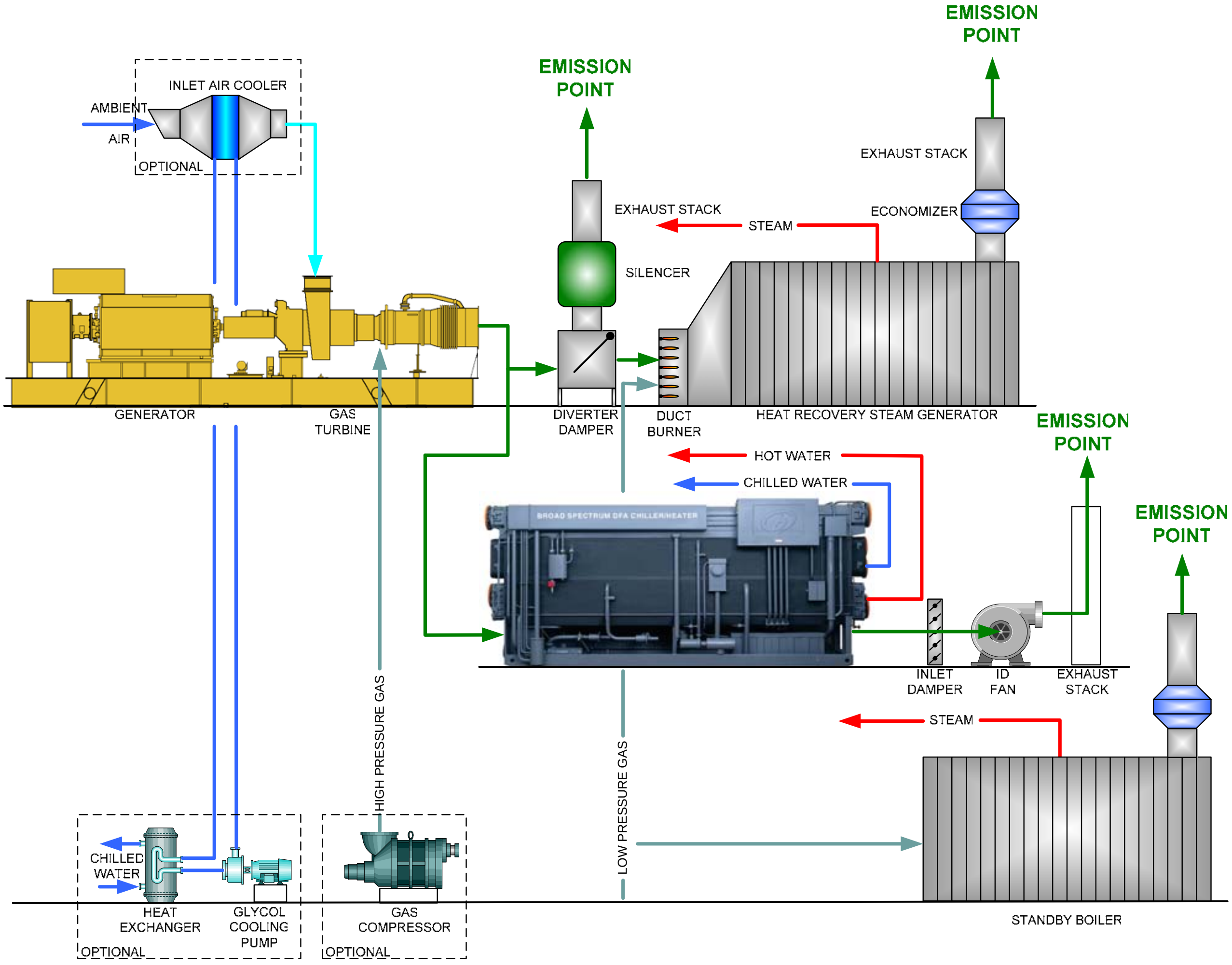


Figure 2-1. System Arrangement: Reference Design R-1

The system arrangement for Reference Designs R-2, R-4, and R-8 is shown in Figure 2-2. (Note: The inlet air cooler is optional, depending on environmental conditions and energy cost considerations at each particular field site.)

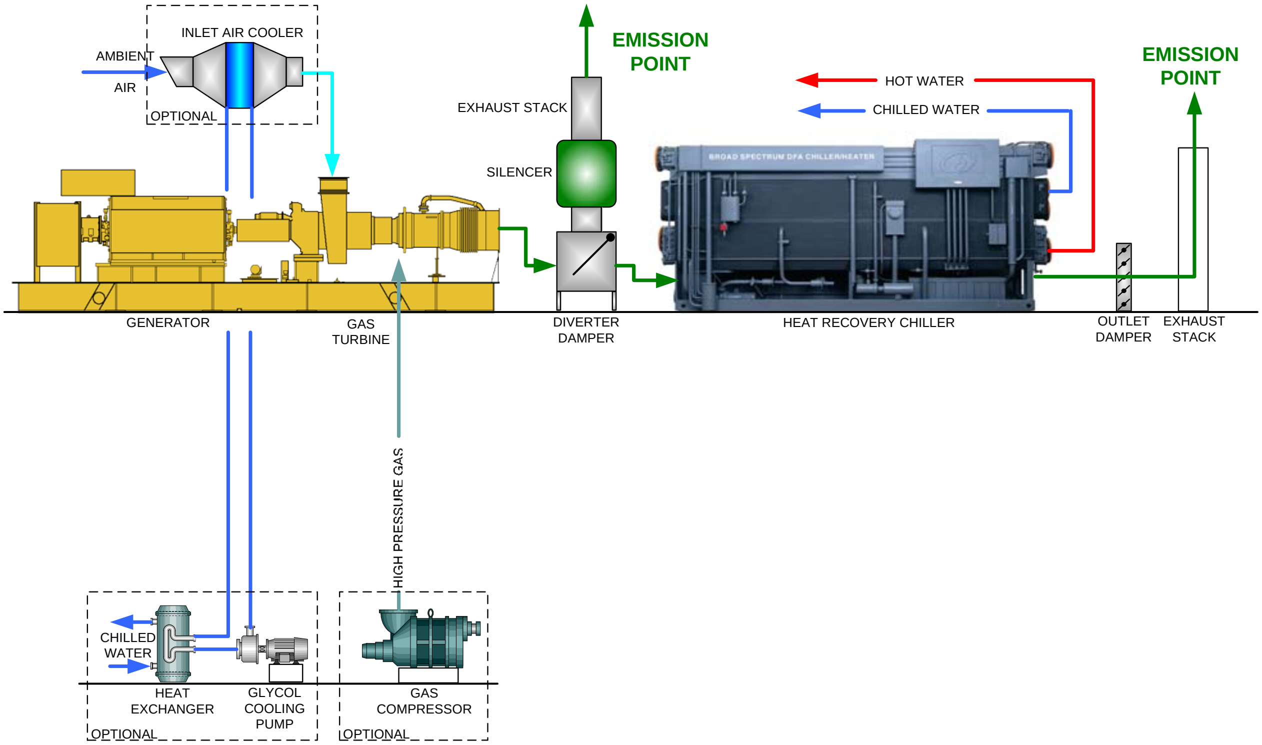


Figure 2-2. System Arrangement: Reference Design R-2, R-4, and R-8

The system arrangement Reference Design R-6 is shown in Figure 2-3. (Note: The inlet air cooler is optional, depending on environmental conditions and energy cost considerations at each particular field site.)

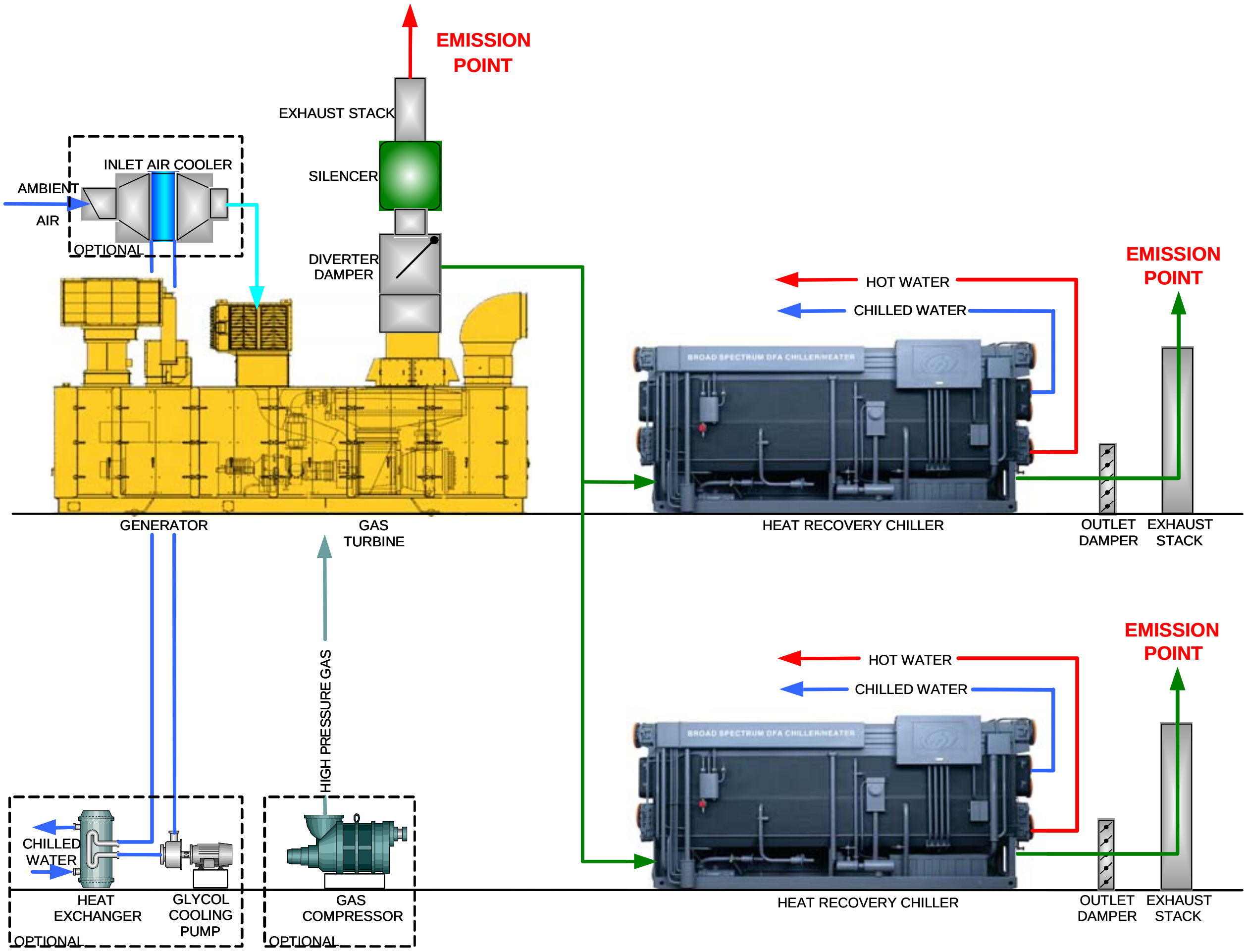


Figure 2-3. System Arrangement: Reference Design R-6

The Reference Designs each include an exhaust-driven absorption chiller (or chiller-heater). An overview of the chiller-heater internal design is shown in Figure 2-4.

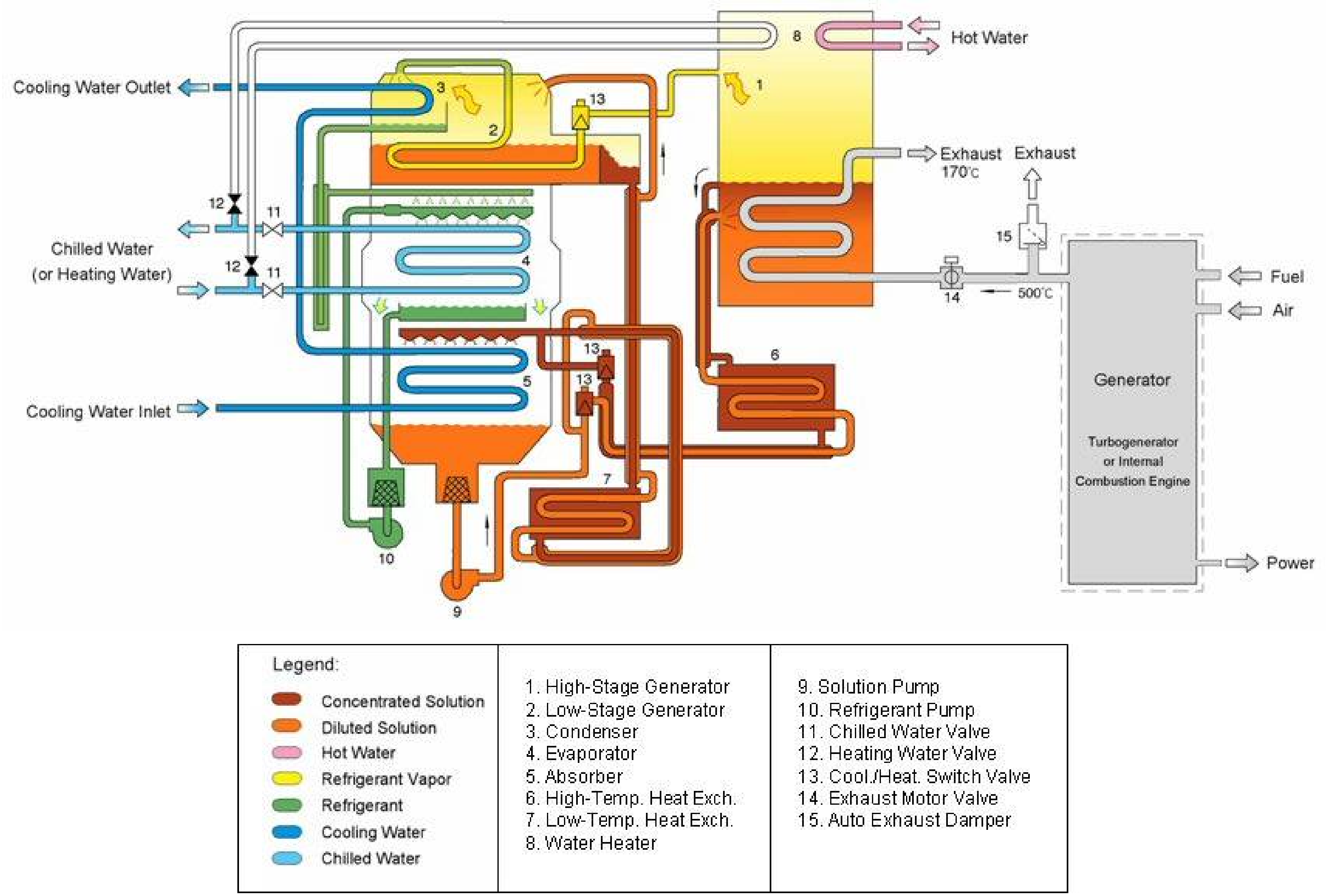


Figure 2-4. Chiller-Heater Internal Design

2.1 Major Equipment

The major equipment used in the Reference Designs is described in Table 2-2.

Table 2-2. Major Equipment

Item	Manufacturer	Web link
Turbine Generator	Solar Turbines	www.solarturbines.com
Absorption Chiller	Broad Air Conditioning	www.broadusa.com
Heat Recovery Steam Generator, HRSG -- (used only in Reference Design R1)	Rentech	www.rentechboilers.com

Notes:

1. Reference Design R1 is patterned after the Ft. Bragg 82nd Central Heating Plant application. The major equipment in R1 is sized to meet the loads for that specific site. For the summer design condition at full turbine generator output, this equates to applying approximately 40% of the recovered energy to drive the absorption chiller, with approximately 60% available to deliver to the HRSG.
2. The electric output rating for Reference Design R1 has been increased by approximately 500kw due to the use of an inlet air cooler.
3. The HRSG package used in Reference Design R1, also includes associated equipment such as the Duct Burner, Economizer, Bypass Diverter, Stack Silencer, etc. See additional information in Appendices.

Equipment from other suppliers could easily be applied in a specific IES application. These Reference Designs serve as examples, which could be suitably altered by the user to incorporate other brands of major equipment.

2.2 Balance of Plant Equipment

The key balance of plant equipment for the R-1 Reference Design is described in Table 2-3. The equipment listed below was selected for the Ft. Bragg site application. Other manufacturers may offer equivalent equipment that could be applied to other sites.

Table 2-3. Balance of Plant Equipment

Item	Manufacturer	Model
Combustion Air Filter	Universal Silencer	DRIFDEK-IL
Combustion Air Cooler	Aerofin	30200006
Glycol Pump	Peerless	F21230AM
Glycol / Chilled Water Heat Exchanger	Graham	03-53547-1
Chiller Exhaust Induced Draft Fan	Champion	353 RRT
Cooing Tower	BAC	3781A-2
Condenser Water Pump	Peerless	10AE14J
Primary Chilled Water Pump	Peerless	8AE15

Section 3. Reference Design Concept

The key principles of the Modular Integrated Energy Systems (IES) Reference Design concept are presented in the Table 3-1.

Table 3-1. Reference Design Concept and Limitations

Purpose	Packaging these systems into a number of component modules with each corresponding to a piece of major equipment (i.e. gas turbine-generator, heat recovery steam generator, absorption chiller or chiller-heater, and exhaust ductwork) simplifies the design and installation process by reducing the amount of site-specific engineering required.
Structure	The Reference Designs are developed as a set of individual designs of varying capacity (i.e. electric generating, heating, and cooling output). This set of designs spans the range of approximately 1 to 5 MW.
Primary User	A registered Professional Engineer (P.E.), who has previous experience in CHP system design (or closely related expertise).
Other Users	Facility engineers, energy managers and others who have a technical understanding of CHP systems may also make use of the Reference Designs in feasibility studies. However, all design work and use of the Reference Design should be performed under the direction of a registered P.E.
Design Intent	The Reference Designs will not replace the need for direct technical oversight by a competent registered P.E. Any use of a Reference Design in a specific project must be performed under the direction of the cognizant P.E. and the resulting final project design is the sole responsibility of the P.E.
Compliance	These designs are offered for reference only. Compliance with all applicable local codes and standards is the responsibility of the cognizant P.E.
Application Scenario	The Reference Designs describe the repeatable portion of the system that is not site specific. Application of a Reference Design to a specific site, and the design of all interconnections to other systems and any additional equipment required will be performed by the cognizant P.E.
Design Scope	The Reference Designs focus on the mechanical engineering design of these systems. Less emphasis is placed on the electrical design, due to its site-specific nature.
Other Disciplines	The Reference Designs do not include structural, architectural, or environmental elements. These other disciplines are the responsibility of the design engineering team for the specific project or site.
Equipment Selection	The major equipment (gas turbine-generator, and absorption chiller or chiller-heater) have been carefully matched in order to maximize the system performance. Most of the reference designs utilize a chiller-heater configuration for simplicity and to minimize installed cost.
Technical Support	No direct application support for the Reference Designs is offered as part of this DOE/ORNL project.
Communications and Outreach	As part of the technology outreach efforts of the U.S. Department of Energy, these Reference Designs are useful to those who have previous experience with CHP system design as well as those who do not -- including site owner decision makers.

Section 4. Scope of the Reference Designs

The scope of the Reference Design R-1 is illustrated in Figure 4-1. The other Reference Designs have a similar scope.

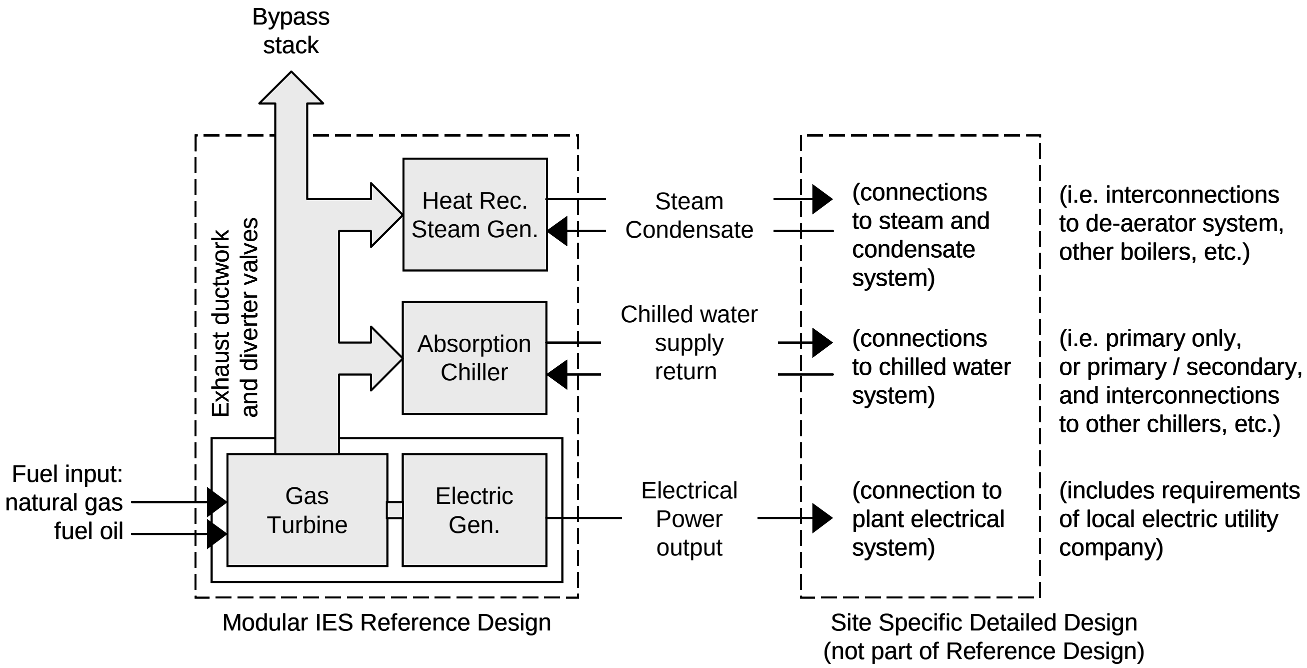


Figure 4-1. Scope of Reference Design R-1

Section 5. Content of the Reference Designs

Elements of the Reference Designs are described in the following sections.

5.1 Reference Design Content

Reference Designs are comprised of the design artifacts shown in Table 5-1. This data for each of the Reference Designs is contained in the Appendices.

Table 5-1. Reference Design Content

Item	Description
CAD Drawings	• Cover sheet, notes, symbols and nomenclature. • P&ID (Piping and Instrumentation Drawing), up to balance-of-plant (BOP) connections. This also includes a mass/energy matrix, showing performance data for winter, ISO and summer conditions. • General arrangement of equipment (floor plan layout), including major equipment. Elevation views are also provided. • Plan view of balance-of-plant (BOP) connections. • Electrical interconnect (one-line) from the generation equipment through the generation voltage switchgear. • Electrical power plan, including major equipment.
Description of Major Equipment (see Note 1)	For Turbine-generator, absorption chiller, and HRSG: Excerpts from manufacturer's specification sheets: • Physical dimensions, weights, etc. • Nominal performance data.
Other Technical Data (see Note 1)	• Performance specifications for auxiliary equipment (i.e. cooling tower, pumps, etc.) (Note: These items are included for reference only. The performance requirements for a specific application will depend on the site characteristics, and should be specified by the P.E.) • Brief sequence of operation. This covers the turbine-generator and heat recovery portions of the system. (Note: The auxiliary cooling equipment (e.g. cooling tower, pumps, etc.) are not included in this sequence of operation. Operation of these systems will be similar to conventional practice, and should be specified by the P.E.)

Note 1: Equipment specifications and technical data are provided for Reference Design R-1 only. For technical data on the major equipment for the other reference designs, please refer to the manufacturers websites.

5.2 Notes to the Reference Design Drawings

The following points should be noted:

- A turbine inlet air cooling coil is shown as “optional” in each of the Reference Designs. The application of an inlet air cooler is site dependent, based on environmental and energy price considerations. The decision to include an inlet air cooler for a given site installation will be made by the cognizant engineer.
- The drawings indicate a "Level Switch Low" (LSL) sensor at each cooling tower. This device triggers the filling of the reservoir to the proper level when a low water level condition is detected.
- The drawings indicate a flow control valve in the condenser water line leading to each cooling tower. This device provides for automated draining of some of the condenser water, to achieve the proper reservoir level when a high water level condition is detected in the cooling tower.
- Each Reference Design includes a system energy performance table. This table shows the design performance for each of three design conditions (winter, summer, and spring/fall). Additional discussion of this tabular data is presented in the next section.
- The energy performance tables do not account for parasitic power (i.e. natural gas compressor, pumps, controls, etc.) -- due to the site specific nature of actual designs as implemented in the field.

5.3 Performance Estimates for the Reference Designs

As mentioned above, each Reference Design includes a system energy performance table. The following points should be noted:

- The values stated for “System Useful Energy Conversion” are estimates of energy efficiency which are based on the amount of turbine gross electrical energy output and the amount of turbine heat that is recovered and delivered to the Chiller-Heater for producing heating and/or cooling. Traditionally, this has been accepted practice by many engineers in the industry.
- However, a more recent and complete description of overall system performance can be found in a document entitled “Distributed Generation Combined Heat and Power Long Term Monitoring Protocols” Interim Version, October 29, 2004, prepared by the Association of State Energy Research and Technology Transfer Institutions (ASERTTI) http://www.asertti.org . Using this standard, we can calculate a system efficiency figure which is defined as follows:

$$\text{System Efficiency} = \frac{\text{useful energy output from the system}}{\text{energy input (fuel)}} = \frac{\text{electric output + heating output + cooling output}}{\text{energy input (fuel)}}$$

This system efficiency value can be easily calculated from the data in the performance table in each Reference Design (Note: Inlet air cooling and system parasitic energy should be handled appropriately in performing this calculation. See the ASERTTI document for guidance.)

5.4 Site Specific Instrumentation Considerations

The following points should be noted:

- The instrumentation shown in the Reference Designs is limited to that required for system control and operation purposes.
- The site owner and the cognizant engineer are encouraged to consider adding more complete instrumentation for use in more detailed performance monitoring. These types of instrumentation should be considered:
    - Turbine exhaust flow instrumentation
    - Water flow instrumentation (i.e. chilled water, condenser water, hot water, etc.)
    - Additional temperature and pressure instrumentation
    - Instrumentation to measure parasitic power

Section 6. Site Specific Design Work

Site specifics dictate that certain technical details must be defined by the P.E. to suit the particular application. These elements of a specific design should be tailored to the requirements of local codes, accepted practice in the site locale, and the preferences of the design P.E. and the construction contractor. These items are shown in Table 6-1.

Table 6-1. Design Work Performed by Others

Item	Description
Equipment Selection	• Electrical switchgear. • Auxiliary balance-of-plant (BOP) equipment.
Details of Construction	• Exhaust ductwork construction. • Expansion joints. • Equipment and system access points.
Material Specifications	• Exhaust ductwork materials. • Piping and insulation. • Valves and other miscellaneous materials.
Control Integration	• Field controller hardware and programming. • Front end computer for plant operator station. • Integration with controllers in major CHP equipment. • Integration with existing plant HVAC systems.

Site specific design work will be required for interfacing the Reference Design to the conventional HVAC system at the building site. A set of technical resources for this interfacing work is presented in the Appendices.

An example control sequence of operations is included the Appendices. This information is specific to the Ft. Bragg 82nd Central Heating Plant application (from which Reference Design R-1 was derived), but can serve as a starting point for other applications. In reviewing this sequence of operations, the following points should be noted:

- Reference is made to certain field devices (by tag name). These tag names are specific to the Ft. Bragg 82nd Central Heating Plant application.
- Reference is made to certain engineering drawings (by drawing name). These drawing names are specific to the Ft. Bragg 82nd Central Heating Plant application, and these drawings are not included in this Reference Design document.
- The section covering Plant Steam Master Boiler Control is specific to the Ft. Bragg 82nd Central Heating Plant application. Other site applications may or may not have similar design constraints. The steam master control technique should be defined by the P.E. to meet the technical requirements and conditions of the specific site application. The same remarks apply to the section covering Burner Firing Rate Control – Boiler Master.
- Reference is made to the COEN burner controls for the Duct Burner, which is specific to the Ft. Bragg 82nd Central Heating Plant application. These references will likely require some modifications for a different site application.
- Reference is made to the Hayes Republic boiler controls, and the existing No. 5 package boiler. These references are specific to the Ft. Bragg 82nd Central Heating Plant application.
- Reference is made steam pressure setpoints and flow rates. These values are specific to the Ft. Bragg 82nd Central Heating Plant application.
- Reference is made to firing rates and number of active elements in the Duct Burner. These descriptions are specific to the Ft. Bragg 82nd Central Heating Plant application.
- Timing of control sequences in the section entitled Purging the HRSG and Broad Chiller, are specific to the Ft. Bragg 82nd Central Heating Plant application.

Section 7. Reference Design Documents

The Reference Design documents are contained in the Appendices of this document. The contents of the various Appendices are described in Table 7-1.

Table 7-1. Reference Design Documents

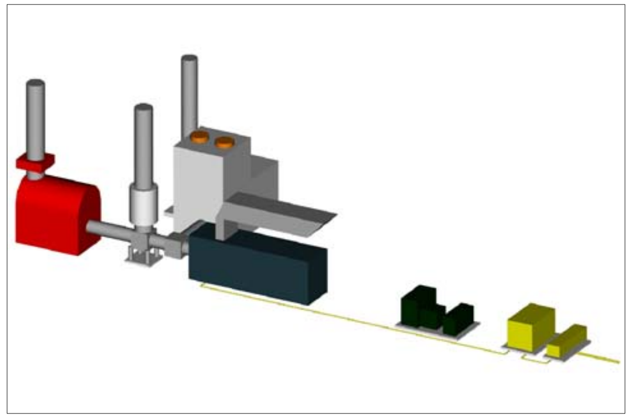
	Contents
Appendix A	Reference Design R-1, Design Documents
Appendix B	Reference Design R-2, Design Documents
Appendix C	Reference Design R-4, Design Documents
Appendix D	Reference Design R-6, Design Documents
Appendix E	Reference Design R-8, Design Documents
Appendix F	Major Equipment (for design R-1)
Appendix G	Site Interface Resources
Appendix H	Sequence of Operations (for design R-1)

Appendix A

Reference Design R-1, Design Documents

INTEGRATED ENERGY SYSTEM
FORT BRAGG DESIGN R-1

POWER	CHILLED WATER	STEAM
5.7 MW	1000 TON	80,000 PPH



SHEET INDEX

COVER	COVER SHEET
R1-PI1	SYMBOLS LEGEND
R1-PI2	P&ID - HEATING EQUIPMENT
R1-PI3	P&ID - COOLING EQUIPMENT
R1-PI4	PERFORMANCE DATA
R1-S1	GENERAL ARRANGEMENT & SITE PLAN
R1-M1	BOILER & TURBINE - EQUIPMENT ELEVATIONS
R1-M2	UTILITY TIE-INS
R1-E1	ELECTRICAL ONE-LINE DIAGRAM
R1-E2	ELECTRICAL POWER PLAN

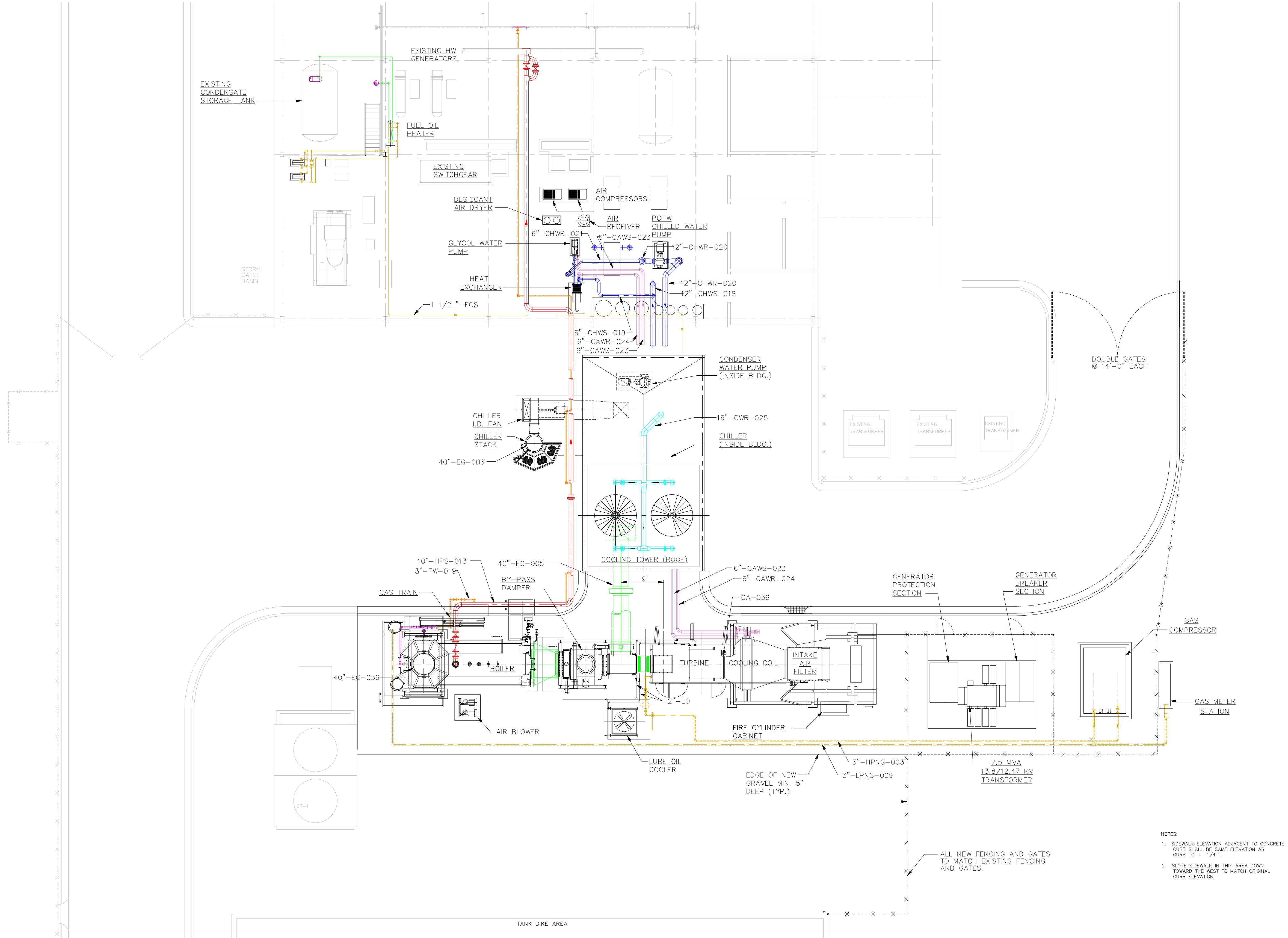
REFERENCE DESIGNS

R-1	5.7 MW INTEGRATED ENERGY SYSTEM
R-2	5.3 MW INTEGRATED ENERGY SYSTEM
R-4	4.6 MW INTEGRATED ENERGY SYSTEM
R-6	3.4 MW INTEGRATED ENERGY SYSTEM
R-8	1.2 MW INTEGRATED ENERGY SYSTEM

Broad USA
I.C. Thomasson
CHELSEA GROUP LIMITED
Honeywell
OAK RIDGE NATIONAL LABORATORY

COVER SHEET
5.7 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R-1
PROTOTYPE PLANT
FORT BRAGG, N.C.
I.C. THOMASSON ASSOCIATES, INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

DRAWN BY BDG
CHECKED BY RDB
JOB No. 1336.08
ISSUE DATE 04-20-05
SHEET No. COVER



NOTES:

1. SIDEWALK ELEVATION ADJACENT TO CONCRETE CURB SHALL BE SAME ELEVATION AS CURB TO + 1/4 ".
2. SLOPE SIDEWALK IN THIS AREA DOWN TOWARD THE WEST TO MATCH ORIGINAL CURB ELEVATION.

GENERAL ARRANGEMENT SITE PLAN

0 5 10
1/8 "=1'-0"

Broad USA

I.C. Thomasson

CHELSEA GROUP LIMITED

Honeywell

OAK RIDGE NATIONAL LABORATORY

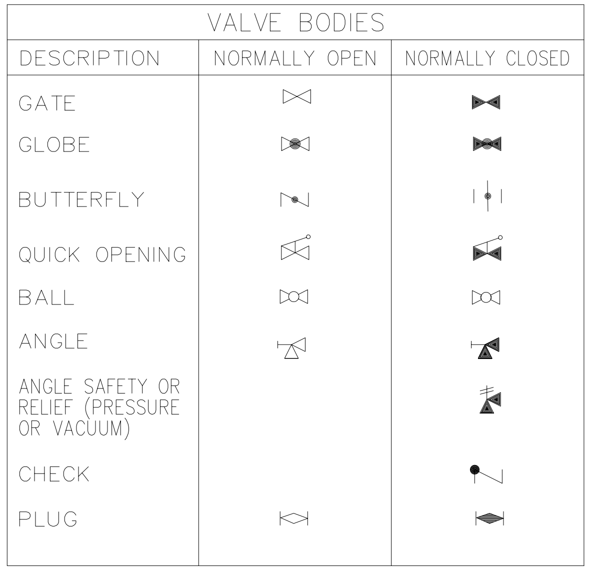
GENERAL ARRANGEMENT & SITE PLAN

5.7 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R-1

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

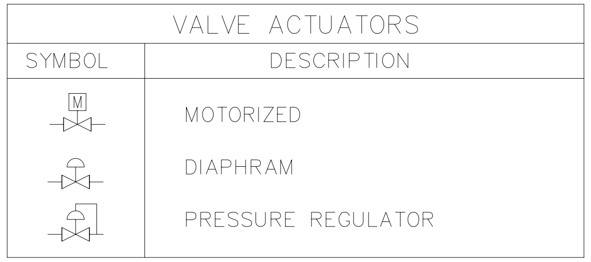
DRAWN BY	KER	JOB No.	1336.08	SHEET No.	R1-S1
CHECKED BY	JBD	ISSUE DATE	04/20/05		

DATE BY



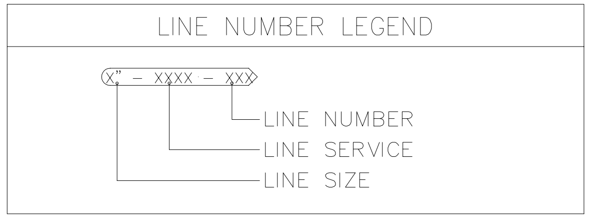
VALVE BODIES

DESCRIPTION	NORMALLY OPEN	NORMALLY CLOSED
GATE		
GLOBE		
BUTTERFLY		
QUICK OPENING		
BALL		
ANGLE		
ANGLE SAFETY OR RELIEF (PRESSURE OR VACUUM)		
CHECK		
PLUG		

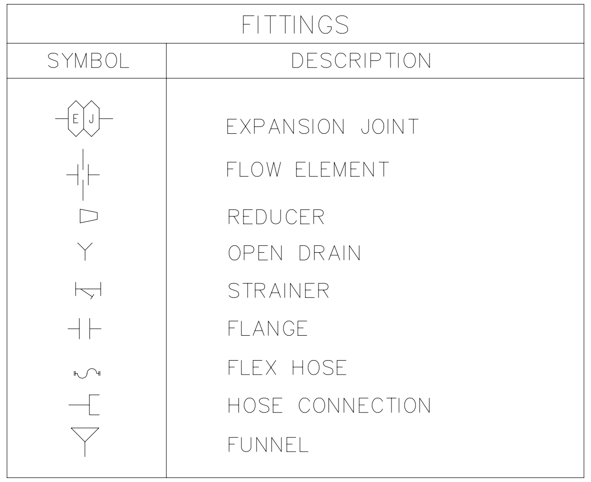


VALVE ACTUATORS

SYMBOL	DESCRIPTION
	MOTORIZED
	DIAPHRAM
	PRESSURE REGULATOR

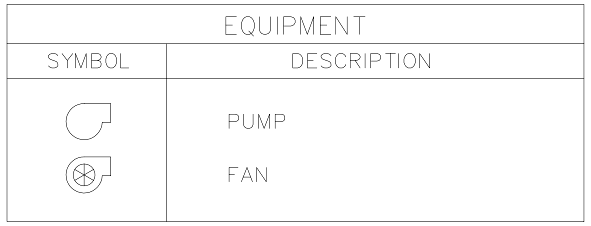


LINE NUMBER LEGEND



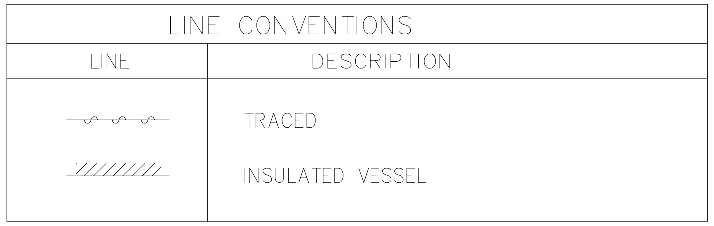
FITTINGS

SYMBOL	DESCRIPTION
	EXPANSION JOINT
	FLOW ELEMENT
	REDUCER
	OPEN DRAIN
	STRAINER
	FLANGE
	FLEX HOSE
	HOSE CONNECTION
	FUNNEL



EQUIPMENT

SYMBOL	DESCRIPTION
	PUMP
	FAN



LINE CONVENTIONS

LINE	DESCRIPTION
	TRACED
	INSULATED VESSEL

LINE SERVICE LEGEND

CA	COMBUSTION AIR
CAWR	CHILLED GLYCOL RETURN
CAWS	CHILLED GLYCOL SUPPLY
CB	CONTINUOUS BLOWDOWN
CF	CHEMICAL FEED
CHWR	CHILLED WATER RETURN
CHWS	CHILLED WATER SUPPLY
CR	CONDENSATE RETURN
CWR	COOLING WATER RETURN
CWS	COOLING WATER SUPPLY
CW	CITY WATER
DR	DRAIN
EG	EXHAUST GAS
FOS	FUEL OIL SUPPLY
FOR	FUEL OIL RETURN
FW	BOILER FEEDWATER
HPNG	HIGH PRESSURE NATURAL GAS
HPR	HIGH PRESSURE RETURN
HPS	HIGH PRESSURE STEAM
IA	INSTRUMENT AIR
IB	INTERMITTENT BLOWDOWN
LO	LUBE OIL
LOCA	LUBE OIL COOLER AIR
LPNG	LOW PRESSURE NATURAL GAS
LPR	LOW PRESSURE RETURN
LPS	LOW PRESSURE STEAM
MPR	MEDIUM PRESSURE RETURN
MPS	MEDIUM PRESSURE STEAM
VT	VENT

FIELD DEVICE LEGEND

AE	ANALYZER
dPT	DIFFERENTAL PRESSURE TRANSMITTER
FCV	FLOW CONTROL VALVE
FE	FLOW ELEMENT
FQ	FLOW QUANTITY
FT	FLOW TRANSMITTER
LCV	LEVEL CONTROL VALVE
LT	LEVEL TRANSMITTER
PCV	PRESSURE CONTROL VALVE
PI	PRESSURE INDICATOR
PSH	PRESSURE SWITCH HIGH
PSV	PRESSURE SAFETY VALVE
PT	PRESSURE TRANSMITTER
TCV	TEMPERATURE CONTROL VALVE
TE	TEMPERATURE ELEMENT
TI	TEMPERATURE INDICATOR

NOTE: THIS IS A PARTIAL P&ID TO BE USED FOR DEMONSTRATION PURPOSES ONLY. ADDITIONAL EQUIPMENT & FIELD DEVICES MAY BE REQUIRED.

Broad USA

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CHELSEA GROUP LIMITED

Honeywell

OAK RIDGE NATIONAL LABORATORY

SYMBOLS LEGEND

5.7 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R–1

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

DRAWN BY BDG	JOB No. 1336.08	SHEET No. R1–PI1
CHECKED BY RBD	ISSUE DATE 04/20/05	

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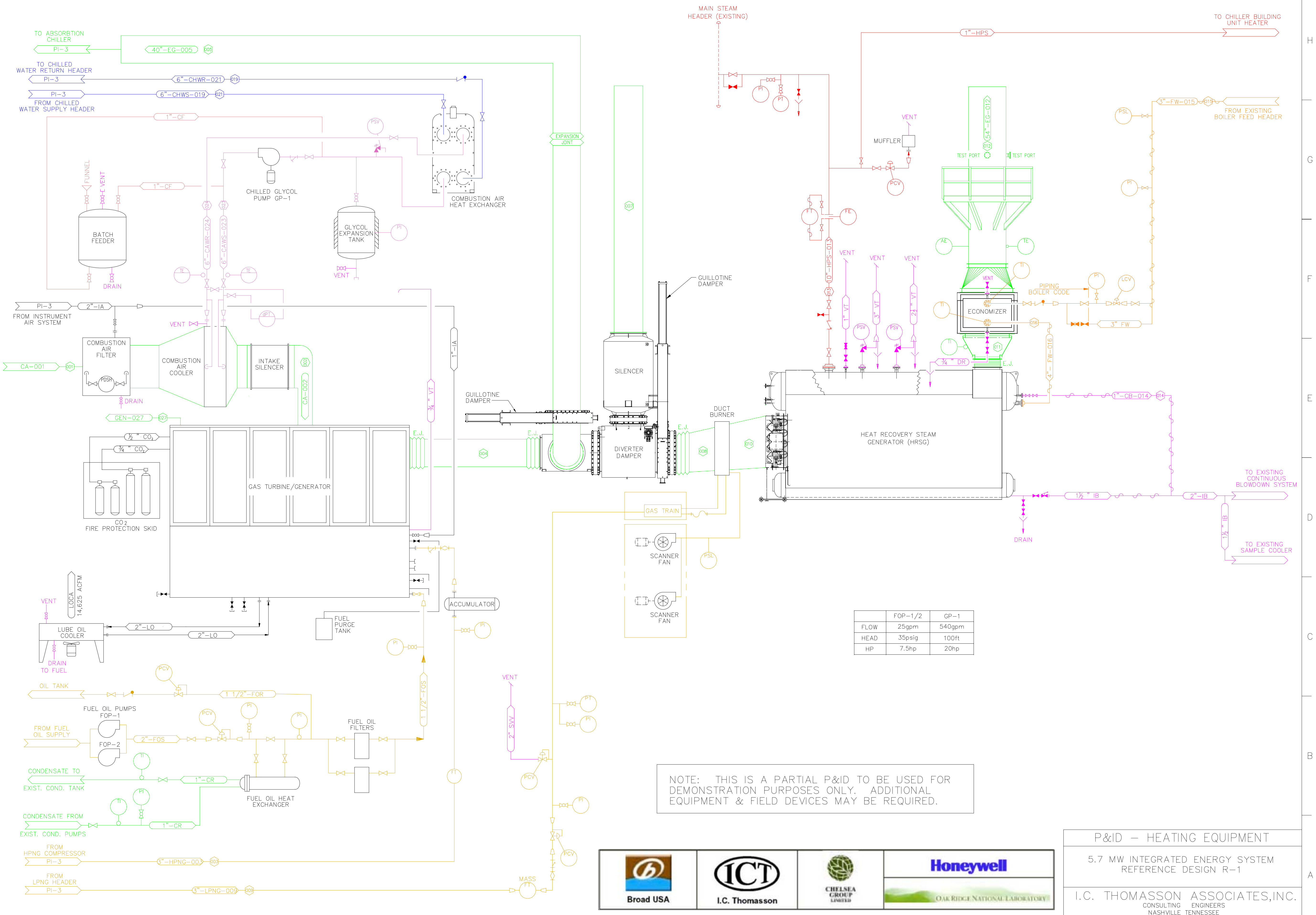

	FOP-1/2	GP-1
FLOW	25gpm	540gpm
HEAD	35psig	100ft
HP	7.5hp	20hp

NOTE: THIS IS A PARTIAL P&ID TO BE USED FOR DEMONSTRATION PURPOSES ONLY. ADDITIONAL EQUIPMENT & FIELD DEVICES MAY BE REQUIRED.

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Honeywell
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P&ID – HEATING EQUIPMENT

5.7 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R-1

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

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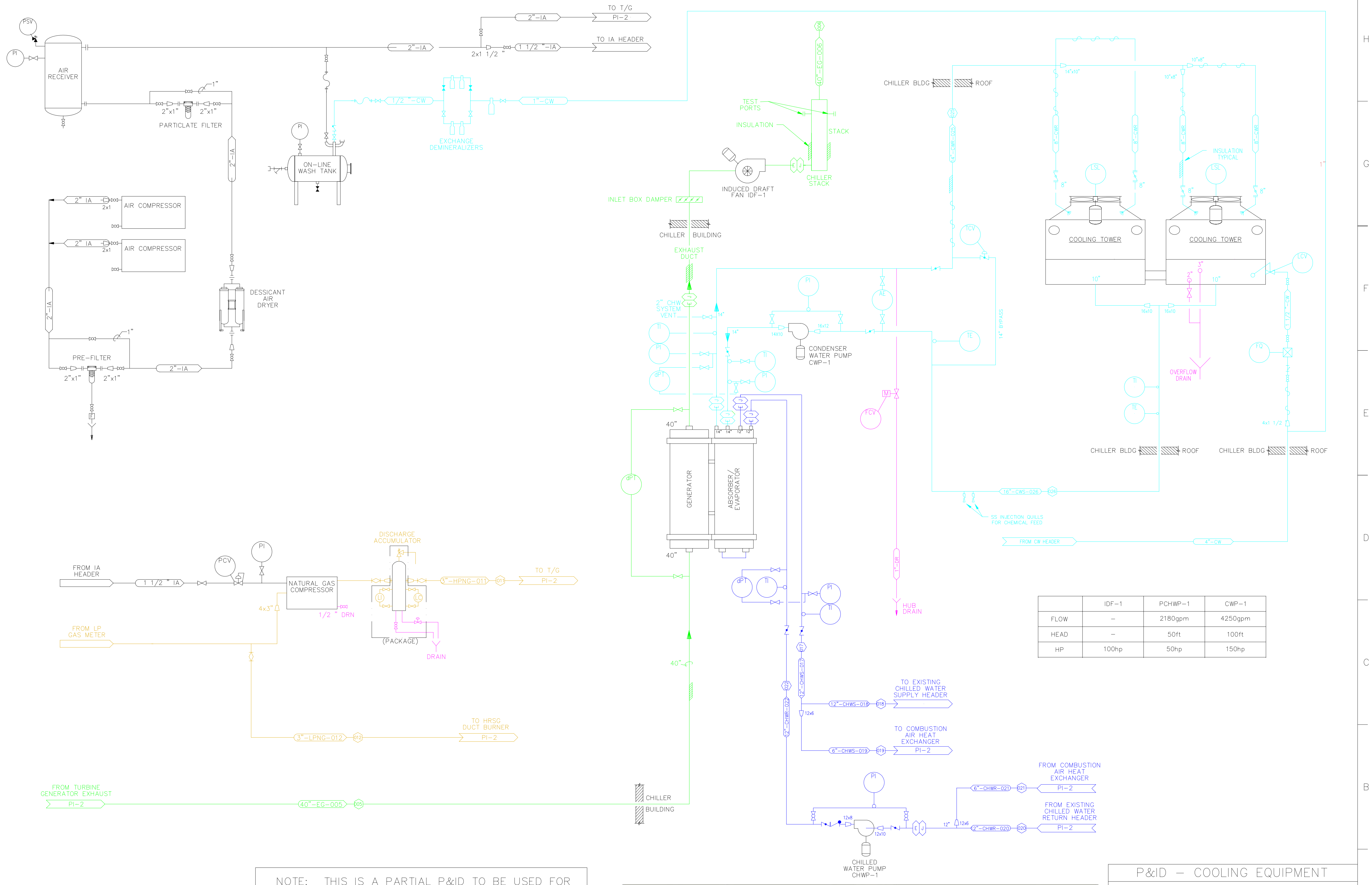

	IDF–1	PCHWP–1	CWP–1
FLOW	–	2180gpm	4250gpm
HEAD	–	50ft	100ft
HP	100hp	50hp	150hp

NOTE: THIS IS A PARTIAL P&ID TO BE USED FOR DEMONSTRATION PURPOSES ONLY. ADDITIONAL EQUIPMENT & FIELD DEVICES MAY BE REQUIRED.

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P&ID – COOLING EQUIPMENT

5.7 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R–1

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

DRAWN BY KER
CHECKED BY JBD
JOB No. 1336.08
ISSUE DATE 04/20/05
SHEET No. R1–PI3

90ºF AMBIENT AIR CONDITION
INLET AIR COOLER IN OPERATION
NO SUPPLEMENTAL STEAM PRODUCED

MASS BALANCE (90ºF, 60% RH)

PID LOCATION	FLUID/SERVICE	FLOW RATE		TEMP	
CA-001	COMBUSTION AIR TO INLET AIR COOLER	167,162	PPH	90	°F
CA-002	COMBUSTION AIR TO TURBINE	167,162	PPH	60	°F
3"-HPNG-003	NATURAL GAS TO TURBINE	2,927	PPH	NA	
EG-004	TURBINE EXHAUST TOTAL	170,089	PPH	960	°F
40"-EG-005	TURBINE EXHAUST TO CHILLER	69,200	PPH	960	°F
40"-EG-006	CHILLER EXHAUST TO ATMOSPHERE	69,200	PPH	350	°F
48"-EG-007	TURBINE EXHAUST TO ATMOSPHERE	0	PPH	NA	
EG-008	TURBINE EXHAUST TO DUCT BURNER	100,889	PPH	960	°F
3"-LPNG-009	NATURAL GAS TO DUCT BURNER	0	PPH	NA	
EG-010	DUCT BURNER TO HRSG	100,889	PPH	960	°F
EG-011	HRSG EXHAUST TO ECONOMIZER	100,889	PPH	411	°F
54"-EG-012	ECONOMIZER EXHAUST TO ATMOSPHERE	100,889	PPH	325	°F
10"-HPS-013	HIGH PRESSURE STEAM TO DISTRIBUTION SYSTEM	17,000	PPH	353	°F
1"-CB-014	BOILER BLOW DOWN	850	PPH	353	°F
3"-FW-015	FEED WATER TO ECONOMIZER	17,850	PPH	228	°F
4"-FW-016	ECONOMIZER FEED WATER TO BOILER	17,850	PPH	313	°F
12"-CHWS-017	CHILLED WATER LEAVING CHILLER	2,180	GPM	42	°F
12"-CHWS-018	CHILLED WATER TO DISTRIBUTION SYSTEM	1,395	GPM	42	°F
6"-CHWS-019	CHILLED WATER TO COMBUSTION AIR HEAT EXCHANGER	785	GPM	42	°F
12"-CHWR-020	CHILLED WATER FROM DISTRIBUTION SYSTEM	1,395	GPM	56	°F
6"-CHWR-021	CHILLED WATER FROM COMBUSTION AIR HEAT EXCHANGER	785	GPM	54	°F
12"-CHWR-022	CHILLED WATER TO CHILLER	2,180	GPM	55	°F
6"-CAWS-023	CHILLED GLYCOL TO TURBINE COMBUSTION AIR COOLER	515	GPM	44	°F
6"-CAWR-024	CHILLED GLYCOL FROM TURBINE COMBUSTION AIR COOLER	515	GPM	64	°F
14"-CWR-025	COOLING WATER LEAVING CHILLER	4,250	GPM	95	°F
14"-CWS-026	COOLING WATER TO CHILLER	4,250	GPM	85	°F
GEN-027	ELECTRICITY PRODUCED	5,250	KW	NA	

ENERGY CONVERSION CALCULATIONS

PID LOCATION	ENERGY INPUT	ENERGY		
3"-LPNG-003	NATURAL GAS TO TURBINE	60,330	MBH	
3"-LPNG-009	NATURAL GAS TO DUCT BURNER	0	MBH	
6"-CHWR-019	CHILLED WATER TO/FROM COMBUSTION AIR HEAT EXCHANGER	4,710	MBH	
	TOTAL ENERGY CONSUMED	65,040	MBH	
	ELECTRICAL OUTPUT			
GEN-027	ELECTRICITY PRODUCED	17,914	MBH	
	ENERGY CONVERTED TO ELECTRICAL	28%		
	HEAT RECOVERY			
10"-HPS-013	STEAM PRODUCED (NET OF FEED WATER HEATING)	15,674	MBH	
	ENERGY CONVERTED TO THERMAL	24%		
	COOLING OUTPUT			
12"-CHWS-018	CHILLED WATER PRODUCED	1,206	TON	
40"-EG-005	EXHAUST HEAT UTILIZED	11,819	MBH	
14"-CWR-025	COOLING WATER HEAT REJECTION	21,250	MBH	
	ENERGY CONVERTED TO COOLING	18%		COP
	SYSTEM USEFUL ENERGY CONVERSION	70%		1.2

60ºF AMBIENT AIR CONDITION
INLET AIR COOLER NOT IN OPERATION
NO SUPPLEMENTAL STEAM PRODUCED

MASS BALANCE (60ºF, 60% RH)

PID LOCATION	FLUID/SERVICE	FLOW RATE		TEMP	
CA-001	COMBUSTION AIR TO INLET AIR COOLER	167,162	PPH	60	°F
CA-002	COMBUSTION AIR TO TURBINE	167,162	PPH	60	°F
3"-HPNG-003	NATURAL GAS TO TURBINE	2,927	PPH	NA	
EG-004	TURBINE EXHAUST TOTAL	170,089	PPH	960	°F
40"-EG-005	TURBINE EXHAUST TO CHILLER	69,200	PPH	960	°F
40"-EG-006	CHILLER EXHAUST TO ATMOSPHERE	69,200	PPH	350	°F
48"-EG-007	TURBINE EXHAUST TO ATMOSPHERE	0	PPH	NA	
EG-008	TURBINE EXHAUST TO DUCT BURNER	100,889	PPH	960	°F
3"-LPNG-009	NATURAL GAS TO DUCT BURNER	0	PPH	NA	
EG-010	DUCT BURNER TO HRSG	100,889	PPH	960	°F
EG-011	HRSG EXHAUST TO ECONOMIZER	100,889	PPH	411	°F
54"-EG-012	ECONOMIZER EXHAUST TO ATMOSPHERE	100,889	PPH	325	°F
10"-HPS-013	HIGH PRESSURE STEAM TO DISTRIBUTION SYSTEM	17,000	PPH	353	°F
1"-CB-014	BOILER BLOW DOWN	850	PPH	353	°F
3"-FW-015	BOILER FEED WATER TO ECONOMIZER	17,850	PPH	228	°F
4"FW-016	ECONOMIZER BOILER FEED WATER TO BOILER	17,850	PPH	313	°F
12"-CHWS-017	CHILLED WATER LEAVING CHILLER	2,068	GPM	42	°F
12"-CHWS-018	CHILLED WATER TO DISTRIBUTION SYSTEM	2,068	GPM	42	°F
6"-CHWS-019	CHILLED WATER TO COMBUSTION AIR HEAT EXCHANGER	0	GPM	NA	
12"-CHWR-020	CHILLED WATER FROM DISTRIBUTION SYSTEM	2,068	GPM	56	°F
6"-CHWR-021	CHILLED WATER FROM COMBUSTION AIR HEAT EXCHANGER	0	GPM	NA	
12"-CHWR-022	CHILLED WATER TO CHILLER	2,068	GPM	56	°F
6"-CAWS-023	CHILLED GLYCOL TO TURBINE COMBUSTION AIR COOLER	0	GPM	NA	
6"-CAWR-024	CHILLED GLYCOL FROM TURBINE COMBUSTION AIR COOLER	0	GPM	NA	
14"-CWR-025	COOLING WATER LEAVING CHILLER	4,250	GPM	95	°F
14"-CWS-026	COOLING WATER TO CHILLER	4,250	GPM	85	°F
GEN-027	ELECTRICITY PRODUCED	5,250	KW	NA	

ENERGY CONVERSION CALCULATIONS

PID LOCATION	ENERGY INPUT	ENERGY		
3"-LPNG-003	NATURAL GAS TO TURBINE	60,330	MBH	
3"-LPNG-009	NATURAL GAS TO DUCT BURNER	0	MBH	
6"-CHWR-019	CHILLED WATER TO/FROM COMBUSTION AIR HEAT EXCHANGER	0	MBH	
	TOTAL ENERGY CONSUMED	60,330	MBH	
	ELECTRICAL OUTPUT			
GEN-027	ELECTRICITY PRODUCED	17,914	MBH	
	ENERGY CONVERTED TO ELECTRICAL	30%		
	HEAT RECOVERY			
10"-HPS-013	STEAM PRODUCED (NET OF FEED WATER HEATING)	15,674	MBH	
	ENERGY CONVERTED TO THERMAL	26%		
	COOLING OUTPUT			
12"-CHWS-018	CHILLED WATER PRODUCED	1,206	TON	
40"-EG-005	EXHAUST HEAT UTILIZED	11,819	MBH	
14"-CWR-025	COOLING WATER HEAT REJECTION	21,250	MBH	
	ENERGY CONVERTED TO COOLING	20%		COP
	SYSTEM USEFUL ENERGY CONVERSION	75%		1.2

30ºF AMBIENT AIR CONDITION
INLET AIR COOLER NOT IN OPERATION
MAXIMUM SUPPLEMENTAL STEAM PRODUCED

MASS BALANCE (30ºF, 60% RH)

PID LOCATION	FLUID/SERVICE	FLOW RATE		TEMP	
CA-001	COMBUSTION AIR TO INLET AIR COOLER	174,994	PPH	30	°F
CA-002	COMBUSTION AIR TO TURBINE	174,994	PPH	30	°F
3"-HPNG-003	NATURAL GAS TO TURBINE	3,136	PPH	NA	
EG-004	TURBINE EXHAUST TOTAL	178,130	PPH	981	°F
40"-EG-005	TURBINE EXHAUST TO CHILLER	0	PPH	NA	
40"-EG-006	CHILLER EXHAUST TO ATMOSPHERE	0	PPH	NA	
48"-EG-007	TURBINE EXHAUST TO ATMOSPHERE	0	PPH	NA	
EG-008	TURBINE EXHAUST TO DUCT BURNER	178,000	PPH	981	°F
3"-LPNG-009	NATURAL GAS TO DUCT BURNER	2,700	PPH	NA	
EG-010	DUCT BURNER TO HRSG	180,700	PPH	1973	°F
EG-011	HRSG EXHAUST TO ECONOMIZER	180,700	PPH	411	°F
54"-EG-012	ECONOMIZER EXHAUST TO ATMOSPHERE	180,700	PPH	325	°F
10"-HPS-013	HIGH PRESSURE STEAM TO DISTRIBUTION SYSTEM	81,200	PPH	353	°F
1"-CB-014	BOILER BLOW DOWN	4,060	PPH	353	°F
3"-FW-015	BOILER FEED WATER TO ECONOMIZER	85,260	PPH	228	°F
4"FW-016	ECONOMIZER BOILER FEED WATER TO BOILER	85,260	PPH	313	°F
12"-CHWS-017	CHILLED WATER LEAVING CHILLER	0	GPM	NA	
12"-CHWS-018	CHILLED WATER TO DISTRIBUTION SYSTEM	0	GPM	NA	
6"-CHWS-019	CHILLED WATER TO COMBUSTION AIR HEAT EXCHANGER	0	GPM	NA	
12"-CHWR-020	CHILLED WATER FROM DISTRIBUTION SYSTEM	0	GPM	NA	
6"-CHWR-021	CHILLED WATER FROM COMBUSTION AIR HEAT EXCHANGER	0	GPM	NA	
12"-CHWR-022	CHILLED WATER TO CHILLER	0	GPM	NA	
6"-CAWS-023	CHILLED GLYCOL TO TURBINE COMBUSTION AIR COOLER	0	GPM	NA	
6"-CAWR-024	CHILLED GLYCOL FROM TURBINE COMBUSTION AIR COOLER	0	GPM	NA	
14"-CWR-025	COOLING WATER LEAVING CHILLER	0	GPM	NA	
14"-CWS-026	COOLING WATER TO CHILLER	0	GPM	NA	
GEN-027	ELECTRICITY PRODUCED	5,741	KW	NA	

ENERGY CONVERSION CALCULATIONS

PID LOCATION	ENERGY INPUT	ENERGY		
3"-LPNG-003	NATURAL GAS TO TURBINE	64,640	MBH	
3"-LPNG-009	NATURAL GAS TO DUCT BURNER	55,644	MBH	
6"-CHWR-019	CHILLED WATER TO/FROM COMBUSTION AIR HEAT EXCHANGER	0	MBH	
	TOTAL ENERGY CONSUMED	120,284	MBH	
	ELECTRICAL OUTPUT			
GEN-027	ELECTRICITY PRODUCED	19,589	MBH	
	ENERGY CONVERTED TO ELECTRICAL	30%		
	HEAT RECOVERY			
10"-HPS-013	STEAM PRODUCED (NET OF FEED WATER HEATING)	74,866	MBH	
	ENERGY CONVERTED TO THERMAL	62%		
	COOLING OUTPUT			
12"-CHWS-018	CHILLED WATER PRODUCED	0	TON	
40"-EG-005	EXHAUST HEAT UTILIZED	0	MBH	
14"-CWR-025	COOLING WATER HEAT REJECTION	0	MBH	
	ENERGY CONVERTED TO COOLING	0%		COP
	SYSTEM USEFUL ENERGY CONVERSION	79%		--

5% boiler blowdown. Deaerator steam not included.
Natural gas LHV = 20,609 Btu/lb.
"Energy Converted" is the percentage of fuel input energy converted into useable energy.
No parasitic losses are included.
Glycol and combustion air heat exchangers efficiency >98%.
SOLAR TAURUS 60 / BROAD USA BE-300
3% radiation and convection heat loss from chiller.

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PERFORMANCE DATA

5.7 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R-1

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

DRAWN BY JBD	JOB No. 1336.08	SHEET No.
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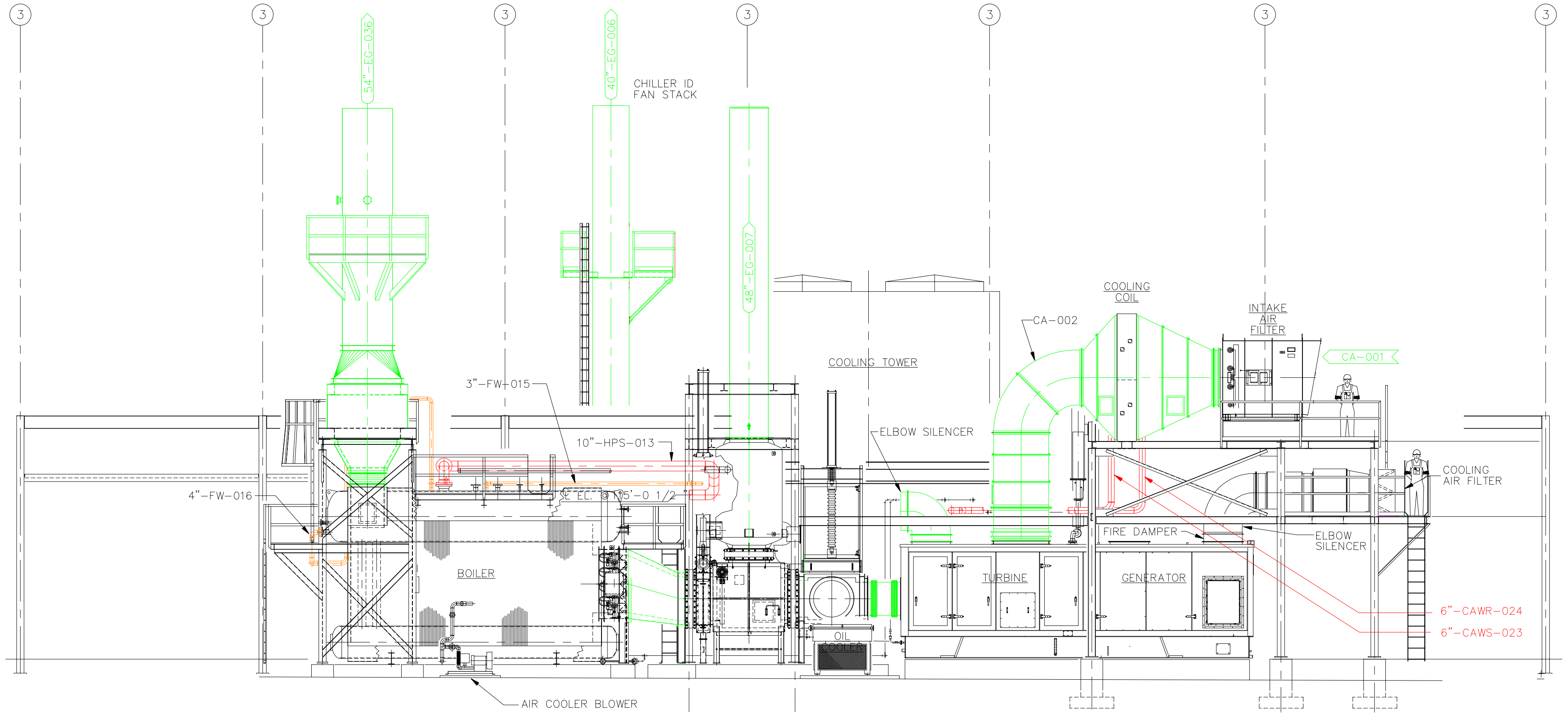
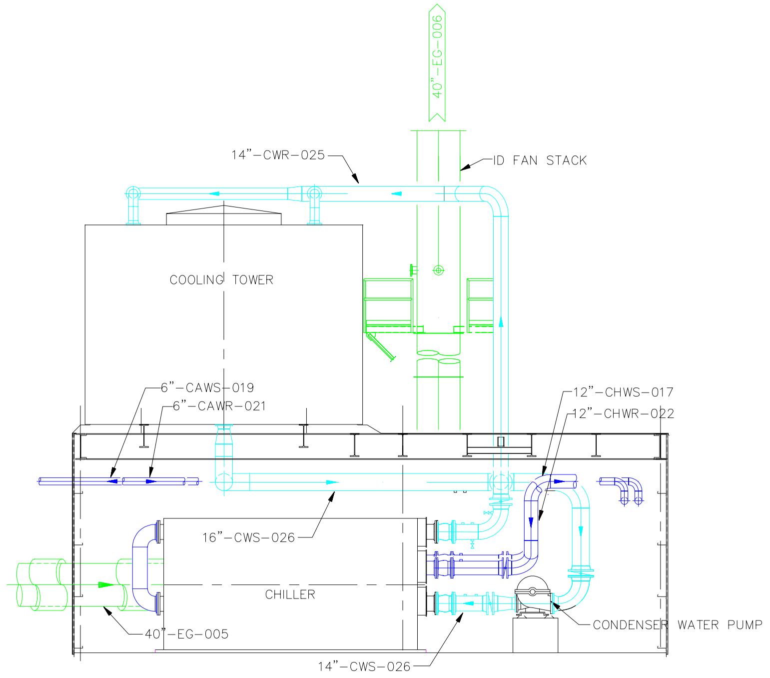


BOILER & TURBINE – PIPING SECTION

(ELEVATION LOOKING NORTH)

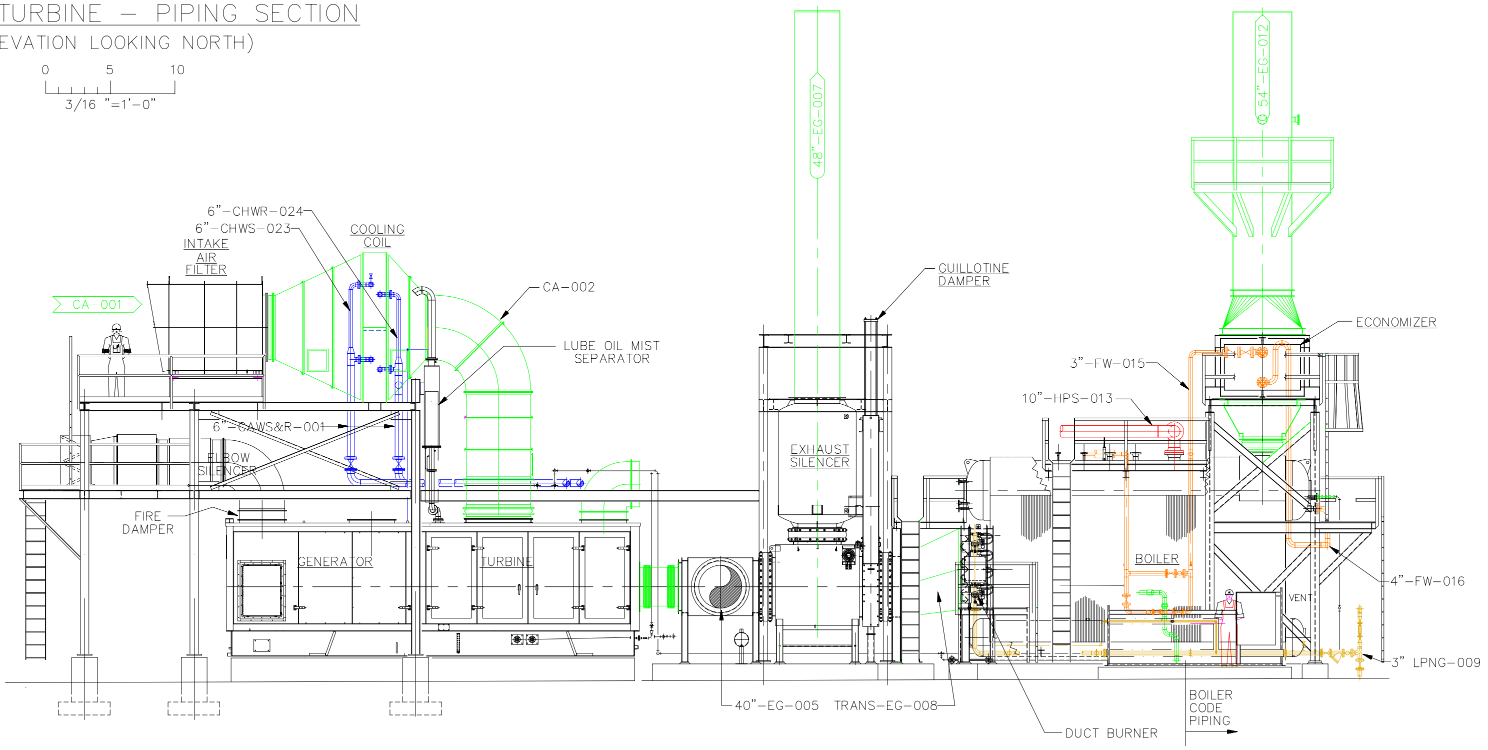
0 5 10
3/16 "=1'-0"



CHILLER BUILDING – PIPING SECTION

(ELEVATION LOOKING WEST)

0 5 10
3/16 "=1'-0"



BOILER & TURBINE – PIPING SECTION

(ELEVATION LOOKING SOUTH)

0 5 10
3/16 "=1'-0"

FIELD ROUTE VENT PIPING FROM PCV-0004
ALONG STEEL STRUCTURE TO SAFE VENTING
POINT ABOVE HIGHEST PLATFORM.

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CHELSEA
GROUP
LIMITED
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OAK RIDGE NATIONAL LABORATORY

BOILER & TURBINE – EQUIPMENT ELEVATIONS

5.7MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R-1

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CONSULTING ENGINEERS
NASHVILLE TENNESSEE

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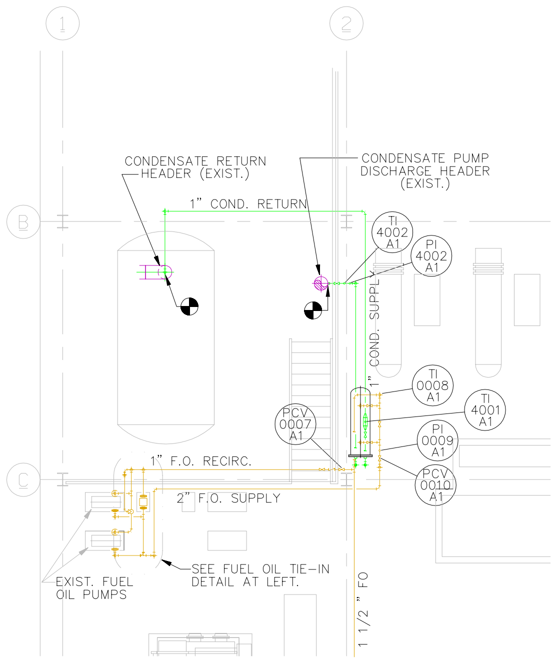
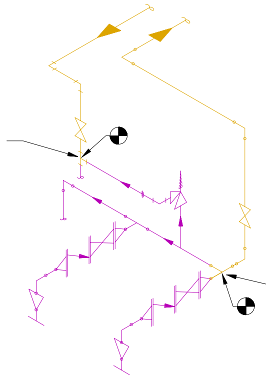
CHECKED BY	JBD	ISSUE DATE	04/20/05	



FUEL OIL & CONDENSATE TIE-IN

0 5 10
3/16 "=1'-0"

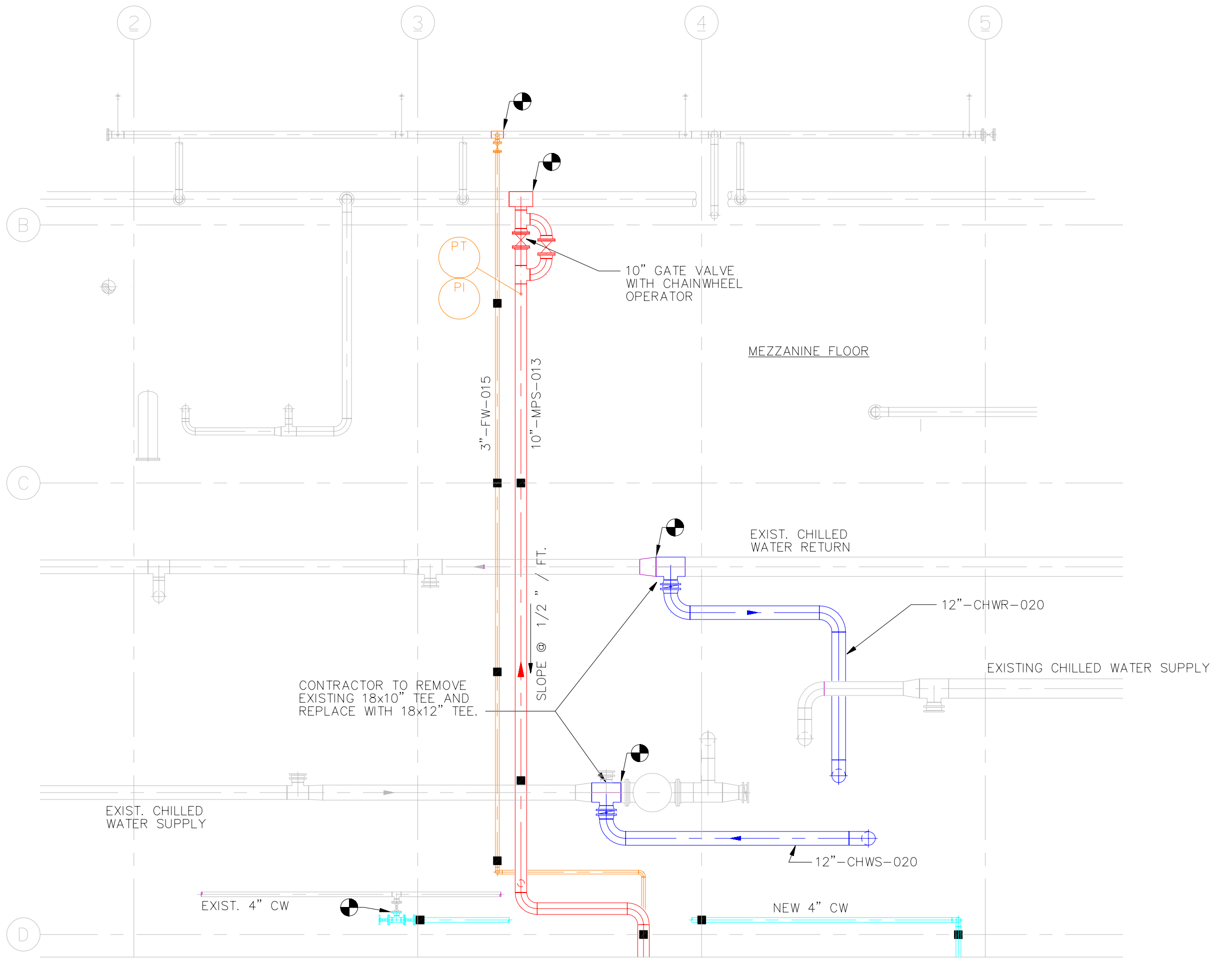
REMOVE ELL FROM EXIST. RECIRC. LINE AND INSTALL A TEE. FIELD ROUTE PIPING FROM NEW FUEL OIL HEATER AS DIAGRAMATICALLY SHOWN ON DRAWING.



REMOVE ELL FROM EXIST. FUEL OIL DISCHARGE LINE AND INSTALL A TEE. FIELD ROUTE PIPING TO NEW FUEL OIL HEATER AS DIAGRAMATICALLY SHOWN ON DRAWING.

FUEL OIL ISOMETRIC TIE-IN DETAIL

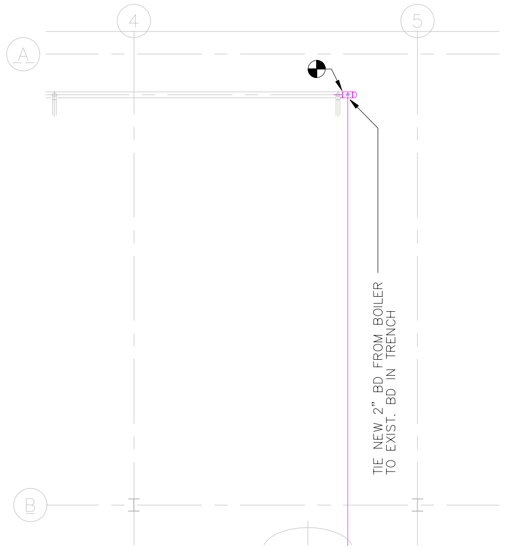
NO SCALE



CONTRACTOR TO REMOVE EXISTING 18x10" TEE AND REPLACE WITH 18x12" TEE.

STEAM, CONDENSATE, COOLING WATER & CITY WATER TIE-IN

0 5 10
3/16 "=1'-0"



BLOWDOWN TIE-IN

0 5 10
3/16 "=1'-0"

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OAK RIDGE NATIONAL LABORATORY

UTILITY TIE-INS

5.7 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R-1

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

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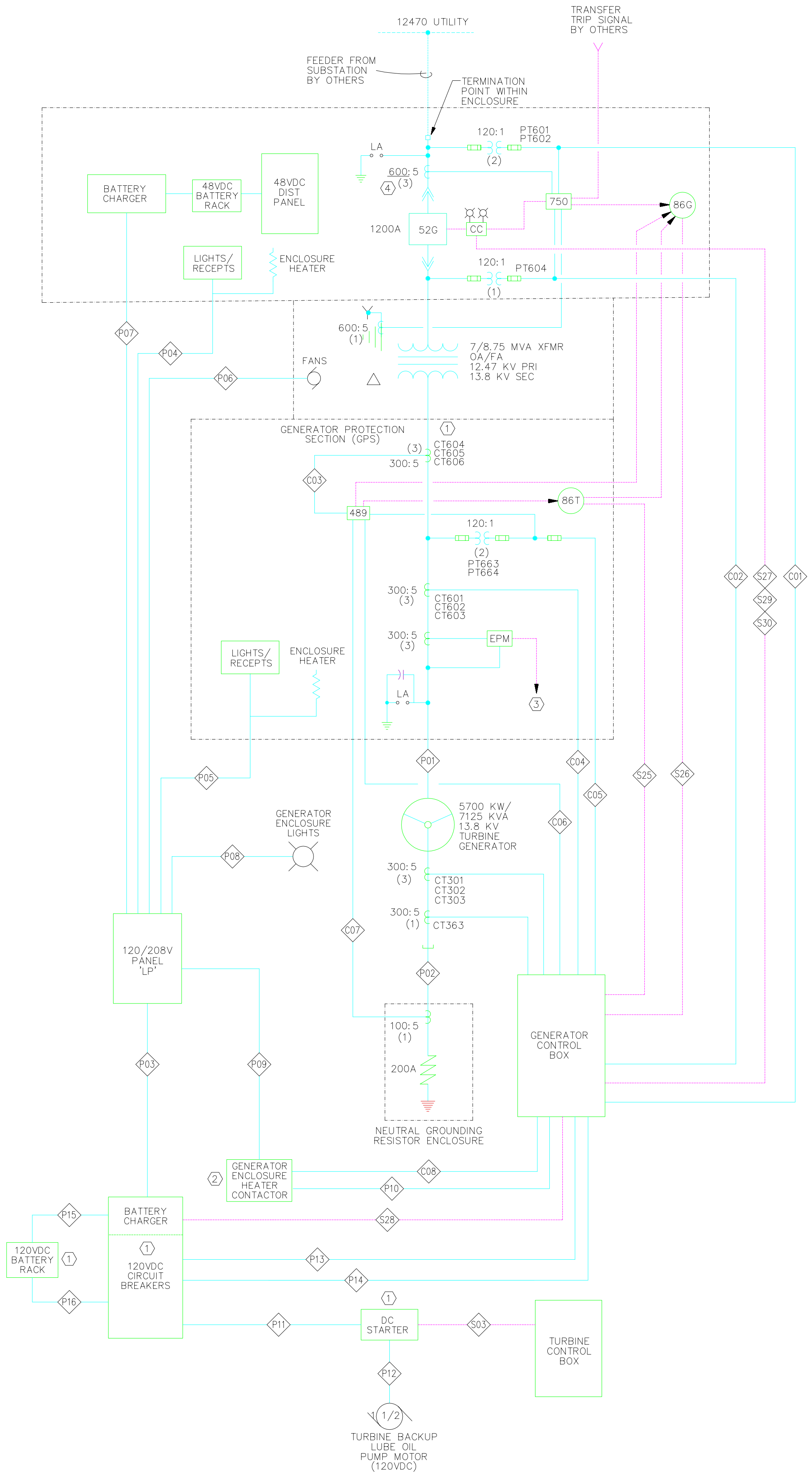
BY



CONDUCTOR SCHEDULE

No.	Wire Spec.	Remarks
C01	2- 1/C #14 in 1"C	
C02	2- 1/C #14 (route with C01)	
C03	3-#10 TWISTED PAIRS (JUMPERS)	CT's shipped loose by Solar, installed by contractor
C04	2-#10 TWISTED PAIRS in 1"C	
C05	3- 1/C #14 (route with C04)	
C06	3-#10 TWISTED PAIRS in 1"C	Generator Neutral Side
C07	1-#10 TWISTED PAIR in 3/4"C	
C08	2- 1/C #14 in 1"C	(120VAC)
P01	3-1/C #350 & 1-1/C #1/0 Gnd in 5"C	15KV, MV-105, Shielded Cable
P02	1-1/C #2/0 in 2"C	8KV, MV-105, Shielded Cable
P03	2- 1/C #8 & 1-1/C #10 Gnd in 3/4"C	(208V, 1-PH)
P04	3- 1/C #12 & 1-1/C #12 Gnd in 1"C	(120VAC)
P05	3- 1/C #12 & 1-1/C #12 Gnd in 1"C	(120VAC)
P06	3- 1/C #12 & 1-1/C #12 Gnd in 1"C	(208VAC)
P07	2- 1/C #12 & 1-1/C #12 Gnd in 1"C	(120VAC)
P08	2- 1/C #12 & 1-1/C #12 Gnd in 1"C	(120VAC)
P09	2- 1/C #12 & 1-1/C #12 Gnd in 3/4"C	(120VAC)
P10	2- 1/C #12 & 1-1/C #12 Gnd in 1"C	(120VAC)
P11	2- 1/C #6 in 3/4 "C	(120VDC)
P12	2- 1/C #6 in 1"C	(120VDC)
P13	2- 1/C #12 (route with P14)	(120VDC)
P14	2- 1/C #4 in 2"C	(120VDC)
P15	2-1/C #12 in 3/4"C	(120VDC)
P16	2-1/C #2 in 1"C	(120VDC)
S03	2- 1/C #14 in 1"C	(24VDC)
S25	2- 1/C #14 in 1"C	86T trips turbine and generator (24 VDC)
S26	2- 1/C #14 in 1"C	86G trips generator only (24 VDC)
S27	3- 1/C #14 (route with S26)	Breaker position (24 VDC)
S28	2- 1/C #14 in 1"C	(24V DC)
S29	2- 1/C #14 (route with S26)	(48V DC)
S30	2- 1/C #14 (route with S26)	(48V DC)

LEGEND

489 -MULTILIN GENERATOR MANAGEMENT RELAY.
750 -MULTILIN FEEDER MANAGEMENT RELAY.
-CURRENT TRANSFORMERS
-POTENTIAL TRANSFORMERS
86 -LOCK-OUT RELAY. 86T TRIPS TURBINE AND GENERATOR BREAKER. 86G TRIPS GENERATOR BREAKER ONLY.
-SURGE CAPACITOR, ONE-3 PHASE UNIT.
LA -LIGHTNING ARRESTOR, 3 REQUIRED.
(1) - NUMBER = QUANTITY OF DEVICES
- FUSE
CC - CONTROL CIRCUIT WITH INDICATOR LIGHTS
- GROUND
52G - MED/HIGH VOLTAGE GENERATOR SYNCHRONIZING BREAKER
C# - CONDUCTOR RUN DESIGNATOR ('C'= CONTROL, 'P'= POWER, 'S'= SIGNAL). SIGNIFIES CONDUCTORS TO BE INSTALLED BY CONTRACTOR. SEE CONDUCTOR SCHEDULE FOR MORE INFORMATION.
EPM - ELECTRONIC POWER METER

NOTES:

1. EQUIPMENT PROVIDED LOOSE BY SOLAR FOR INSTALLATION BY CONTRACTOR.
2. HEATER CONTACTOR PROVIDED AND INSTALLED BY CONTRACTOR.
3. THIS CONTRACTOR TO INSTALL POWER METER CONDUIT FROM UNIT SUB TO JUNCTION BOX INSIDE NEW CHILLER BUILDING. CONDUIT FROM JUNCTION BOX TO PLANT CONTROL SYSTEM BY OTHERS. METER OUTPUT WIRING INSTALLED BY OTHERS.
4. CURRENT TRANSFORMER SHALL BE OF MULTI-TAP TYPE. USE 400:5 SECONDARY TAP.

Broad USA
I.C. Thomasson
CHELSEA GROUP LIMITED
Honeywell
OAK RIDGE NATIONAL LABORATORY

ELECTRICAL ONE-LINE DIAGRAM

5.7 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R-1
PROTOTYPE PLANT
FORT BRAGG, N.C.

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

DRAWN BY MGP
CHECKED BY CSH
JOB No. 1336.08
ISSUE DATE 04/20/05
SHEET No. R1-E1

GENERAL NOTES:

B. THE FOLLOWING MINIMUM WIRING STANDARD WILL BE FOLLOWED IN THE WIRING CONSTRUCTION ON THIS PROJECT–

1. DEFINITION: POWER CONDUCTORS INCLUDE PANEL FEEDERS AND BRANCH CIRCUITS AS WELL AS MOTOR FEEDS FROM THE MOTOR CONTROL CENTER. POWER CONDUCTORS WILL ALSO INCLUDE THOSE CONDUCTORS USED TO POWER FIELD DEVICES.
2. CONTROL CONDUCTORS INCLUDE CONDUCTORS BELOW 300 VOLTS USED IN THE INSTRUMENTATION AND CONTROL OF THE FACILITY.
3. CONTROL POWER CONDUCTORS ARE THOSE USED TO POWER FIELD DEVICES FROM PLC CABINETS, CONTROL POWER TRANSFORMERS IN MCC BUCKETS, OR PANELS DESIGNATED AS CONTROL POWER SOURCES.
4. ALL CONTROL WIRING WILL BE COLOR–CODED. POWER CONDUCTORS, CONTROL POWER CONDUCTORS AND CONTROL CONDUCTORS WILL NOT BE THE SAME COLOR. COLOR CODE AS FOLLOWS:

   120 VAC POWER: BLACK OR RED WITH BLACK STRIPE

   120 VAC POWER NEUTRAL: WHITE

   120 VAC CONTROL: RED

   120 VAC CONTROL NEUTRAL: WHITE OR RED WITH WHITE STRIPE

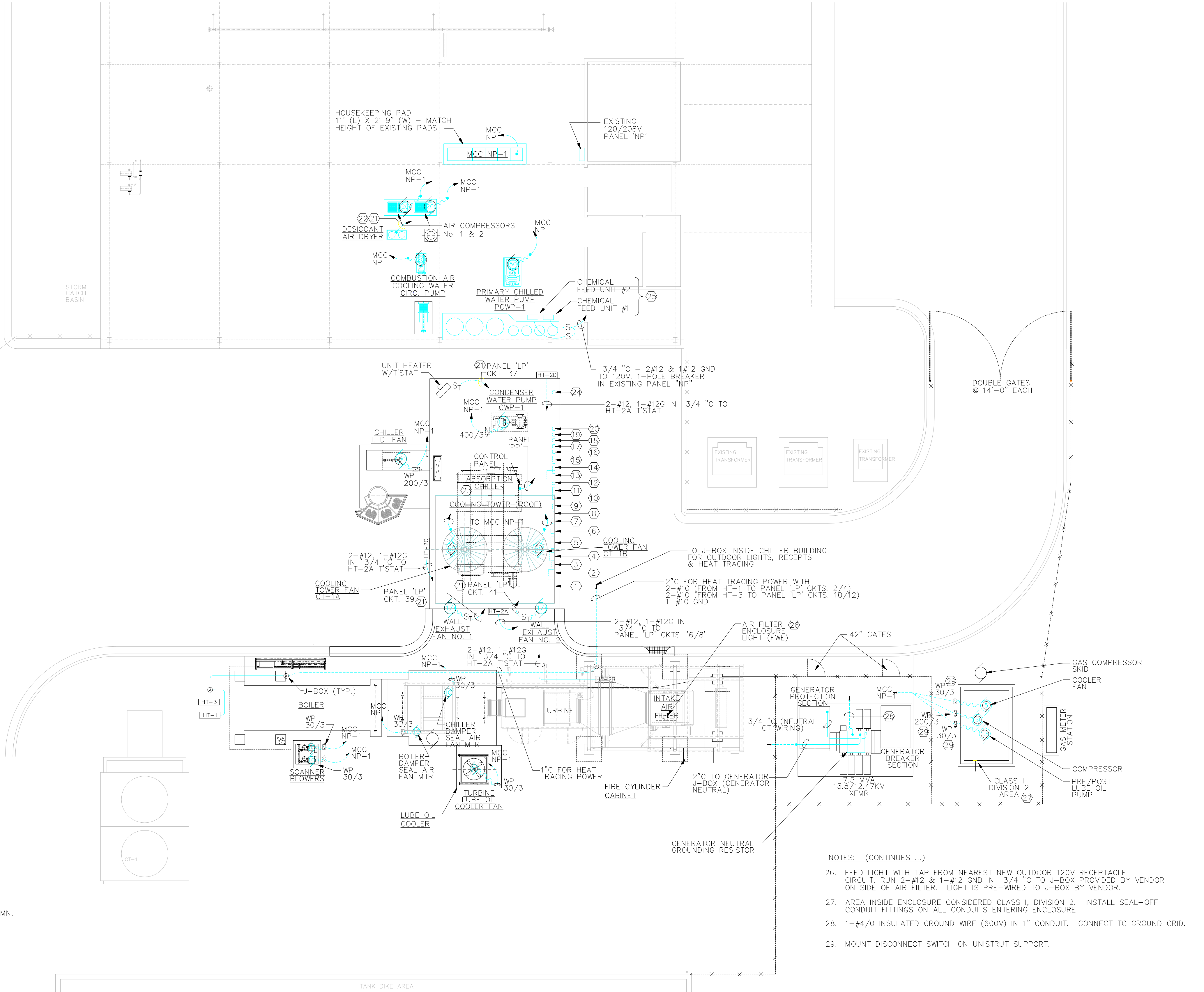
   24 VDC (+): BLUE

   24 VDC (–): WHITE WITH BLUE STRIPE OR BROWN

5. 120 VAC CONTROL OUTPUTS WILL NOT BOTH BE RED CONDUCTORS. 120 VAC SUPPLY OUTPUT WILL BE RED AND THE RETURN WILL BE A NEUTRAL. THIS MEANS THAT EVERY SOLENOID, ACTUATOR, OR OTHER FIELD DEVICE GETS A WHITE OR WHITE STRIPED WIRE.
6. MULTIPLE FIELD DEVICES REQUIRING A CONTROL POWER SOURCE WILL NOT BE FIELD WIRED IN A DAISY–CHAIN CIRCUIT FROM THE SAME CIRCUIT UNLESS SPECIFICALLY CALLED OUT ON DRAWINGS. WIRING FOR EACH DEVICE MUST BE BROUGHT BACK TO A TERMINAL.
7. CONTROL WIRING WILL BE INTEGRATED INTO THE PROJECT, NOT ADDED AT THE END WHEN EVERYONE IS INVOLVED IN START–UP.
8. CONTROL WIRING WILL NOT SHARE RACEWAYS WITH POWER WIRING, UNLESS SPECIFICALLY INDICATED ON THE DRAWINGS.
9. NO BUTT SPLICES WILL BE USED FOR ANY WIRING. ALL CONNECTIONS WILL BE MADE ON A TERMINAL STRIP.
10. LABELING WILL BE DONE IN A CONSISTENT MANNER WITH THE OTHER END OF THE CONDUCTOR. ALL WIRE NUMBERS WILL BE AS SHOWN ON THE PROJECT CONNECTION DRAWINGS OR LABELED ACCORDING TO THE VENDOR PANEL DESIGNATION IF NOT SHOWN ON THE PROJECT DRAWINGS. FOR EXAMPLE, "BMS#1 TERM 801a", "FAN 12 STARTER CPT–N" (CONTROL POWER NEUTRAL) ETC. FOR VENDOR REQUIRED FIELD WIRING.
11. ALL STARTERS WILL HAVE CONTROL POWER TRANSFORMERS AND THE NEUTRAL SIDE WILL BE GROUNDED, UNLESS SPECIFICALLY NOTED OTHERWISE.
12. ALL FIELD DEVICES WILL BE MOUNTED ABOVE THE ADJACENT JUNCTION BOX TO PREVENT WATER COLLECTION. LIQUID TIGHT FLEX WILL BE USED FOR FIELD DEVICES; GREENFIELD IS NOT ALLOWED.
13. ALL RACEWAYS WILL BE DEPICTED ON THE RECORD DRAWINGS AND THEIR CONTENTS LABELED. SIMPLY SHOWING HOME RUNS FOR CONTROL WIRING IS NOT ACCEPTABLE.
14. EACH CONTROL WIRING RUN WILL INCLUDE AT LEAST ONE SET OF SPARE CONDUCTORS, AND CONDUIT FILL WILL NOT EXCEED 30%. ALL CONTROL POWER RUNS WILL BE PULLED BY HAND.
15. WHERE SWITCH CONTACTS OR LIMITS ARE IN SERIES, BOTH SIDES OF EACH CONTACT WILL BE BROUGHT BACK TO THE CONTROL PANEL TO AID IN TROUBLE SHOOTING.
16. ANALOG SHIELDED CABLE WILL BE DRESSED AT EACH END USING HEAT SHRINK TUBING.

NOTES:

1. GENERATOR BATTERY RACK
2. GENERATOR BATTERY CHARGER
3. TURBINE BACKUP LUBE OIL PUMP DC STARTER
4. TURBINE AC DIRECT START VFD (MOUNT REACTOR ABOVE VFD)
5. TURBINE AC DIRECT START VFD 600V, 400A, 3–PH, 3–WIRE FUSED DISCONNECT SWITCH. FUSES TO BE 250A TYPE "J" CURRENT LIMITING, DUAL ELEMENT TIME DELAY.
6. TURBINE FUEL PUMP VFD SNUBBER RESISTOR
7. TURBINE FUEL PUMP VFD
8. TURBINE FUEL PUMP VFD 600V, 30A, 3–PH, 3–WIRE NON–FUSED DISCONNECT SWITCH.
9. COAX TAP BOX. FIELD SUPPLY AND INSTALL 12" X 12" (APPROX.) NEMA 1 BOX FOR CONTROLNET TAPS FURNISHED LOOSE BY SOLAR.
10. QUIET GROUND TERMINAL BOX.
11. CHILLER REMOTE CONTROL PANEL
12. GENERATOR ENCLOSURE HEATER CONTACTOR.
13. 480–120/208V, 3–PH, 45 KVA TRANSFORMER 'T–LP'. MOUNT 8'–0" AFF AGAINST COLUMN. BOND SECONDARY NEUTRAL TO COLUMN WITH #4 BARE COPPER WIRE.
14. 120/208V PANEL 'LP'
15. 277/480V PANEL 'PP'
16. LIGHTING CONTACTOR WITH H0A SWITCH.
17. TIMER FOR OUTDOOR LIGHTS.
18. J–BOX FOR OUTDOOR LIGHTS, RECEPTACLES AND HEAT TRACING.
19. J–BOX FOR 120VAC POWER TO BMS AND GAS COMPRESSOR CONTROL PANELS AND UNIT SUB
20. J–BOX FOR FUTURE 120VAC CONTROL TO GENERATOR CONTROL BOX
21. 2–#12 & 1–#12 GND IN 3/4 "C.
22. ROUTE WIRING TO NEW (OR EXISTING SPARE) 1–POLE, 20A CIRCUIT BREAKER IN EXISTING 120/208V PANEL 'NP'.
23. CHILLER SOLUTION PUMP VARIABLE FREQUENCY DRIVE IS SHIPPED LOOSE FOR INSTALLATION ON SKID BY CONTRACTOR.
24. J–BOX FOR WIRING TO UNIT SUB POWER METER.
25. CONTRACTOR TO COORDINATE FINAL LOCATION OF CHEMICAL FEED UNITS AND SWITCHES WITH OWNER.



ELECTRICAL POWER PLAN

0 5 10
1/8 "=1'–0"

NOTES: (CONTINUES ...)

26. FEED LIGHT WITH TAP FROM NEAREST NEW OUTDOOR 120V RECEPTACLE CIRCUIT. RUN 2–#12 & 1–#12 GND IN 3/4 "C TO J–BOX PROVIDED BY VENDOR ON SIDE OF AIR FILTER. LIGHT IS PRE–WIRED TO J–BOX BY VENDOR.
27. AREA INSIDE ENCLOSURE CONSIDERED CLASS I, DIVISION 2. INSTALL SEAL–OFF CONDUIT FITTINGS ON ALL CONDUITS ENTERING ENCLOSURE.
28. 1–#4/0 INSULATED GROUND WIRE (600V) IN 1" CONDUIT. CONNECT TO GROUND GRID.
29. MOUNT DISCONNECT SWITCH ON UNISTRUT SUPPORT.

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ELECTRICAL POWER PLAN

5.7 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R–1

PROTOTYPE PLANT
FORT BRAGG, N.C.

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

DRAWN BY	MGP	JOB No.	1336.08	SHEET No.	R1–E2
CHECKED BY	LJS	ISSUE DATE	04/20/05		

DATE BY F
DATE BY E
DATE BY D
DATE BY C
DATE BY B
DATE BY A

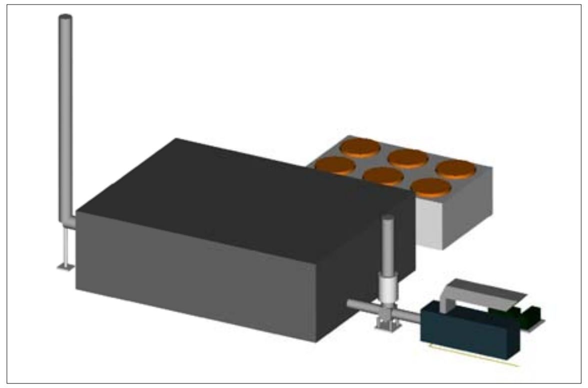
Appendix B

Reference Design R-2, Design Documents

INTEGRATED ENERGY SYSTEM
DESIGN R-2

POWER
5.3 MW

CHILLED WATER
3300 TON



SHEET INDEX

COVER	COVER SHEET
R2-PI1	SYMBOLS LEGEND
R2-PI2	P&ID – HEATING EQUIPMENT
R2-PI3	P&ID – COOLING EQUIPMENT
R2-PI4	PERFORMANCE DATA
R2-S1	GENERAL ARRANGEMENT & SITE PLAN
R2-M1	BOILER & TURBINE – EQUIPMENT ELEVATIONS
R2-E1	ELECTRICAL ONE-LINE DIAGRAM
R2-E2	ELECTRICAL POWER PLAN

REFERENCE DESIGNS

R-1	5.7 MW INTEGRATED ENERGY SYSTEM
R-2	5.3 MW INTEGRATED ENERGY SYSTEM
R-4	4.6 MW INTEGRATED ENERGY SYSTEM
R-6	3.4 MW INTEGRATED ENERGY SYSTEM
R-8	1.2 MW INTEGRATED ENERGY SYSTEM

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COVER SHEET
5.3 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R-2

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CONSULTING ENGINEERS
NASHVILLE TENNESSEE

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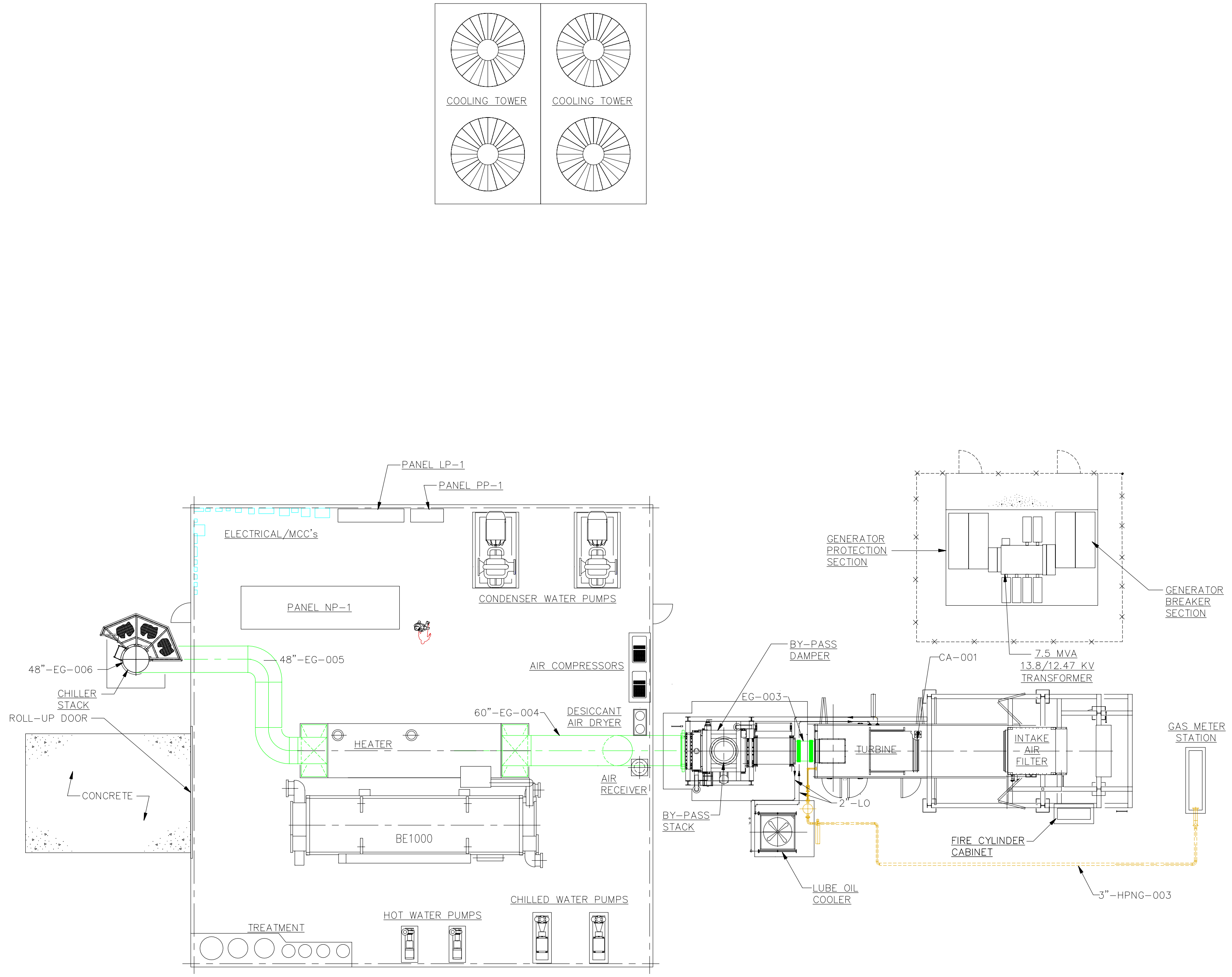

GENERAL ARRANGEMENT SITE PLAN

0 5 10
1/8 "=1'-0"

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GENERAL ARRANGEMENT & SITE PLAN

5.3 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R-2

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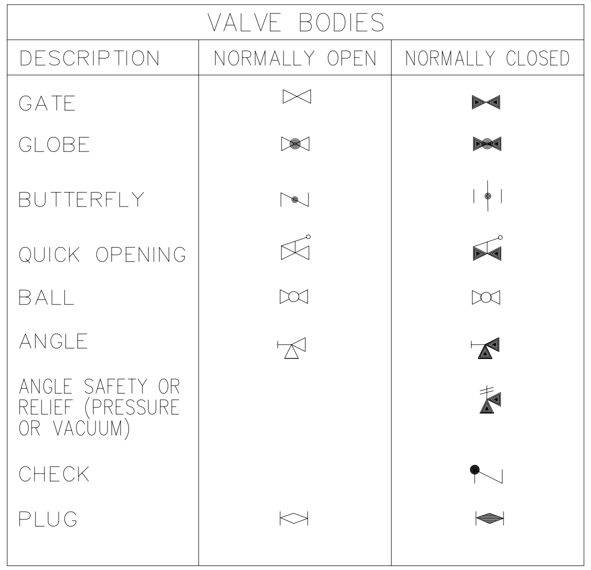
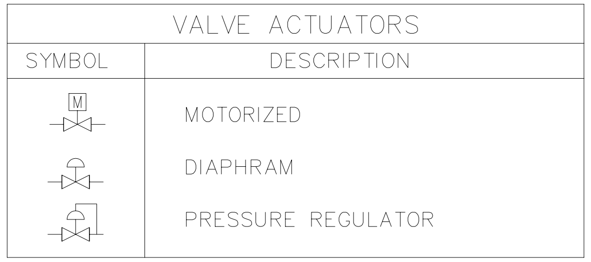
SHEET No. R2-S1



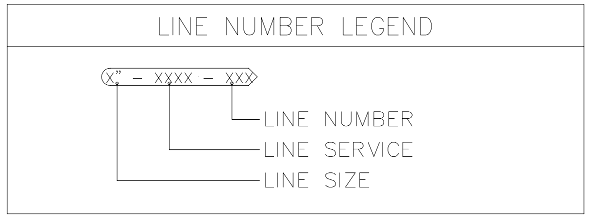
VALVE BODIES

DESCRIPTION	NORMALLY OPEN	NORMALLY CLOSED
GATE		
GLOBE		
BUTTERFLY		
QUICK OPENING		
BALL		
ANGLE		
ANGLE SAFETY OR RELIEF (PRESSURE OR VACUUM)		
CHECK		
PLUG		

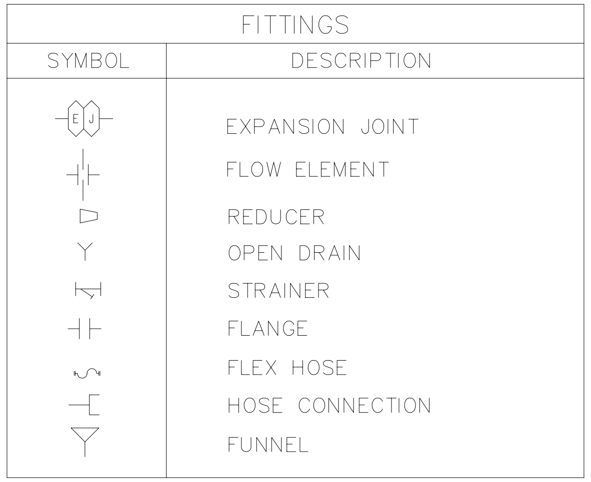


VALVE ACTUATORS

SYMBOL	DESCRIPTION
	MOTORIZED
	DIAPHRAM
	PRESSURE REGULATOR

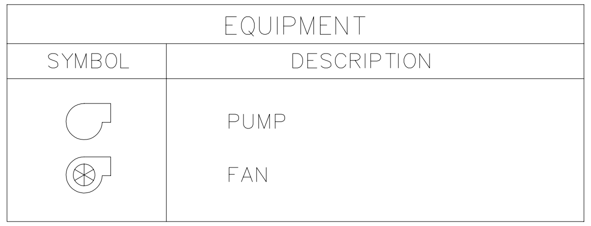


LINE NUMBER LEGEND



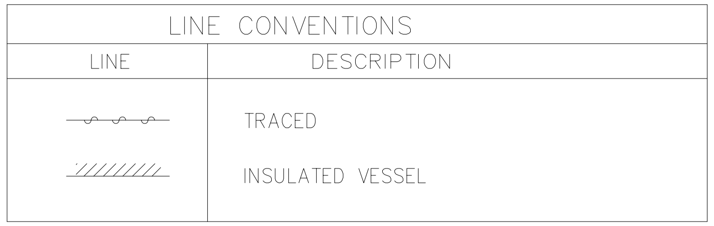
FITTINGS

SYMBOL	DESCRIPTION
	EXPANSION JOINT
	FLOW ELEMENT
	REDUCER
	OPEN DRAIN
	STRAINER
	FLANGE
	FLEX HOSE
	HOSE CONNECTION
	FUNNEL



EQUIPMENT

SYMBOL	DESCRIPTION
	PUMP
	FAN



LINE CONVENTIONS

LINE	DESCRIPTION
	TRACED
	INSULATED VESSEL

LINE SERVICE LEGEND

CA	COMBUSTION AIR
CB	CONTINUOUS BLOWDOWN
CF	CHEMICAL FEED
CHWR	CHILLED WATER RETURN
CHWS	CHILLED WATER SUPPLY
CWR	COOLING WATER RETURN
CWS	COOLING WATER SUPPLY
CW	CITY WATER
DR	DRAIN
EG	EXHAUST GAS
FOS	FUEL OIL SUPPLY
FOR	FUEL OIL RETURN
HPNG	HIGH PRESSURE NATURAL GAS
IA	INSTRUMENT AIR
LO	LUBE OIL
LOCA	LUBE OIL COOLER AIR
VT	VENT

FIELD DEVICE LEGEND

AE	ANALYZER
dPT	DIFFERENTAL PRESSURE TRANSMITTER
FCV	FLOW CONTROL VALVE
FE	FLOW ELEMENT
FQ	FLOW QUANTITY
FT	FLOW TRANSMITTER
LCV	LEVEL CONTROL VALVE
LT	LEVEL TRANSMITTER
PCV	PRESSURE CONTROL VALVE
PI	PRESSURE INDICATOR
PSH	PRESSURE SWITCH HIGH
PSV	PRESSURE SAFETY VALVE
PT	PRESSURE TRANSMITTER
TCV	TEMPERATURE CONTROL VALVE
TE	TEMPERATURE ELEMENT
TI	TEMPERATURE INDICATOR

NOTE: THIS IS A PARTIAL P&ID
TO BE USED FOR DEMONSTRATION
PURPOSES ONLY. ADDITIONAL
EQUIPMENT & FIELD DEVICES
MAY BE REQUIRED.

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SYMBOLS LEGEND

5.3 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R–2

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

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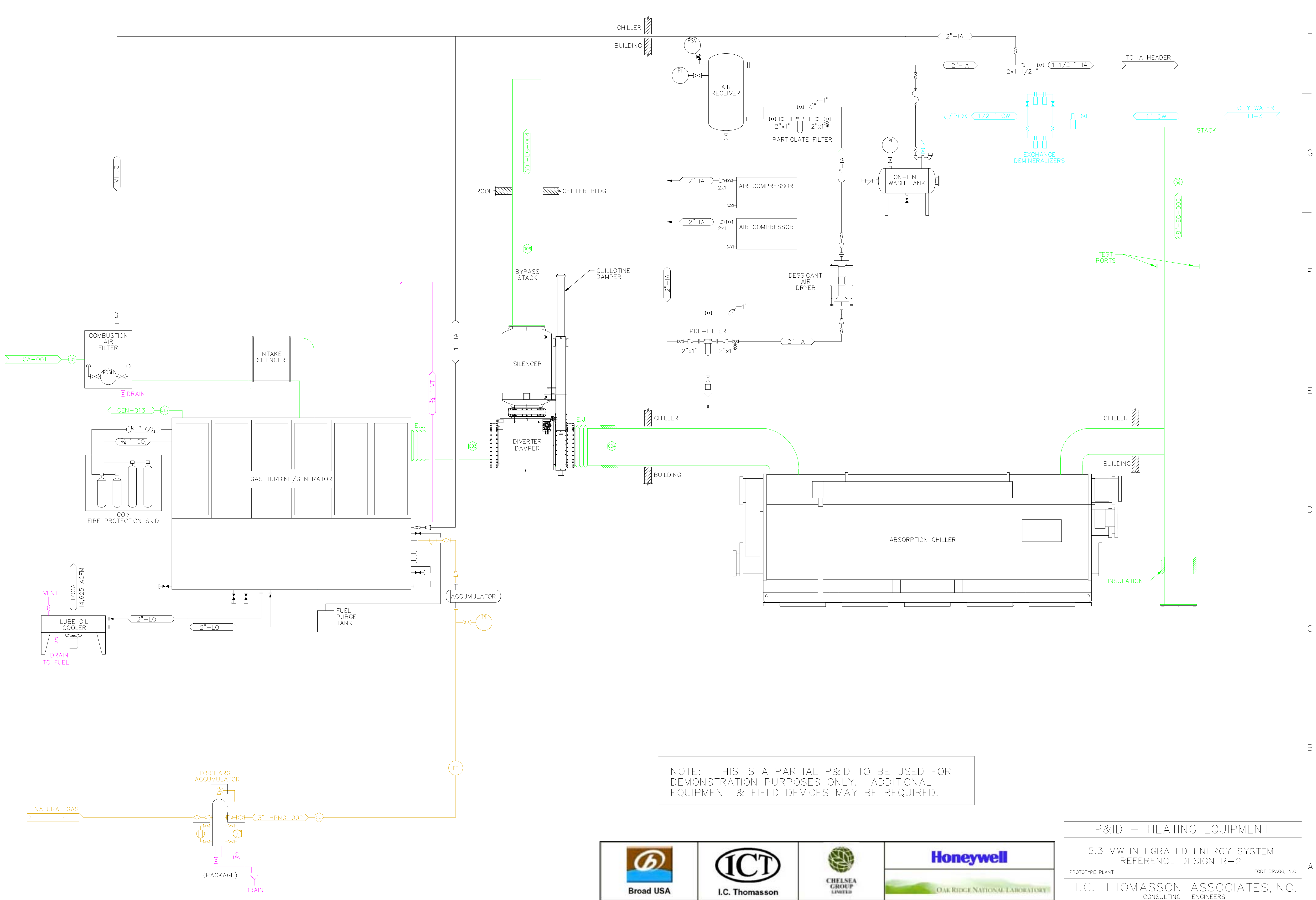

NOTE: THIS IS A PARTIAL P&ID TO BE USED FOR DEMONSTRATION PURPOSES ONLY. ADDITIONAL EQUIPMENT & FIELD DEVICES MAY BE REQUIRED.

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P&ID – HEATING EQUIPMENT

5.3 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R–2

PROTOTYPE PLANT
FORT BRAGG, N.C.

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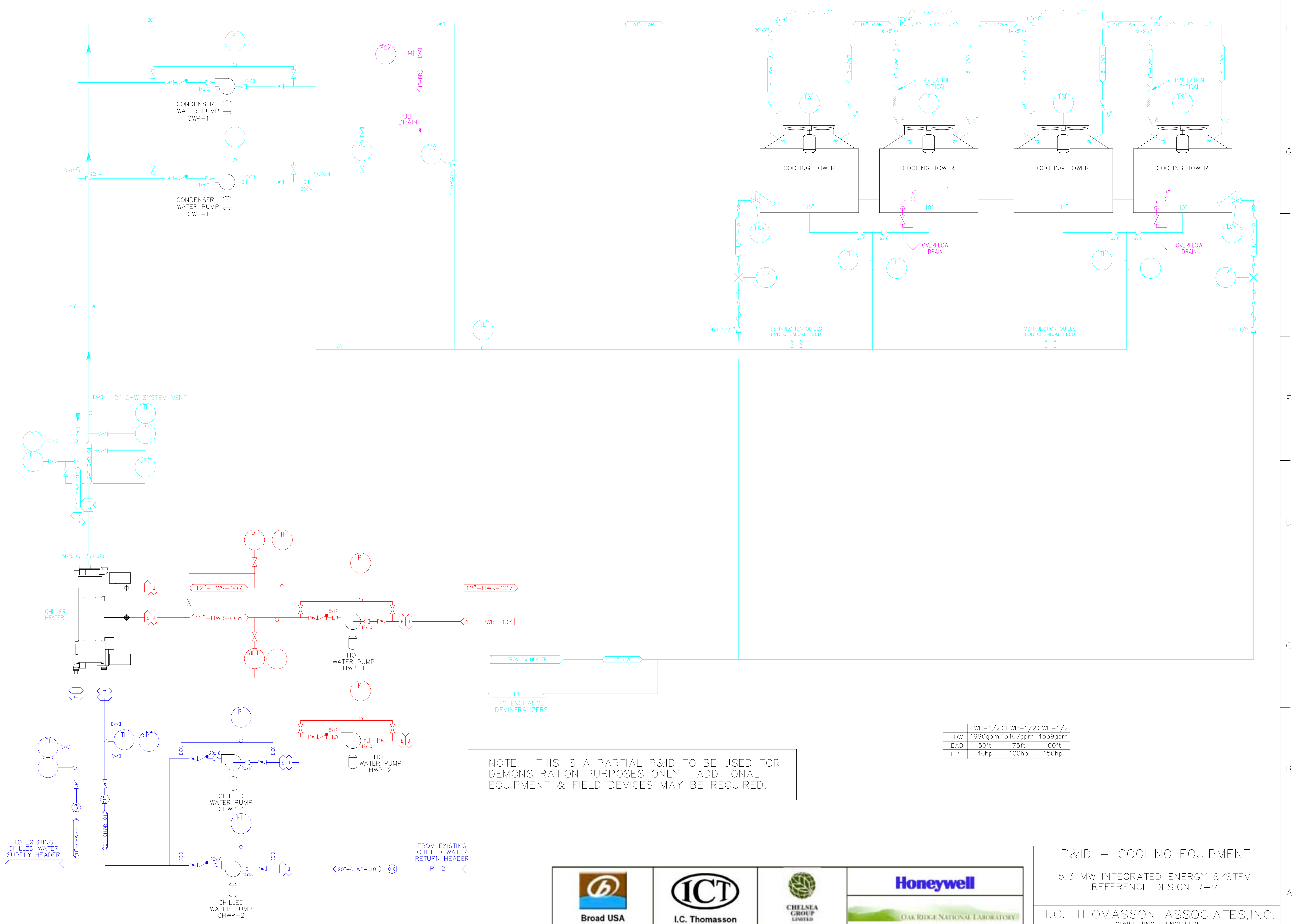

NOTE: THIS IS A PARTIAL P&ID TO BE USED FOR DEMONSTRATION PURPOSES ONLY. ADDITIONAL EQUIPMENT & FIELD DEVICES MAY BE REQUIRED.

	HWP-1/2	CHWP-1/2	CWP-1/2
FLOW	1990gpm	3467gpm	4539gpm
HEAD	50ft	75ft	100ft
HP	40hp	100hp	150hp

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P&ID – COOLING EQUIPMENT

5.3 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R-2

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CONSULTING ENGINEERS
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DATE
BY

90ºF AMBIENT AIR CONDITION
INLET AIR COOLER IN OPERATION
MAXIMUM CHILLED WATER PRODUCTION

MASS BALANCE (90ºF, 60% RH)

PID LOCATION	FLUID/SERVICE	FLOW RATE		TEMP	
CA-001	COMBUSTION AIR TO TURBINE	157,667	PPH	90	°F
3"-HPNG-002	NATURAL GAS TO TURBINE	2,717	PPH	NA	
EG-003	TURBINE EXHAUST TOTAL	160,384	PPH	980	°F
60"-EG-004	TURBINE EXHAUST TO CHILLER	160,384	PPH	980	°F
48"-EG-005	CHILLER EXHAUST TO ATMOSPHERE	160,384	PPH	338	°F
60"-EG-006	TURBINE EXHAUST TO ATMOSPHERE	0	PPH	NA	
12"-HWS-007	HOT WATER LEAVING CHILLER	0	GPM	140	°F
12"-HWR-008	HOT WATER TO CHILLER	0	GPM	125.6	°F
20"-CHWS-009	CHILLED WATER LEAVING CHILLER	6,934	GPM	44	°F
20"-CHWR-010	CHILLED WATER TO CHILLER	6,934	GPM	54	°F
24"-CWR-011	COOLING WATER LEAVING CHILLER	9,950	GPM	96.6	°F
24"-CWS-012	COOLING WATER TO CHILLER	9,950	GPM	84	°F
GEN-013	ELECTRICITY PRODUCED	4,691	KW	NA	

ENERGY CONVERSION CALCULATIONS

PID LOCATION	ENERGY INPUT	ENERGY		
3"-HPNG-002	NATURAL GAS TO TURBINE	56,000	MBTU/HR	
	TOTAL ENERGY CONSUMED	56,000	MBTU/HR	
	ELECTRICAL OUTPUT			
GEN-013	ELECTRICITY PRODUCED	16,006	MBTU/HR	
	ENERGY CONVERTED TO ELECTRICAL	29%		
	HEAT RECOVERY			
60"-EG-004	EXHAUST HEAT UTILIZED	28,885	MBTU/HR	
	ENERGY CONVERTED TO HEATING/COOLING	52%		
	COOLING WATER HEAT REJECTION	62,686	MBH	
	COOLING/HEATING OUTPUT			
20"-CHWS-009	CHILLED WATER PRODUCED	2,889	TON	
12"-HWS-007	HOT WATER PRODUCED	0	MBH	
				COP
	SYSTEM USEFUL ENERGY CONVERSION	80%		1.2

60ºF AMBIENT AIR CONDITION
INLET AIR COOLER NOT IN OPERATION
MIXED CHILLED WATER AND HOT WATER PRODUCTION

MASS BALANCE (60ºF, 60% RH)

PID LOCATION	FLUID/SERVICE	FLOW RATE		TEMP	
CA-001	COMBUSTION AIR TO TURBINE	168,950	PPH	60	°F
3"-HPNG-002	NATURAL GAS TO TURBINE	2,960	PPH	NA	
EG-003	TURBINE EXHAUST TOTAL	171,910	PPH	959	°F
60"-EG-004	TURBINE EXHAUST TO CHILLER	171,910	PPH	959	°F
48"-EG-005	CHILLER EXHAUST TO ATMOSPHERE	171,910	PPH	338	°F
60"-EG-006	TURBINE EXHAUST TO ATMOSPHERE	0	PPH	NA	
12"-HWS-007	HOT WATER LEAVING CHILLER	1,901	GPM	140	°F
12"-HWR-008	HOT WATER TO CHILLER	1,901	GPM	125.6	°F
20"-CHWS-009	CHILLED WATER LEAVING CHILLER	3,571	GPM	44	°F
20"-CHWR-010	CHILLED WATER TO CHILLER	3,571	GPM	54	°F
24"-CWR-011	COOLING WATER LEAVING CHILLER	5,243	GPM	96.6	°F
24"-CWS-012	COOLING WATER TO CHILLER	5,243	GPM	84	°F
GEN-013	ELECTRICITY PRODUCED	5,305	KW	NA	

ENERGY CONVERSION CALCULATIONS

PID LOCATION	ENERGY INPUT	ENERGY		
3"-HPNG-002	NATURAL GAS TO TURBINE	61,000	MBTU/HR	
	TOTAL ENERGY CONSUMED	61,000	MBTU/HR	
	ELECTRICAL OUTPUT			
GEN-013	ELECTRICITY PRODUCED	18,101	MBTU/HR	
	ENERGY CONVERTED TO ELECTRICAL	30%		
	HEAT RECOVERY			
60"-EG-004	EXHAUST HEAT UTILIZED	29,757	MBTU/HR	
	ENERGY CONVERTED TO HEATING/COOLING	49%		
	COOLING WATER HEAT REJECTION	33,032	MBH	
	COOLING/HEATING OUTPUT			
20"-CHWS-009	CHILLED WATER PRODUCED	1,488	TON	
12"-HWS-007	HOT WATER PRODUCED	13,688	MBH	
				COP
	SYSTEM USEFUL ENERGY CONVERSION	78%		1.1

30ºF AMBIENT AIR CONDITION
INLET AIR COOLER NOT IN OPERATION
MAXIMUM HOT WATER PRODUCTION

MASS BALANCE (30ºF, 60% RH)

PID LOCATION	FLUID/SERVICE	FLOW RATE		TEMP	
CA-001	COMBUSTION AIR TO TURBINE	176,864	PPH	30	°F
3"-HPNG-002	NATURAL GAS TO TURBINE	3,169	PPH	NA	
EG-003	TURBINE EXHAUST TOTAL	180,033	PPH	947	°F
60"-EG-004	TURBINE EXHAUST TO CHILLER	180,033	PPH	947	°F
48"-EG-005	CHILLER EXHAUST TO ATMOSPHERE	180,033	PPH	338	°F
60"-EG-006	TURBINE EXHAUST TO ATMOSPHERE	0	PPH	NA	
12"-HWS-007	HOT WATER LEAVING CHILLER	3,890	GPM	140	°F
12"-HWR-008	HOT WATER TO CHILLER	3,890	GPM	125.6	°F
20"-CHWS-009	CHILLED WATER LEAVING CHILLER	0	GPM	NA	
20"-CHWR-010	CHILLED WATER TO CHILLER	0	GPM	NA	
24"-CWR-011	COOLING WATER LEAVING CHILLER	0	GPM	NA	
24"-CWS-012	COOLING WATER TO CHILLER	0	GPM	NA	
GEN-013	ELECTRICITY PRODUCED	5,800	KW	NA	

ENERGY CONVERSION CALCULATIONS

PID LOCATION	ENERGY INPUT	ENERGY		
3"-HPNG-002	NATURAL GAS TO TURBINE	65,300	MBTU/HR	
	TOTAL ENERGY CONSUMED	65,300	MBTU/HR	
	ELECTRICAL OUTPUT			
GEN-013	ELECTRICITY PRODUCED	19,790	MBTU/HR	
	ENERGY CONVERTED TO ELECTRICAL	30%		
	HEAT RECOVERY			
60"-EG-004	EXHAUST HEAT UTILIZED	30,447	MBTU/HR	
	ENERGY CONVERTED TO HEATING/COOLING	47%		
	COOLING WATER HEAT REJECTION	0	MBH	
	COOLING/HEATING OUTPUT			
20"-CHWS-009	CHILLED WATER PRODUCED	0	TON	
12"-HWS-007	HOT WATER PRODUCED	28,011	MBH	
				COP
	SYSTEM USEFUL ENERGY CONVERSION	77%		0.9

Natural gas LHV = 20,609 Btu/lb.
"Energy Converted" is the percentage of fuel input energy converted into useable energy.
No parasitic losses are included.
SOLAR TAURUS 60-T7800SII / BROAD USA BE-1000
3% radiation and convection heat loss from chiller.

Broad USA
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CHELSEA GROUP LIMITED
Honeywell
OAK RIDGE NATIONAL LABORATORY

PERFORMANCE DATA

5.3 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R-2

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

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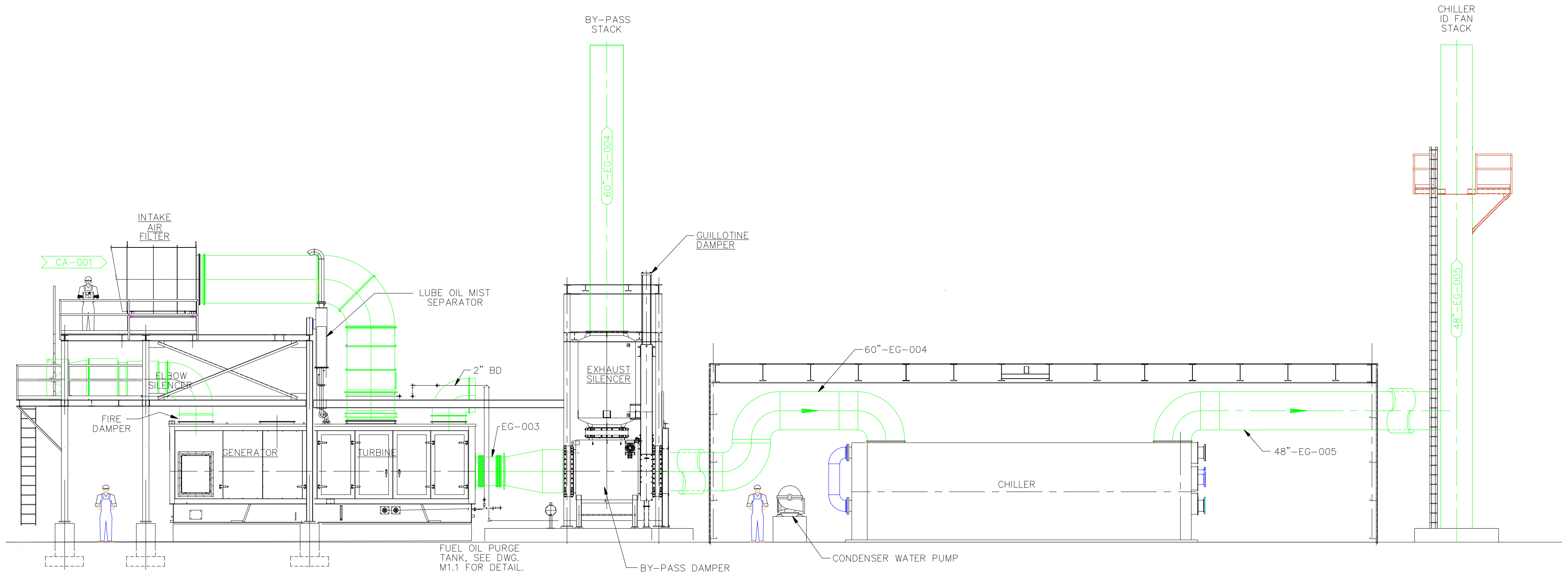

BOILER & TURBINE – PIPING SECTION

0 5 10
3/16 "=1'-0"

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OAK RIDGE NATIONAL LABORATORY

BOILER & TURBINE – EQUIPMENT ELEVATIONS

5.3 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R-1

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

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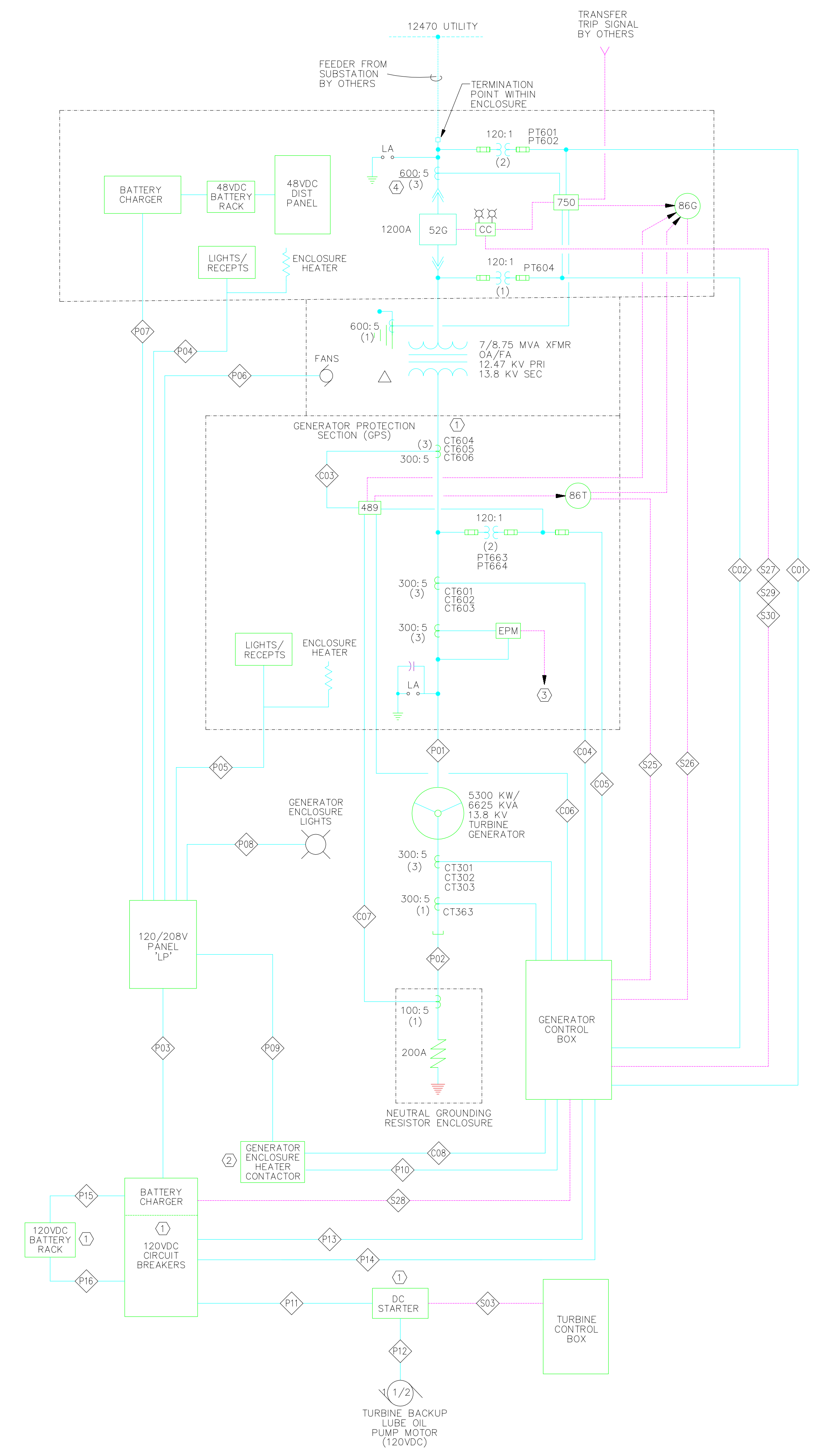
CHECKED BY	JBD	ISSUE DATE	04/20/05		

DATE BY	F	DATE BY	E	DATE BY	D	DATE BY	C	DATE BY	B	DATE BY	A



CONDUCTOR SCHEDULE

No.	Wire Spec.	Remarks
C01	2- 1/C #14 in 1"C	
C02	2- 1/C #14 (route with C01)	
C03	3-#10 TWISTED PAIRS (JUMPERS)	CT's shipped loose by Solar, installed by contractor
C04	2-#10 TWISTED PAIRS in 1"C	
C05	3- 1/C #14 (route with C04)	
C06	3-#10 TWISTED PAIRS in 1"C	Generator Neutral Side
C07	1-#10 TWISTED PAIR in 3/4"C	
C08	2- 1/C #14 in 1"C	(120VAC)
P01	3-1/C #350 & 1-1/C #1/0 Gnd in 5"C	15KV, MV-105, Shielded Cable
P02	1-1/C #2/0 in 2"C	8KV, MV-105, Shielded Cable
P03	2- 1/C #8 & 1-1/C #10 Gnd in 3/4"C	(208V, 1-PH)
P04	3- 1/C #12 & 1-1/C #12 Gnd in 1"C	(120VAC)
P05	3- 1/C #12 & 1-1/C #12 Gnd in 1"C	(120VAC)
P06	3- 1/C #12 & 1-1/C #12 Gnd in 1"C	(208VAC)
P07	2- 1/C #12 & 1-1/C #12 Gnd in 1"C	(120VAC)
P08	2- 1/C #12 & 1-1/C #12 Gnd in 1"C	(120VAC)
P09	2- 1/C #12 & 1-1/C #12 Gnd in 3/4"C	(120VAC)
P10	2- 1/C #12 & 1-1/C #12 Gnd in 1"C	(120VAC)
P11	2- 1/C #6 in 3/4 "C	(120VDC)
P12	2- 1/C #6 in 1"C	(120VDC)
P13	2- 1/C #12 (route with P14)	(120VDC)
P14	2- 1/C #4 in 2"C	(120VDC)
P15	2-1/C #12 in 3/4"C	(120VDC)
P16	2-1/C #2 in 1"C	(120VDC)
S03	2- 1/C #14 in 1"C	(24VDC)
S25	2- 1/C #14 in 1"C	86T trips turbine and generator (24 VDC)
S26	2- 1/C #14 in 1"C	86G trips generator only (24 VDC)
S27	3- 1/C #14 (route with S26)	Breaker position (24 VDC)
S28	2- 1/C #14 in 1"C	(24V DC)
S29	2- 1/C #14 (route with S26)	(48V DC)
S30	2- 1/C #14 (route with S26)	(48V DC)

LEGEND

489	-MULTILIN GENERATOR MANAGEMENT RELAY.
750	-MULTILIN FEEDER MANAGEMENT RELAY.
	-CURRENT TRANSFORMERS
	-POTENTIAL TRANSFORMERS
86	-LOCK-OUT RELAY. 86T TRIPS TURBINE AND GENERATOR BREAKER. 86G TRIPS GENERATOR BREAKER ONLY.
	-SURGE CAPACITOR, ONE-3 PHASE UNIT.
LA	-LIGHTNING ARRESTOR, 3 REQUIRED.
(1)	- NUMBER = QUANTITY OF DEVICES
▭	- FUSE
CC	- CONTROL CIRCUIT WITH INDICATOR LIGHTS
⏚	- GROUND
52G	- MED/HIGH VOLTAGE GENERATOR SYNCHRONIZING BREAKER
C#	- CONDUCTOR RUN DESIGNATOR ('C'= CONTROL, 'P'= POWER, 'S'= SIGNAL). SIGNIFIES CONDUCTORS TO BE INSTALLED BY CONTRACTOR. SEE CONDUCTOR SCHEDULE FOR MORE INFORMATION.
EPM	- ELECTRONIC POWER METER

NOTES:

1. EQUIPMENT PROVIDED LOOSE BY SOLAR FOR INSTALLATION BY CONTRACTOR.
2. HEATER CONTACTOR PROVIDED AND INSTALLED BY CONTRACTOR.
3. THIS CONTRACTOR TO INSTALL POWER METER CONDUIT FROM UNIT SUB TO JUNCTION BOX INSIDE NEW CHILLER BUILDING. CONDUIT FROM JUNCTION BOX TO PLANT CONTROL SYSTEM BY OTHERS. METER OUTPUT WIRING INSTALLED BY OTHERS.
4. CURRENT TRANSFORMER SHALL BE OF MULTI-TAP TYPE. USE 300:5 SECONDARY TAP.

Broad USA
I.C. Thomasson
CHELSEA GROUP LIMITED
Honeywell
OAK RIDGE NATIONAL LABORATORY

ELECTRICAL ONE-LINE DIAGRAM

5.3 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R-2

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

DATE BY F
DATE BY E
DATE BY D
DATE BY C
DATE BY B
DATE BY A

DRAWN BY	MGP	JOB No.	1336.08	SHEET No. R2-E1
CHECKED BY	CSH	ISSUE DATE	04/20/05	

GENERAL NOTES:

A. THE FOLLOWING MINIMUM WIRING STANDARD WILL BE FOLLOWED IN THE WIRING CONSTRUCTION ON THIS PROJECT–

1. DEFINITION: POWER CONDUCTORS INCLUDE PANEL FEEDERS AND BRANCH CIRCUITS AS WELL AS MOTOR FEEDS FROM THE MOTOR CONTROL CENTER. POWER CONDUCTORS WILL ALSO INCLUDE THOSE CONDUCTORS USED TO POWER FIELD DEVICES.
2. CONTROL CONDUCTORS INCLUDE CONDUCTORS BELOW 300 VOLTS USED IN THE INSTRUMENTATION AND CONTROL OF THE FACILITY.
3. CONTROL POWER CONDUCTORS ARE THOSE USED TO POWER FIELD DEVICES FROM PLC CABINETS, CONTROL POWER TRANSFORMERS IN MCC BUCKETS, OR PANELS DESIGNATED AS CONTROL POWER SOURCES.
4. ALL CONTROL WIRING WILL BE COLOR–CODED. POWER CONDUCTORS, CONTROL POWER CONDUCTORS AND CONTROL CONDUCTORS WILL NOT BE THE SAME COLOR. COLOR CODE AS FOLLOWS:

    120 VAC POWER: BLACK OR RED WITH BLACK STRIPE

    120 VAC POWER NEUTRAL: WHITE

    120 VAC CONTROL: RED

    120 VAC CONTROL NEUTRAL: WHITE OR RED WITH WHITE STRIPE

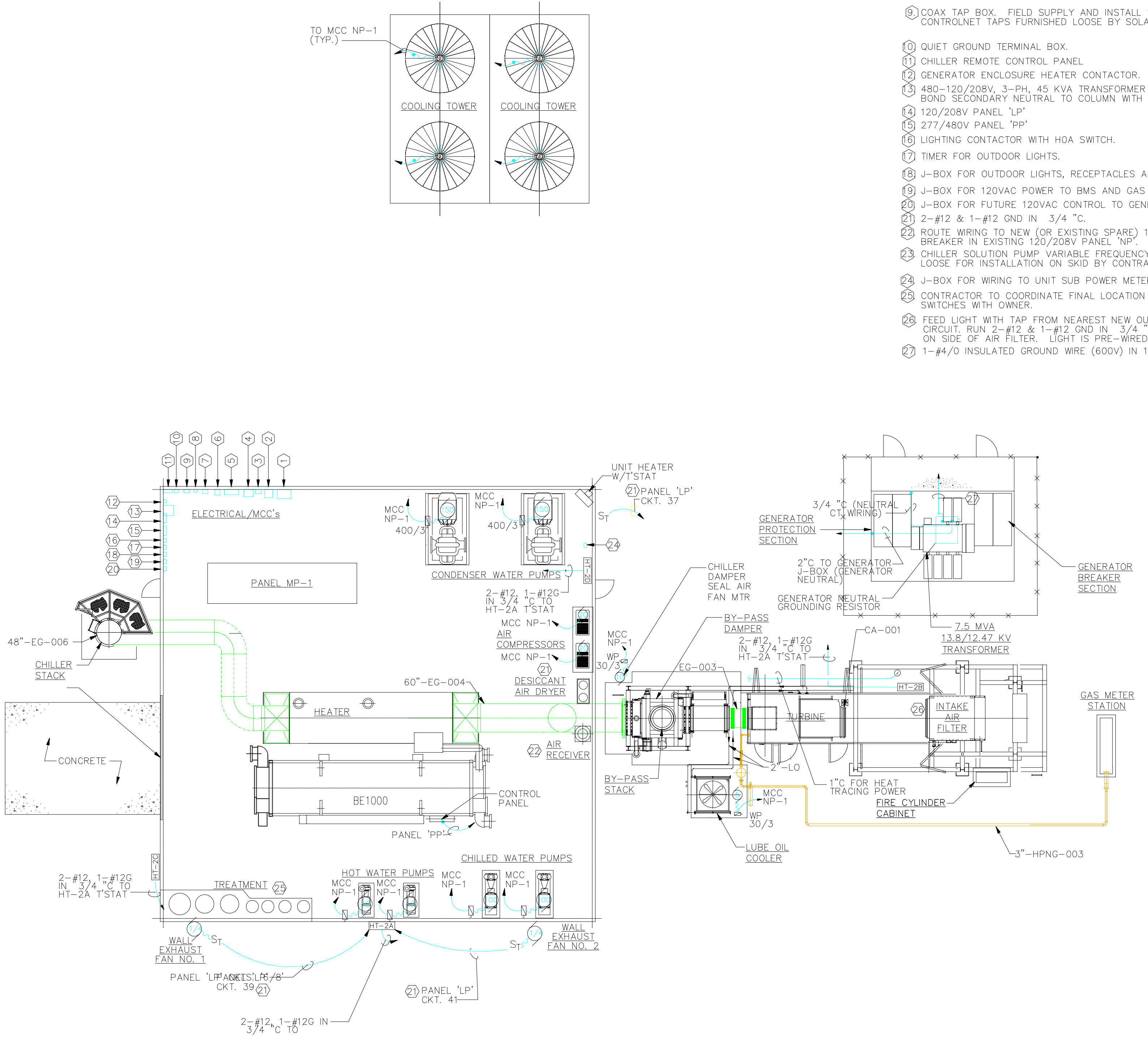
    24 VDC (+): BLUE

    24 VDC (–): WHITE WITH BLUE STRIPE OR BROWN

5. 120 VAC CONTROL OUTPUTS WILL NOT BOTH BE RED CONDUCTORS. 120 VAC SUPPLY OUTPUT WILL BE RED AND THE RETURN WILL BE A NEUTRAL. THIS MEANS THAT EVERY SOLENOID, ACTUATOR, OR OTHER FIELD DEVICE GETS A WHITE OR WHITE STRIPED WIRE.
6. MULTIPLE FIELD DEVICES REQUIRING A CONTROL POWER SOURCE WILL NOT BE FIELD WIRED IN A DAISY–CHAIN CIRCUIT FROM THE SAME CIRCUIT UNLESS SPECIFICALLY CALLED OUT ON DRAWINGS. WIRING FOR EACH DEVICE MUST BE BROUGHT BACK TO A TERMINAL.
7. CONTROL WIRING WILL BE INTEGRATED INTO THE PROJECT, NOT ADDED AT THE END WHEN EVERYONE IS INVOLVED IN START–UP.
8. CONTROL WIRING WILL NOT SHARE RACEWAYS WITH POWER WIRING, UNLESS SPECIFICALLY INDICATED ON THE DRAWINGS.
9. NO BUTT SPLICES WILL BE USED FOR ANY WIRING. ALL CONNECTIONS WILL BE MADE ON A TERMINAL STRIP.
10. LABELING WILL BE DONE IN A CONSISTENT MANNER WITH THE OTHER END OF THE CONDUCTOR. ALL WIRE NUMBERS WILL BE AS SHOWN ON THE PROJECT CONNECTION DRAWINGS OR LABELED ACCORDING TO THE VENDOR PANEL DESIGNATION IF NOT SHOWN ON THE PROJECT DRAWINGS. FOR EXAMPLE, "BMS#1 TERM 801a", "FAN 12 STARTER CPT–N" (CONTROL POWER NEUTRAL) ETC. FOR VENDOR REQUIRED FIELD WIRING.
11. ALL STARTERS WILL HAVE CONTROL POWER TRANSFORMERS AND THE NEUTRAL SIDE WILL BE GROUNDED, UNLESS SPECIFICALLY NOTED OTHERWISE.
12. ALL FIELD DEVICES WILL BE MOUNTED ABOVE THE ADJACENT JUNCTION BOX TO PREVENT WATER COLLECTION. LIQUID TIGHT FLEX WILL BE USED FOR FIELD DEVICES; GREENFIELD IS NOT ALLOWED.
13. ALL RACEWAYS WILL BE DEPICTED ON THE RECORD DRAWINGS AND THEIR CONTENTS LABELED. SIMPLY SHOWING HOME RUNS FOR CONTROL WIRING IS NOT ACCEPTABLE.
14. EACH CONTROL WIRING RUN WILL INCLUDE AT LEAST ONE SET OF SPARE CONDUCTORS, AND CONDUIT FILL WILL NOT EXCEED 30%. ALL CONTROL POWER RUNS WILL BE PULLED BY HAND.
15. WHERE SWITCH CONTACTS OR LIMITS ARE IN SERIES, BOTH SIDES OF EACH CONTACT WILL BE BROUGHT BACK TO THE CONTROL PANEL TO AID IN TROUBLE SHOOTING.
16. ANALOG SHIELDED CABLE WILL BE DRESSED AT EACH END USING HEAT SHRINK TUBING.

NOTES:

(1.) GENERATOR BATTERY RACK
(2.) GENERATOR BATTERY CHARGER
(3.) TURBINE BACKUP LUBE OIL PUMP DC STARTER
(4.) TURBINE AC DIRECT START VFD (MOUNT REACTOR ABOVE VFD)
(5.) TURBINE AC DIRECT START VFD 600V, 400A, 3–PH, 3–WIRE FUSED DISCONNECT SWITCH. FUSES TO BE 250A TYPE "J" CURRENT LIMITING, DUAL ELEMENT TIME DELAY.
(6.) TURBINE FUEL PUMP VFD SNUBBER RESISTOR
(7.) TURBINE FUEL PUMP VFD
(8.) TURBINE FUEL PUMP VFD 600V, 30A, 3–PH, 3–WIRE NON–FUSED DISCONNECT SWITCH.
(9.) COAX TAP BOX. FIELD SUPPLY AND INSTALL 12" X 12" (APPROX.) NEMA 1 BOX FOR CONTROLNET TAPS FURNISHED LOOSE BY SOLAR.
(10.) QUIET GROUND TERMINAL BOX.
(11.) CHILLER REMOTE CONTROL PANEL
(12.) GENERATOR ENCLOSURE HEATER CONTACTOR.
(13.) 480–120/208V, 3–PH, 45 KVA TRANSFORMER 'T–LP'. MOUNT 8'–0" AFF AGAINST COLUMN. BOND SECONDARY NEUTRAL TO COLUMN WITH #4 BARE COPPER WIRE.
(14.) 120/208V PANEL 'LP'
(15.) 277/480V PANEL 'PP'
(16.) LIGHTING CONTACTOR WITH H0A SWITCH.
(17.) TIMER FOR OUTDOOR LIGHTS.
(18.) J–BOX FOR OUTDOOR LIGHTS, RECEPTACLES AND HEAT TRACING.
(19.) J–BOX FOR 120VAC POWER TO BMS AND GAS COMPRESSOR CONTROL PANELS AND UNIT SUB
(20.) J–BOX FOR FUTURE 120VAC CONTROL TO GENERATOR CONTROL BOX
(21.) 2–#12 & 1–#12 GND IN 3/4 "C.
(22). ROUTE WIRING TO NEW (OR EXISTING SPARE) 1–POLE, 20A CIRCUIT BREAKER IN EXISTING 120/208V PANEL 'NP'.
(23). CHILLER SOLUTION PUMP VARIABLE FREQUENCY DRIVE IS SHIPPED LOOSE FOR INSTALLATION ON SKID BY CONTRACTOR.
(24). J–BOX FOR WIRING TO UNIT SUB POWER METER.
(25). CONTRACTOR TO COORDINATE FINAL LOCATION OF CHEMICAL FEED UNITS AND SWITCHES WITH OWNER.
(26). FEED LIGHT WITH TAP FROM NEAREST NEW OUTDOOR 120V RECEPTACLE CIRCUIT. RUN 2–#12 & 1–#12 GND IN 3/4 "C TO J–BOX PROVIDED BY VENDOR ON SIDE OF AIR FILTER. LIGHT IS PRE–WIRED TO J–BOX BY VENDOR.
(27) 1–#4/0 INSULATED GROUND WIRE (600V) IN 1" CONDUIT. CONNECT TO GROUND GRID.



ELECTRICAL POWER PLAN

0 5 10
1/8 "=1'–0"

Broad USA

I.C. Thomasson

CHELSEA GROUP LIMITED

Honeywell

OAK RIDGE NATIONAL LABORATORY

ELECTRICAL POWER PLAN

5.3 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R–2

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

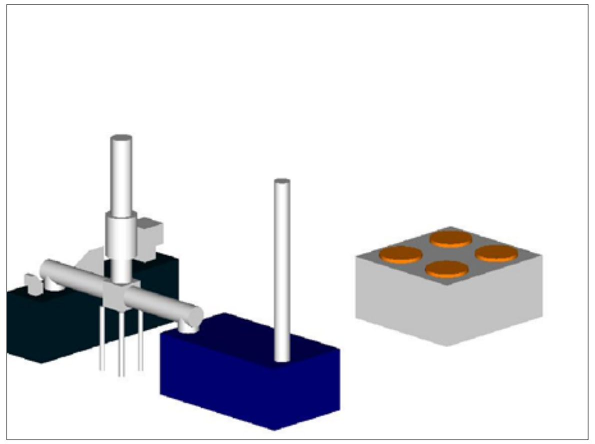
DRAWN BY	CSH	JOB No.	1336.08	SHEET No.	R2–E2
CHECKED BY	LJS	ISSUE DATE	04/20/05		

Appendix C

Reference Design R-4, Design Documents

INTEGRATED ENERGY SYSTEM
DESIGN R-4

POWER	CHILLED WATER
4.6 MW	1300 TON



SHEET INDEX

COVER	COVER SHEET
R1-PI1	SYMBOLS LEGEND
R1-PI2	P&ID - HEATING EQUIPMENT
R1-PI3	P&ID - COOLING EQUIPMENT
R1-PI4	PERFORMANCE DATA
R1-S1	GENERAL ARRANGEMENT & SITE PLAN
R1-M1	TURBINE - EQUIPMENT ELEVATIONS
R1-E1	ELECTRICAL ONE-LINE DIAGRAM
R1-E2	ELECTRICAL POWER PLAN

REFERENCE DESIGNS

R-1	5.7 MW INTEGRATED ENERGY SYSTEM
R-2	5.3 MW INTEGRATED ENERGY SYSTEM
R-4	4.6 MW INTEGRATED ENERGY SYSTEM
R-6	3.4 MW INTEGRATED ENERGY SYSTEM
R-8	1.2 MW INTEGRATED ENERGY SYSTEM

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COVER SHEET

4.6 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R-4

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

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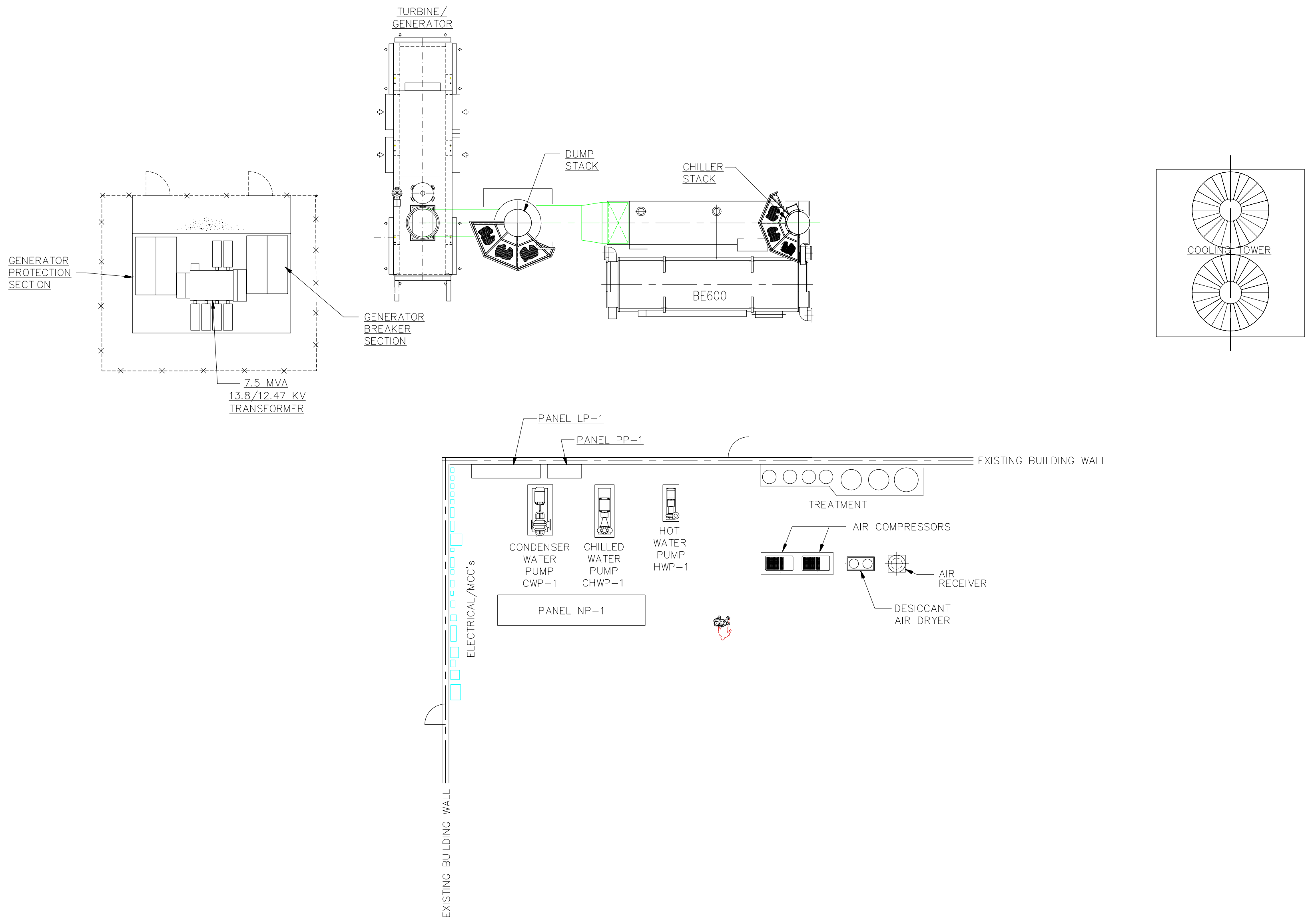
BY



GENERAL ARRANGEMENT SITE PLAN

0 5 10
1/8 "=1'-0"

Broad USA

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Honeywell

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GENERAL ARRANGEMENT & SITE PLAN

4.6 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R-4

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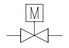
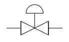
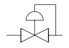
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

DRAWN BY	KER	JOB No.	1336.08	SHEET No. R4-S1
CHECKED BY	JBD	ISSUE DATE	04/20/05	

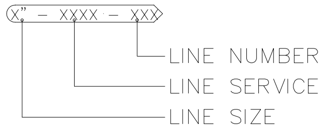
VALVE BODIES

DESCRIPTION	NORMALLY OPEN	NORMALLY CLOSED
GATE		
GLOBE		
BUTTERFLY		
QUICK OPENING		
BALL		
ANGLE		
ANGLE SAFETY OR RELIEF (PRESSURE OR VACUUM)		
CHECK		
PLUG		

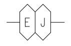
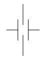
VALVE ACTUATORS

SYMBOL	DESCRIPTION
	MOTORIZED
	DIAPHRAM
	PRESSURE REGULATOR

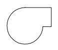
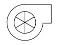
LINE NUMBER LEGEND



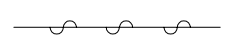
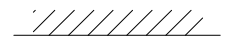
FITTINGS

SYMBOL	DESCRIPTION
	EXPANSION JOINT
	FLOW ELEMENT
	REDUCER
	OPEN DRAIN
	STRAINER
	FLANGE
	FLEX HOSE
	HOSE CONNECTION
	FUNNEL

EQUIPMENT

SYMBOL	DESCRIPTION
	PUMP
	FAN

LINE CONVENTIONS

LINE	DESCRIPTION
	TRACED
	INSULATED VESSEL

LINE SERVICE LEGEND

CA	COMBUSTION AIR
CB	CONTINUOUS BLOWDOWN
CF	CHEMICAL FEED
CHWR	CHILLED WATER RETURN
CHWS	CHILLED WATER SUPPLY
CWR	COOLING WATER RETURN
CWS	COOLING WATER SUPPLY
CW	CITY WATER
DR	DRAIN
EG	EXHAUST GAS
FOS	FUEL OIL SUPPLY
FOR	FUEL OIL RETURN
HPNG	HIGH PRESSURE NATURAL GAS
IA	INSTRUMENT AIR
LO	LUBE OIL
LOCA	LUBE OIL COOLER AIR
VT	VENT

FIELD DEVICE LEGEND

AE	ANALYZER
dPT	DIFFERENTAL PRESSURE TRANSMITTER
FCV	FLOW CONTROL VALVE
FE	FLOW ELEMENT
FQ	FLOW QUANTITY
FT	FLOW TRANSMITTER
LCV	LEVEL CONTROL VALVE
LT	LEVEL TRANSMITTER
PCV	PRESSURE CONTROL VALVE
PI	PRESSURE INDICATOR
PSH	PRESSURE SWITCH HIGH
PSV	PRESSURE SAFETY VALVE
PT	PRESSURE TRANSMITTER
TCV	TEMPERATURE CONTROL VALVE
TE	TEMPERATURE ELEMENT
TI	TEMPERATURE INDICATOR

NOTE: THIS IS A PARTIAL P&ID TO BE USED FOR DEMONSTRATION PURPOSES ONLY. ADDITIONAL EQUIPMENT & FIELD DEVICES MAY BE REQUIRED.

Broad USA
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CHELSEA GROUP LIMITED
Honeywell
OAK RIDGE NATIONAL LABORATORY

SYMBOLS LEGEND

4.6 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R-4

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

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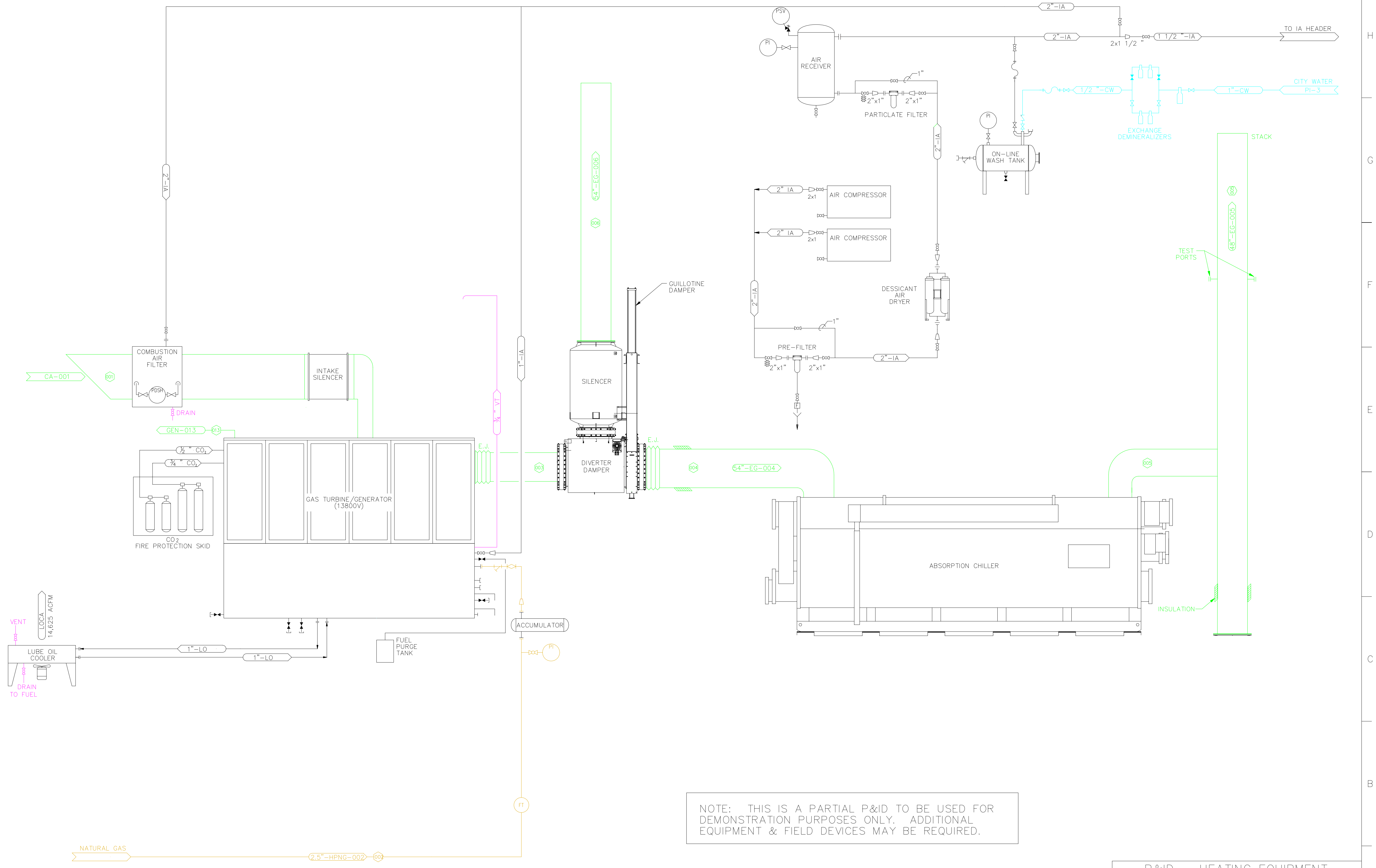

NOTE: THIS IS A PARTIAL P&ID TO BE USED FOR DEMONSTRATION PURPOSES ONLY. ADDITIONAL EQUIPMENT & FIELD DEVICES MAY BE REQUIRED.

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Honeywell
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P&ID – HEATING EQUIPMENT

4.6 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R–4

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

DRAWN BY	JWY	JOB No.	1336.08	SHEET No.	R4–PI2
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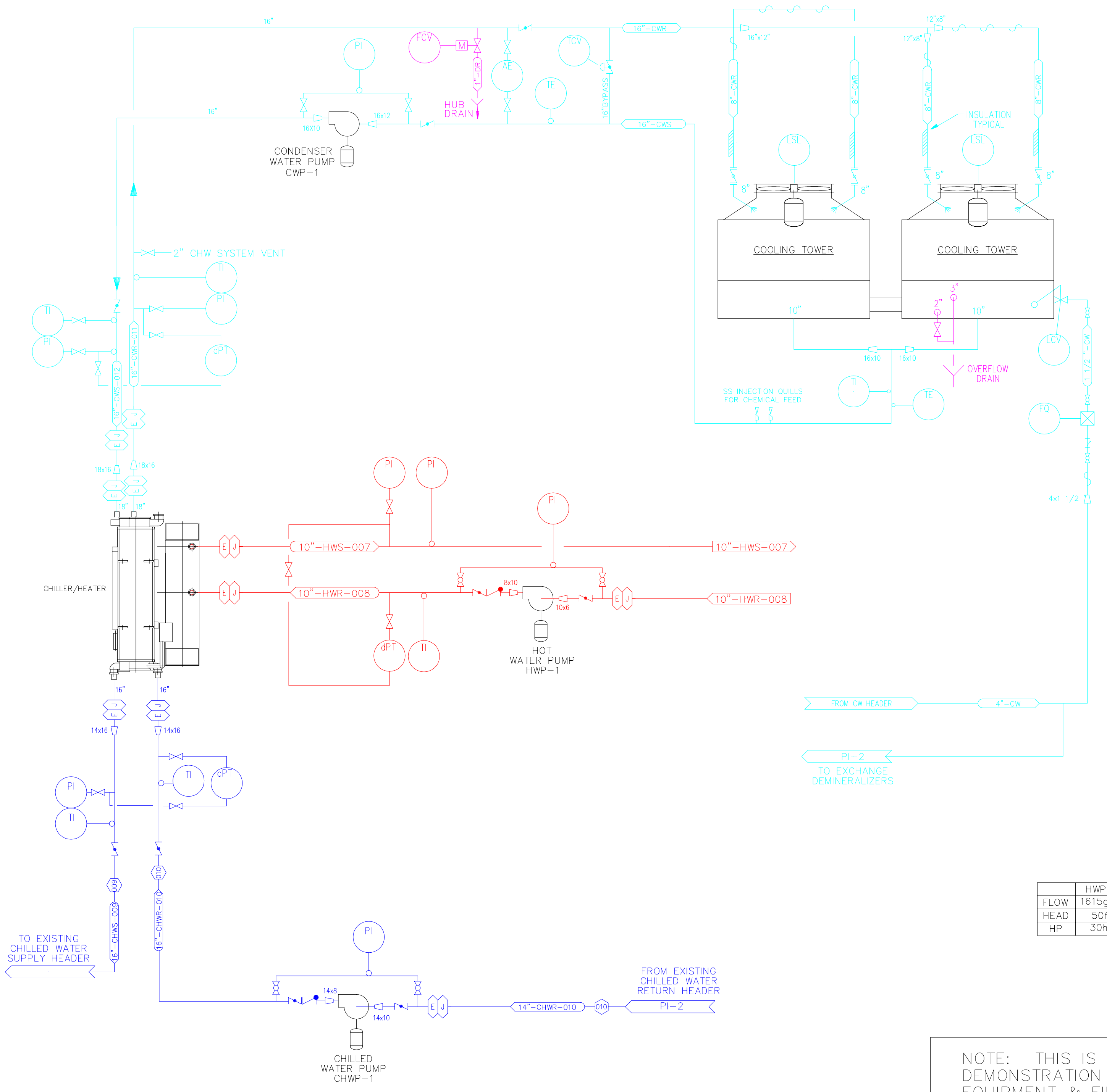

	HWP-1	CHWP-1	CWP-1
FLOW	1615gpm	3156gpm	9133gpm
HEAD	50ft	75ft	100ft
HP	30hp	75hp	150hp

NOTE: THIS IS A PARTIAL P&ID TO BE USED FOR DEMONSTRATION PURPOSES ONLY. ADDITIONAL EQUIPMENT & FIELD DEVICES MAY BE REQUIRED.

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I.C. Thomasson
CHELSEA GROUP LIMITED
Honeywell
OAK RIDGE NATIONAL LABORATORY

P&ID – COOLING EQUIPMENT

4.6 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R-4

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

DRAWN BY	BDG	JOB No.	1336.08	SHEET No.	R4-PI3
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90ºF AMBIENT AIR CONDITION
INLET AIR COOLER IN OPERATION
MAXIMUM CHILLED WATER PRODUCTION

MASS BALANCE (90ºF, 60% RH)

PID LOCATION	FLUID/SERVICE	FLOW RATE		TEMP	
CA-001	COMBUSTION AIR TO TURBINE	127,432	PPH	90	°F
2.5"-HPNG-002	NATURAL GAS TO TURBINE	1,557	PPH	NA	
EG-003	TURBINE EXHAUST TOTAL	128,989	PPH	736	°F
54"-EG-004	TURBINE EXHAUST TO CHILLER	128,989	PPH	736	°F
48"-EG-005	CHILLER EXHAUST TO ATMOSPHERE	128,989	PPH	338	°F
54"-EG-006	TURBINE EXHAUST TO ATMOSPHERE	0	PPH	NA	
10"-HWS-007	HOT WATER LEAVING CHILLER	0	GPM	140	°F
10"-HWR-008	HOT WATER TO CHILLER	0	GPM	125.6	°F
14"-CHWS-009	CHILLED WATER LEAVING CHILLER	3,156	GPM	44	°F
14"-CHWR-010	CHILLED WATER TO CHILLER	3,156	GPM	54	°F
16"-CWR-011	COOLING WATER LEAVING CHILLER	4,529	GPM	96.6	°F
16"-CWS-012	COOLING WATER TO CHILLER	4,529	GPM	84	°F
GEN-013	ELECTRICITY PRODUCED	3,752	KW	NA	

ENERGY CONVERSION CALCULATIONS

PID LOCATION	ENERGY INPUT	ENERGY		
2.5"-HPNG-002	NATURAL GAS TO TURBINE	32,088	MBH	
	TOTAL ENERGY CONSUMED	32,088	MBH	
	ELECTRICAL OUTPUT			
GEN-013	ELECTRICITY PRODUCED	12,802	MBH	
	ENERGY CONVERTED TO ELECTRICAL	40%		
	HEAT RECOVERY			
54"-EG-004	EXHAUST HEAT UTILIZED	13,147	MBH	
	ENERGY CONVERTED TO HEATING/COOLING	41%		
	COOLING WATER HEAT REJECTION	28,533	MBH	
16"-CWR-011	**COOLING/HEATING OUTPUT**			
14"-CHWS-009	CHILLED WATER PRODUCED	1,315	TON	
10"-HWS-007	HOT WATER PRODUCED	0	MBH	
				COP
	SYSTEM USEFUL ENERGY CONVERSION	81%		1.2

60ºF AMBIENT AIR CONDITION
INLET AIR COOLER NOT IN OPERATION
MIXED CHILLED WATER AND HOT WATER PRODUCTION

MASS BALANCE (60ºF, 60% RH)

PID LOCATION	FLUID/SERVICE	FLOW RATE		TEMP	
CA-001	COMBUSTION AIR TO TURBINE	137,976	PPH	60	°F
2.5"-HPNG-002	NATURAL GAS TO TURBINE	1,723	PPH	NA	
EG-003	TURBINE EXHAUST TOTAL	139,699	PPH	709	°F
54"-EG-004	TURBINE EXHAUST TO CHILLER	139,699	PPH	709	°F
48"-EG-005	CHILLER EXHAUST TO ATMOSPHERE	139,699	PPH	338	°F
54"-EG-006	TURBINE EXHAUST TO ATMOSPHERE	0	PPH	NA	
10"-HWS-007	HOT WATER LEAVING CHILLER	836	GPM	140	°F
10"-HWR-008	HOT WATER TO CHILLER	836	GPM	125.6	°F
14"-CHWS-009	CHILLED WATER LEAVING CHILLER	1,570	GPM	44	°F
14"-CHWR-010	CHILLED WATER TO CHILLER	1,570	GPM	54	°F
16"-CWR-011	COOLING WATER LEAVING CHILLER	2,305	GPM	96.6	°F
16"-CWS-012	COOLING WATER TO CHILLER	2,305	GPM	84	°F
GEN-013	ELECTRICITY PRODUCED	4,440	KW	NA	

ENERGY CONVERSION CALCULATIONS

PID LOCATION	ENERGY INPUT	ENERGY		
2.5"-HPNG-002	NATURAL GAS TO TURBINE	35,509	MBTU/HR	
	TOTAL ENERGY CONSUMED	35,509	MBTU/HR	
	ELECTRICAL OUTPUT			
GEN-013	ELECTRICITY PRODUCED	15,150	MBTU/HR	
	ENERGY CONVERTED TO ELECTRICAL	43%		
	HEAT RECOVERY			
54"-EG-004	EXHAUST HEAT UTILIZED	13,090	MBTU/HR	
	ENERGY CONVERTED TO HEATING/COOLING	37%		
	COOLING WATER HEAT REJECTION	14,524	MBH	
16"-CWR-011	**COOLING/HEATING OUTPUT**			
14"-CHWS-009	CHILLED WATER PRODUCED	654	TON	
10"-HWS-007	HOT WATER PRODUCED	6,021	MBH	
				COP
	SYSTEM USEFUL ENERGY CONVERSION	80%		1.1

30ºF AMBIENT AIR CONDITION
INLET AIR COOLER NOT IN OPERATION
MAXIMUM HOT WATER PRODUCTION

MASS BALANCE (30ºF, 60% RH)

PID LOCATION	FLUID/SERVICE	FLOW RATE		TEMP	
CA-001	COMBUSTION AIR TO TURBINE	148,423	PPH	30	°F
2.5"-HPNG-002	NATURAL GAS TO TURBINE	1,883	PPH	NA	
EG-003	TURBINE EXHAUST TOTAL	150,306	PPH	677	°F
54"-EG-004	TURBINE EXHAUST TO CHILLER	150,306	PPH	677	°F
48"-EG-005	CHILLER EXHAUST TO ATMOSPHERE	150,306	PPH	338	°F
54"-EG-006	TURBINE EXHAUST TO ATMOSPHERE	0	PPH	NA	
10"-HWS-007	HOT WATER LEAVING CHILLER	1,615	GPM	140	°F
10"-HWR-008	HOT WATER TO CHILLER	1,615	GPM	125.6	°F
14"-CHWS-009	CHILLED WATER LEAVING CHILLER	0	GPM	NA	
14"-CHWR-010	CHILLED WATER TO CHILLER	0	GPM	NA	
16"-CWR-011	COOLING WATER LEAVING CHILLER	0	GPM	NA	
16"-CWS-012	COOLING WATER TO CHILLER	0	GPM	NA	
GEN-013	ELECTRICITY PRODUCED	5,029	KW	NA	

ENERGY CONVERSION CALCULATIONS

PID LOCATION	ENERGY INPUT	ENERGY		
2.5"-HPNG-002	NATURAL GAS TO TURBINE	38,807	MBTU/HR	
	TOTAL ENERGY CONSUMED	38,807	MBTU/HR	
	ELECTRICAL OUTPUT			
GEN-013	ELECTRICITY PRODUCED	17,160	MBTU/HR	
	ENERGY CONVERTED TO ELECTRICAL	44%		
	HEAT RECOVERY			
54"-EG-004	EXHAUST HEAT UTILIZED	12,636	MBTU/HR	
	ENERGY CONVERTED TO HEATING/COOLING	33%		
	COOLING WATER HEAT REJECTION	0	MBH	
16"-CWR-011	**COOLING/HEATING OUTPUT**			
14"-CHWS-009	CHILLED WATER PRODUCED	0	TON	
10"-HWS-007	HOT WATER PRODUCED	11,625	MBH	
				COP
	SYSTEM USEFUL ENERGY CONVERSION	77%		0.9

Natural gas LHV = 20,609 Btu/lb.
"Energy Converted" is the percentage of fuel input energy converted into useable energy.
No parasitic losses are included.
SOLAR MERCURY 50 / BROAD USA BE-600
3% radiation and convection heat loss from chiller.

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PERFORMANCE DATA

4.6 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R-4

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

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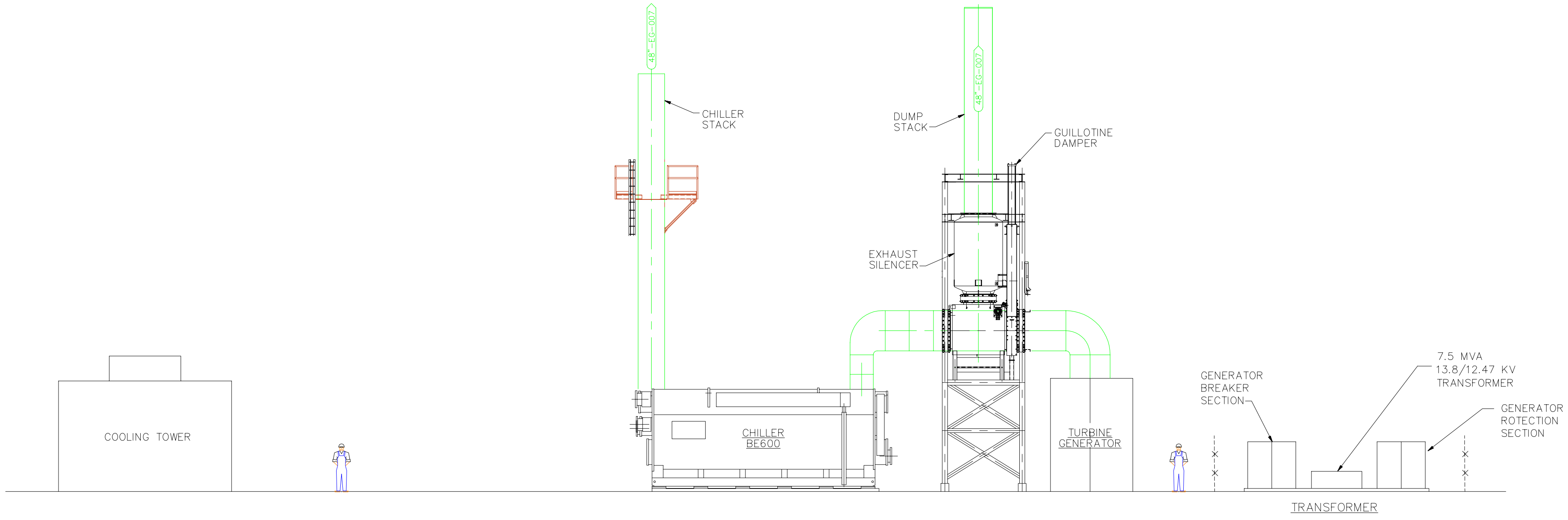

ELEVATION VIEW

0 5 10
3/16 "=1'-0"

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CHELSEA GROUP LIMITED

Honeywell

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BOILER & TURBINE – EQUIPMENT ELEVATIONS

4.6 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R-4

PROTOTYPE PLANT
FORT BRAGG, N.C.

I.C. THOMASSON ASSOCIATES,INC.
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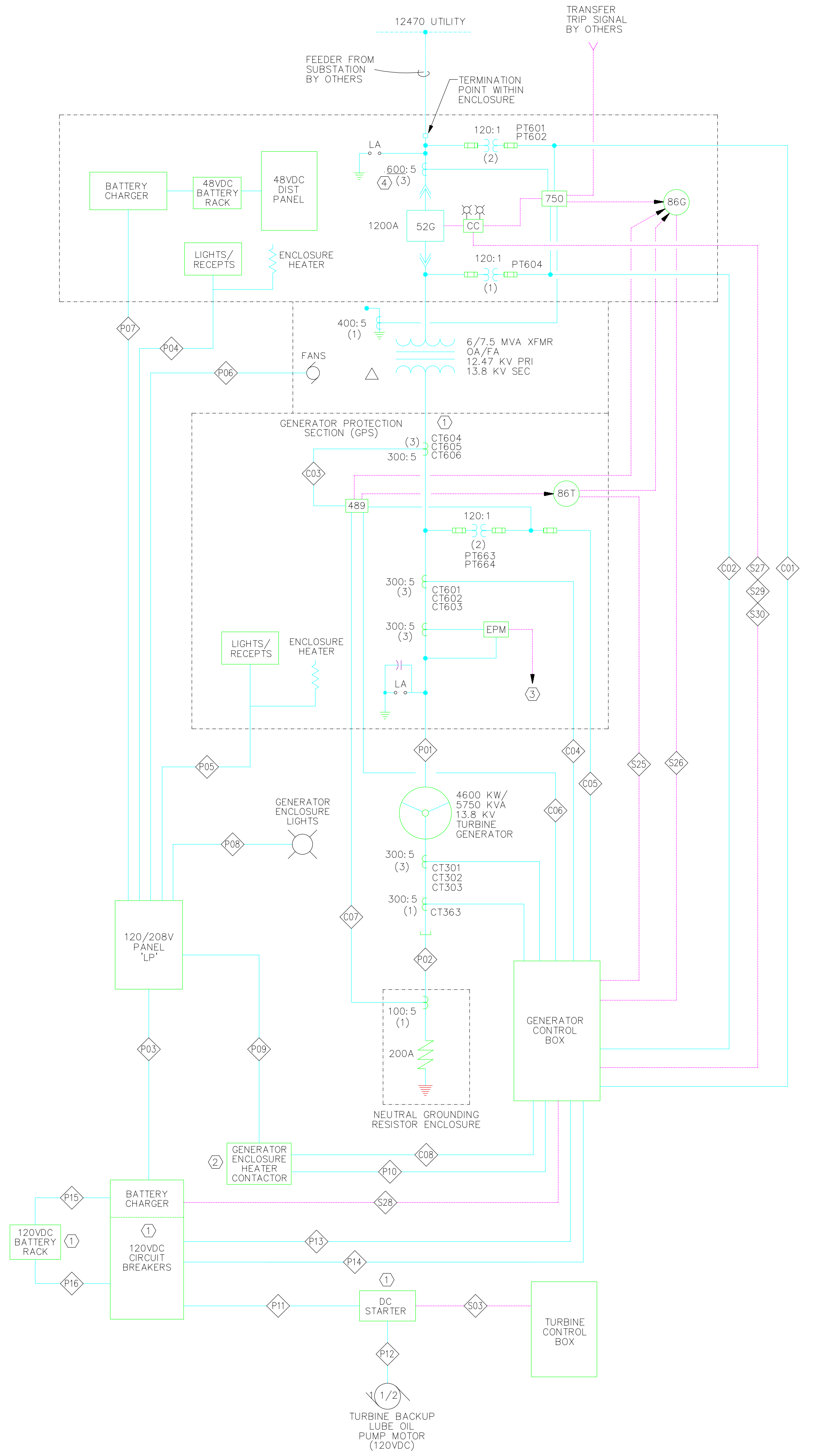

CONDUCTOR SCHEDULE

No.	Wire Spec.	Remarks
C01	2- 1/C #14 in 1"C	
C02	2- 1/C #14 (route with C01)	
C03	3-#10 TWISTED PAIRS (JUMPERS)	CT's shipped loose by Solar, installed by contractor
C04	2-#10 TWISTED PAIRS in 1"C	
C05	3- 1/C #14 (route with C04)	
C06	3-#10 TWISTED PAIRS in 1"C	Generator Neutral Side
C07	1-#10 TWISTED PAIR in 3/4"C	
C08	2- 1/C #14 in 1"C	(120VAC)
P01	3-1/C #4/0 & 1-1/C #1/0 Gnd in 4"C	15KV, MV-105, Shielded Cable
P02	1-1/C #2/0 in 2"C	8KV, MV-105, Shielded Cable
P03	2- 1/C #8 & 1-1/C #10 Gnd in 3/4"C	(208V, 1-PH)
P04	3- 1/C #12 & 1-1/C #12 Gnd in 1"C	(120VAC)
P05	3- 1/C #12 & 1-1/C #12 Gnd in 1"C	(120VAC)
P06	3- 1/C #12 & 1-1/C #12 Gnd in 1"C	(208VAC)
P07	2- 1/C #12 & 1-1/C #12 Gnd in 1"C	(120VAC)
P08	2- 1/C #12 & 1-1/C #12 Gnd in 1"C	(120VAC)
P09	2- 1/C #12 & 1-1/C #12 Gnd in 3/4"C	(120VAC)
P10	2- 1/C #12 & 1-1/C #12 Gnd in 1"C	(120VAC)
P11	2- 1/C #6 in 3/4 "C	(120VDC)
P12	2- 1/C #6 in 1"C	(120VDC)
P13	2- 1/C #12 (route with P14)	(120VDC)
P14	2- 1/C #4 in 2"C	(120VDC)
P15	2-1/C #12 in 3/4"C	(120VDC)
P16	2-1/C #2 in 1"C	(120VDC)
S03	2- 1/C #14 in 1"C	(24VDC)
S25	2- 1/C #14 in 1"C	86T trips turbine and generator (24 VDC)
S26	2- 1/C #14 in 1"C	86G trips generator only (24 VDC)
S27	3- 1/C #14 (route with S26)	Breaker position (24 VDC)
S28	2- 1/C #14 in 1"C	(24V DC)
S29	2- 1/C #14 (route with S26)	(48V DC)
S30	2- 1/C #14 (route with S26)	(48V DC)

LEGEND

489 –MULTILIN GENERATOR MANAGEMENT RELAY.
750 –MULTILIN FEEDER MANAGEMENT RELAY.
–CURRENT TRANSFORMERS
–POTENTIAL TRANSFORMERS
86 –LOCK–OUT RELAY. 86T TRIPS TURBINE AND GENERATOR BREAKER. 86G TRIPS GENERATOR BREAKER ONLY.
–SURGE CAPACITOR, ONE–3 PHASE UNIT.
LA –LIGHTNING ARRESTOR, 3 REQUIRED.
(1) – NUMBER = QUANTITY OF DEVICES
– FUSE
CC – CONTROL CIRCUIT WITH INDICATOR LIGHTS
– GROUND
52G – MED/HIGH VOLTAGE GENERATOR SYNCHRONIZING BREAKER
C# – CONDUCTOR RUN DESIGNATOR ('C'= CONTROL, 'P'= POWER, 'S'= SIGNAL). SIGNIFIES CONDUCTORS TO BE INSTALLED BY CONTRACTOR. SEE CONDUCTOR SCHEDULE FOR MORE INFORMATION.
EPM – ELECTRONIC POWER METER

NOTES:

1. EQUIPMENT PROVIDED LOOSE BY SOLAR FOR INSTALLATION BY CONTRACTOR.
2. HEATER CONTACTOR PROVIDED AND INSTALLED BY CONTRACTOR.
3. THIS CONTRACTOR TO INSTALL POWER METER CONDUIT FROM UNIT SUB TO JUNCTION BOX INSIDE NEW CHILLER BUILDING. CONDUIT FROM JUNCTION BOX TO PLANT CONTROL SYSTEM BY OTHERS. METER OUTPUT WIRING INSTALLED BY OTHERS.
4. CURRENT TRANSFORMER SHALL BE OF MULTI–TAP TYPE. USE 300:5 SECONDARY TAP.

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ELECTRICAL ONE–LINE DIAGRAM

4.6 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R–4

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

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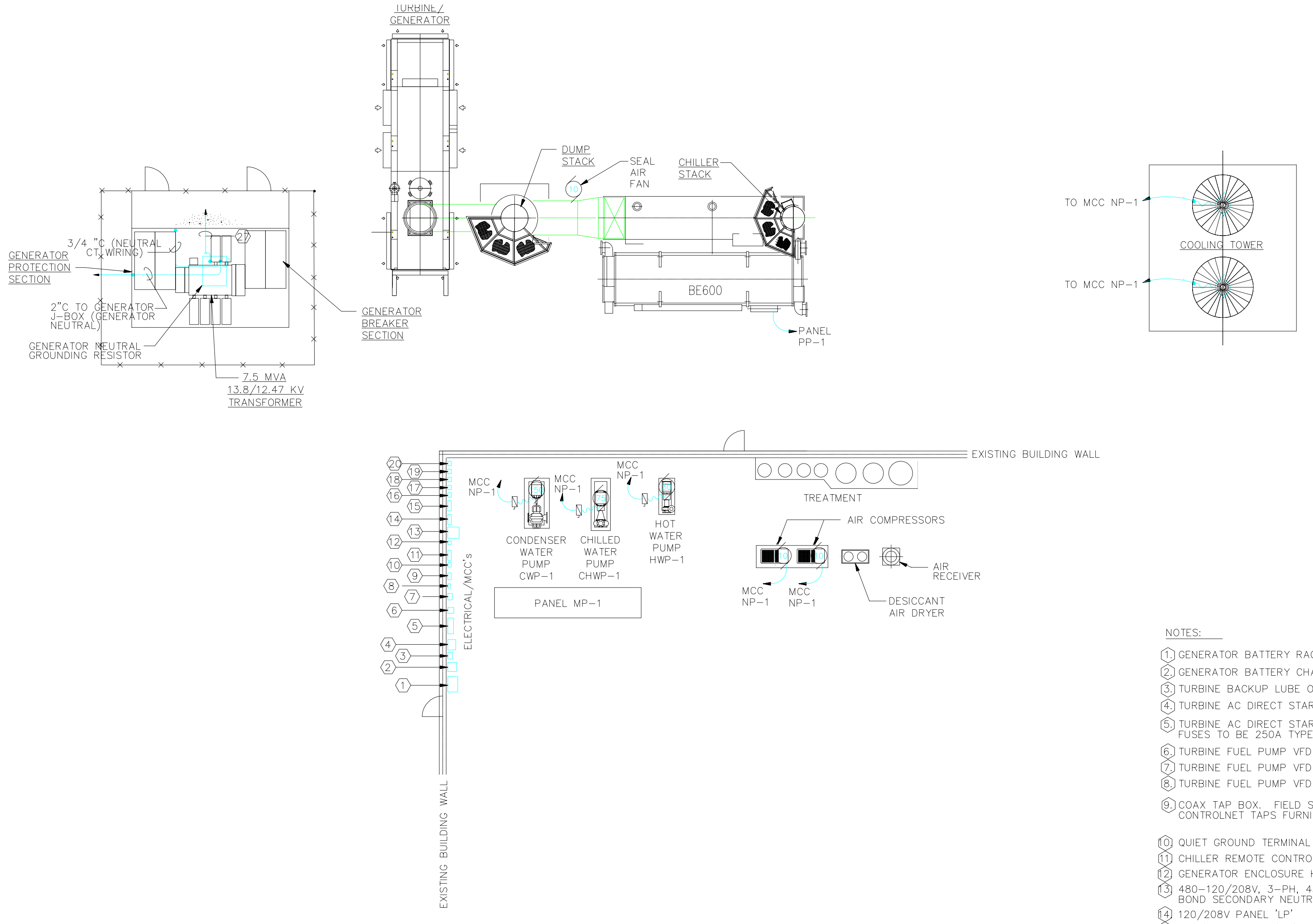

ELECTRICAL POWER PLAN

0 5 10
1/8"=1'-0"

GENERAL NOTES:

B. THE FOLLOWING MINIMUM WIRING STANDARD WILL BE FOLLOWED IN THE WIRING CONSTRUCTION ON THIS PROJECT–

1. DEFINITION: POWER CONDUCTORS INCLUDE PANEL FEEDERS AND BRANCH CIRCUITS AS WELL AS MOTOR FEEDS FROM THE MOTOR CONTROL CENTER. POWER CONDUCTORS WILL ALSO INCLUDE THOSE CONDUCTORS USED TO POWER FIELD DEVICES.
2. CONTROL CONDUCTORS INCLUDE CONDUCTORS BELOW 300 VOLTS USED IN THE INSTRUMENTATION AND CONTROL OF THE FACILITY.
3. CONTROL POWER CONDUCTORS ARE THOSE USED TO POWER FIELD DEVICES FROM PLC CABINETS, CONTROL POWER TRANSFORMERS IN MCC BUCKETS, OR PANELS DESIGNATED AS CONTROL POWER SOURCES.
4. ALL CONTROL WIRING WILL BE COLOR–CODED. POWER CONDUCTORS, CONTROL POWER CONDUCTORS AND CONTROL CONDUCTORS WILL NOT BE THE SAME COLOR. COLOR CODE AS FOLLOWS:

   120 VAC POWER: BLACK OR RED WITH BLACK STRIPE

   120 VAC POWER NEUTRAL: WHITE

   120 VAC CONTROL: RED

   120 VAC CONTROL NEUTRAL: WHITE OR RED WITH WHITE STRIPE

   24 VDC (+): BLUE

   24 VDC (–): WHITE WITH BLUE STRIPE OR BROWN
5. 120 VAC CONTROL OUTPUTS WILL NOT BOTH BE RED CONDUCTORS. 120 VAC SUPPLY OUTPUT WILL BE RED AND THE RETURN WILL BE A NEUTRAL. THIS MEANS THAT EVERY SOLENOID, ACTUATOR, OR OTHER FIELD DEVICE GETS A WHITE OR WHITE STRIPED WIRE.
6. MULTIPLE FIELD DEVICES REQUIRING A CONTROL POWER SOURCE WILL NOT BE FIELD WIRED IN A DAISY–CHAIN CIRCUIT FROM THE SAME CIRCUIT UNLESS SPECIFICALLY CALLED OUT ON DRAWINGS. WIRING FOR EACH DEVICE MUST BE BROUGHT BACK TO A TERMINAL.
7. CONTROL WIRING WILL BE INTEGRATED INTO THE PROJECT, NOT ADDED AT THE END WHEN EVERYONE IS INVOLVED IN START–UP.
8. CONTROL WIRING WILL NOT SHARE RACEWAYS WITH POWER WIRING, UNLESS SPECIFICALLY INDICATED ON THE DRAWINGS.
9. NO BUTT SPLICES WILL BE USED FOR ANY WIRING. ALL CONNECTIONS WILL BE MADE ON A TERMINAL STRIP.
10. LABELING WILL BE DONE IN A CONSISTENT MANNER WITH THE OTHER END OF THE CONDUCTOR. ALL WIRE NUMBERS WILL BE AS SHOWN ON THE PROJECT CONNECTION DRAWINGS OR LABELED ACCORDING TO THE VENDOR PANEL DESIGNATION IF NOT SHOWN ON THE PROJECT DRAWINGS. FOR EXAMPLE, "BMS#1 TERM 801a", "FAN 12 STARTER CPT–N" (CONTROL POWER NEUTRAL) ETC. FOR VENDOR REQUIRED FIELD WIRING.
11. ALL STARTERS WILL HAVE CONTROL POWER TRANSFORMERS AND THE NEUTRAL SIDE WILL BE GROUNDED, UNLESS SPECIFICALLY NOTED OTHERWISE.
12. ALL FIELD DEVICES WILL BE MOUNTED ABOVE THE ADJACENT JUNCTION BOX TO PREVENT WATER COLLECTION. LIQUID TIGHT FLEX WILL BE USED FOR FIELD DEVICES; GREENFIELD IS NOT ALLOWED.
13. ALL RACEWAYS WILL BE DEPICTED ON THE RECORD DRAWINGS AND THEIR CONTENTS LABELED. SIMPLY SHOWING HOME RUNS FOR CONTROL WIRING IS NOT ACCEPTABLE.
14. EACH CONTROL WIRING RUN WILL INCLUDE AT LEAST ONE SET OF SPARE CONDUCTORS, AND CONDUIT FILL WILL NOT EXCEED 30%. ALL CONTROL POWER RUNS WILL BE PULLED BY HAND.
15. WHERE SWITCH CONTACTS OR LIMITS ARE IN SERIES, BOTH SIDES OF EACH CONTACT WILL BE BROUGHT BACK TO THE CONTROL PANEL TO AID IN TROUBLE SHOOTING.
16. ANALOG SHIELDED CABLE WILL BE DRESSED AT EACH END USING HEAT SHRINK TUBING.

NOTES:

1. GENERATOR BATTERY RACK
2. GENERATOR BATTERY CHARGER
3. TURBINE BACKUP LUBE OIL PUMP DC STARTER
4. TURBINE AC DIRECT START VFD (MOUNT REACTOR ABOVE VFD)
5. TURBINE AC DIRECT START VFD 600V, 400A, 3–PH, 3–WIRE FUSED DISCONNECT SWITCH. FUSES TO BE 250A TYPE "J" CURRENT LIMITING, DUAL ELEMENT TIME DELAY.
6. TURBINE FUEL PUMP VFD SNUBBER RESISTOR
7. TURBINE FUEL PUMP VFD
8. TURBINE FUEL PUMP VFD 600V, 30A, 3–PH, 3–WIRE NON–FUSED DISCONNECT SWITCH.
9. COAX TAP BOX. FIELD SUPPLY AND INSTALL 12" X 12" (APPROX.) NEMA 1 BOX FOR CONTROLNET TAPS FURNISHED LOOSE BY SOLAR.
10. QUIET GROUND TERMINAL BOX.
11. CHILLER REMOTE CONTROL PANEL
12. GENERATOR ENCLOSURE HEATER CONTACTOR.
13. 480–120/208V, 3–PH, 45 KVA TRANSFORMER 'T–LP'. MOUNT 8'–0" AFF AGAINST COLUMN. BOND SECONDARY NEUTRAL TO COLUMN WITH #4 BARE COPPER WIRE.
14. 120/208V PANEL 'LP'
15. 277/480V PANEL 'PP'
16. LIGHTING CONTACTOR WITH H0A SWITCH.
17. TIMER FOR OUTDOOR LIGHTS.
18. J–BOX FOR OUTDOOR LIGHTS, RECEPTACLES AND HEAT TRACING.
19. J–BOX FOR 120VAC POWER TO BMS AND GAS COMPRESSOR CONTROL PANELS AND UNIT SUB
20. J–BOX FOR FUTURE 120VAC CONTROL TO GENERATOR CONTROL BOX
21. 2–#12 & 1–#12 GND IN 3/4 "C.
22. ROUTE WIRING TO NEW (OR EXISTING SPARE) 1–POLE, 20A CIRCUIT BREAKER IN EXISTING 120/208V PANEL 'NP'.
23. CHILLER SOLUTION PUMP VARIABLE FREQUENCY DRIVE IS SHIPPED LOOSE FOR INSTALLATION ON SKID BY CONTRACTOR.
24. J–BOX FOR WIRING TO UNIT SUB POWER METER.
25. CONTRACTOR TO COORDINATE FINAL LOCATION OF CHEMICAL FEED UNITS AND SWITCHES WITH OWNER.
26. FEED LIGHT WITH TAP FROM NEAREST NEW OUTDOOR 120V RECEPTACLE CIRCUIT. RUN 2–#12 & 1–#12 GND IN 3/4 "C TO J–BOX PROVIDED BY VENDOR ON SIDE OF AIR FILTER. LIGHT IS PRE–WIRED TO J–BOX BY VENDOR.
27. 1–#4/0 INSULATED GROUND WIRE (600V) IN 1" CONDUIT. CONNECT TO GROUND GRID.

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ELECTRICAL POWER PLAN

4.6 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R–4

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

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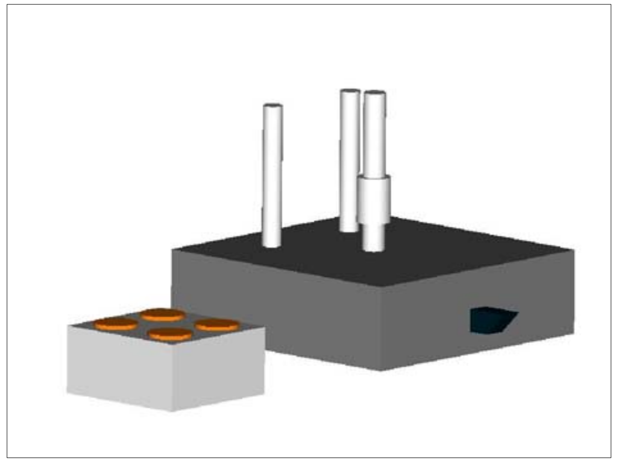
Appendix D

Reference Design R-6, Design Documents

INTEGRATED ENERGY SYSTEM
DESIGN R-6

POWER	CHILLED WATER
3.5 MW	2000 TON



SHEET INDEX

COVER	COVER SHEET
R1-PI1	SYMBOLS LEGEND
R1-PI2	P&ID - HEATING EQUIPMENT
R1-PI3	P&ID - COOLING EQUIPMENT
R1-PI4	PERFORMANCE DATA
R1-S1	GENERAL ARRANGEMENT & SITE PLAN
R1-M1	TURBINE - EQUIPMENT ELEVATIONS
R1-E1	ELECTRICAL ONE-LINE DIAGRAM
R1-E2	ELECTRICAL POWER PLAN

REFERENCE DESIGNS

R-1	5.7 MW INTEGRATED ENERGY SYSTEM
R-2	5.3 MW INTEGRATED ENERGY SYSTEM
R-4	4.6 MW INTEGRATED ENERGY SYSTEM
R-6	3.4 MW INTEGRATED ENERGY SYSTEM
R-8	1.2 MW INTEGRATED ENERGY SYSTEM

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COVER SHEET

3.4MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R-6

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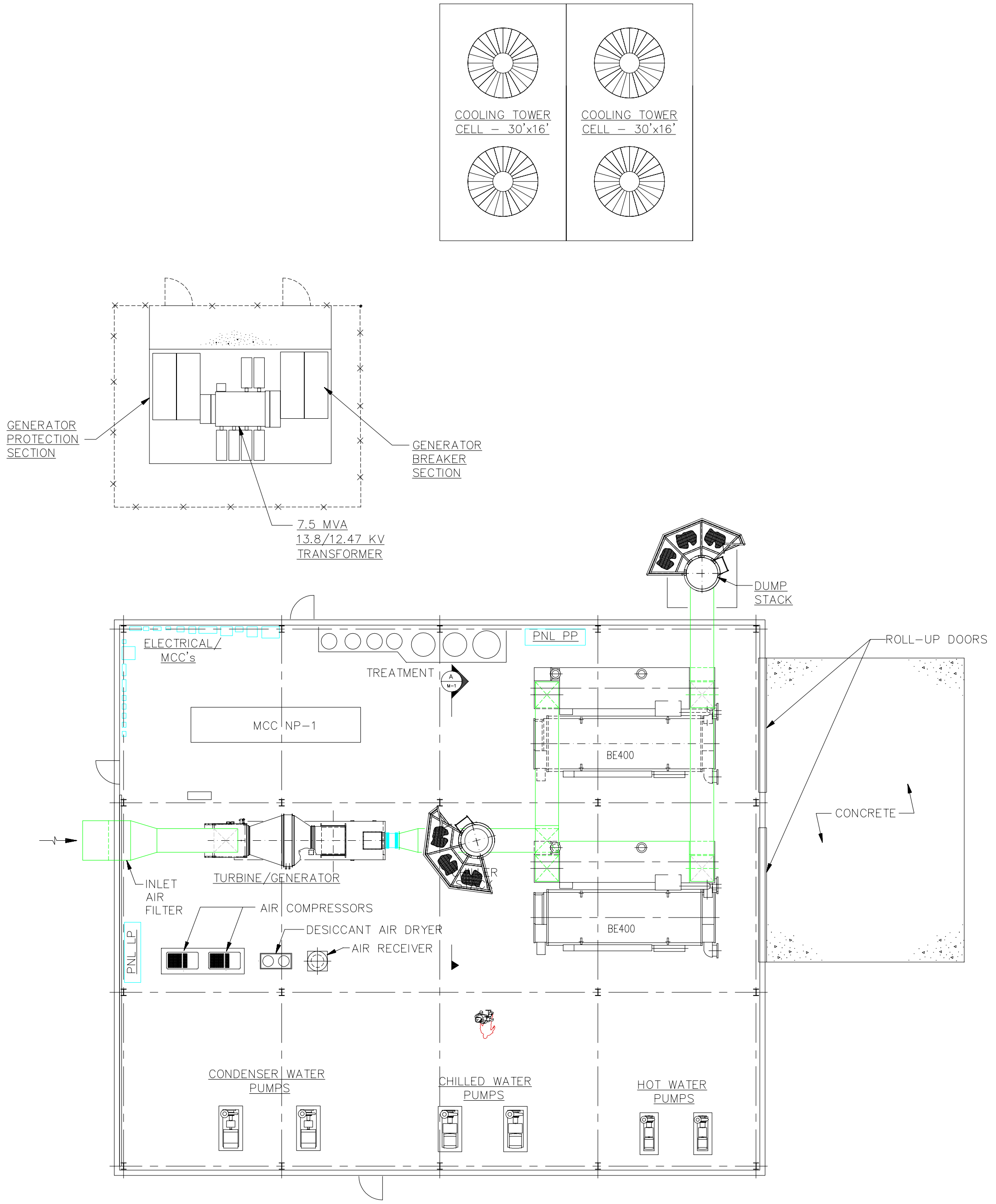

GENERAL ARRANGEMENT SITE PLAN

0 5 10
1/8"=1'-0"

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GENERAL ARRANGEMENT & SITE PLAN

3.4 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R-6

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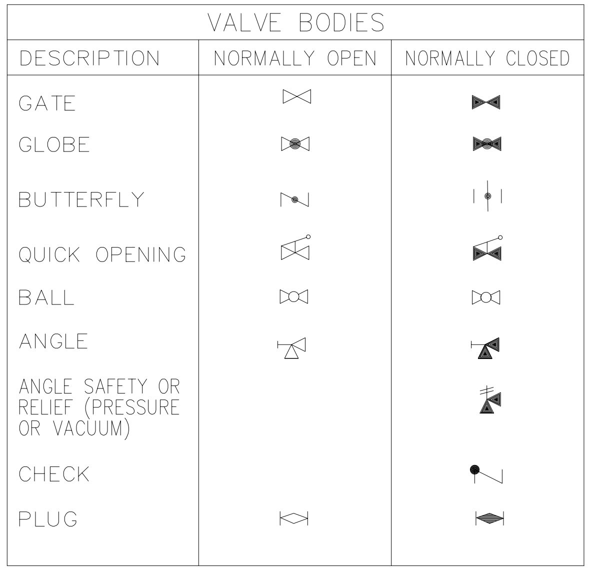
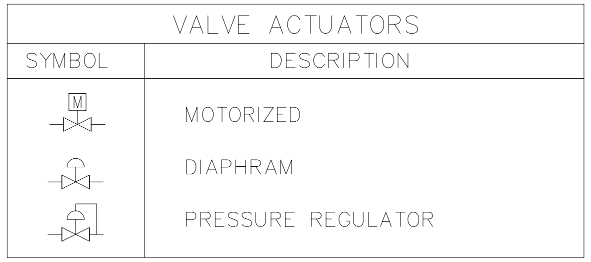


VALVE BODIES

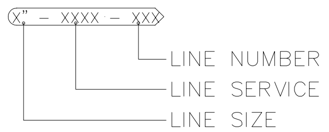
DESCRIPTION	NORMALLY OPEN	NORMALLY CLOSED
GATE		
GLOBE		
BUTTERFLY		
QUICK OPENING		
BALL		
ANGLE		
ANGLE SAFETY OR RELIEF (PRESSURE OR VACUUM)		
CHECK		
PLUG		

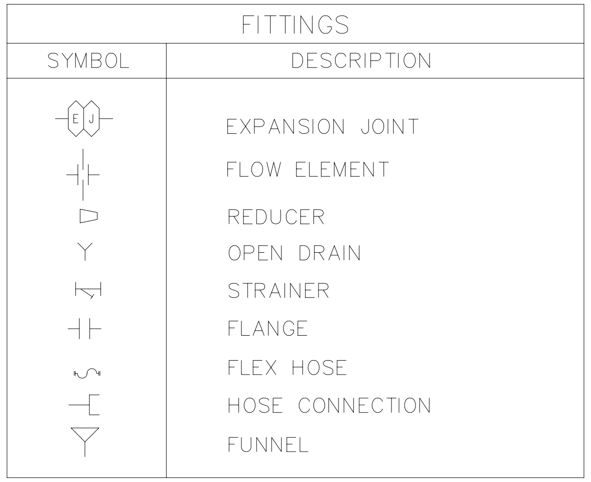


VALVE ACTUATORS

SYMBOL	DESCRIPTION
	MOTORIZED
	DIAPHRAM
	PRESSURE REGULATOR

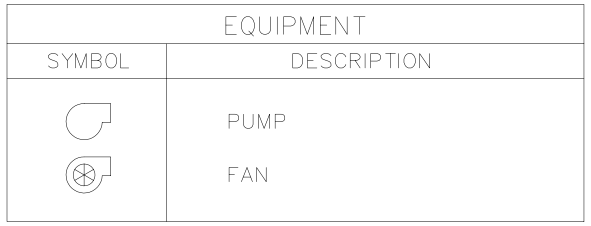
LINE NUMBER LEGEND





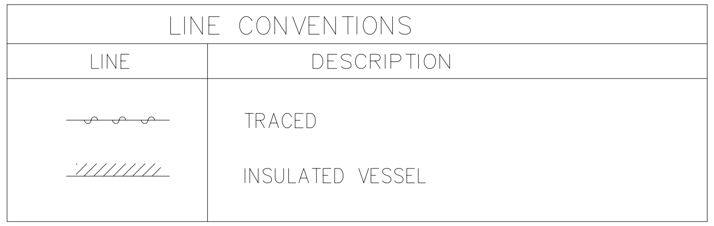
FITTINGS

SYMBOL	DESCRIPTION
	EXPANSION JOINT
	FLOW ELEMENT
	REDUCER
	OPEN DRAIN
	STRAINER
	FLANGE
	FLEX HOSE
	HOSE CONNECTION
	FUNNEL



EQUIPMENT

SYMBOL	DESCRIPTION
	PUMP
	FAN



LINE CONVENTIONS

LINE	DESCRIPTION
	TRACED
	INSULATED VESSEL

LINE SERVICE LEGEND

CA	COMBUSTION AIR
CB	CONTINUOUS BLOWDOWN
CF	CHEMICAL FEED
CHWR	CHILLED WATER RETURN
CHWS	CHILLED WATER SUPPLY
CWR	COOLING WATER RETURN
CWS	COOLING WATER SUPPLY
CW	CITY WATER
DR	DRAIN
EG	EXHAUST GAS
FOS	FUEL OIL SUPPLY
FOR	FUEL OIL RETURN
HPNG	HIGH PRESSURE NATURAL GAS
IA	INSTRUMENT AIR
LO	LUBE OIL
LOCA	LUBE OIL COOLER AIR
VT	VENT

FIELD DEVICE LEGEND

AE	ANALYZER
dPT	DIFFERENTAL PRESSURE TRANSMITTER
FCV	FLOW CONTROL VALVE
FE	FLOW ELEMENT
FQ	FLOW QUANTITY
FT	FLOW TRANSMITTER
LCV	LEVEL CONTROL VALVE
LT	LEVEL TRANSMITTER
PCV	PRESSURE CONTROL VALVE
PI	PRESSURE INDICATOR
PSH	PRESSURE SWITCH HIGH
PSV	PRESSURE SAFETY VALVE
PT	PRESSURE TRANSMITTER
TCV	TEMPERATURE CONTROL VALVE
TE	TEMPERATURE ELEMENT
TI	TEMPERATURE INDICATOR

NOTE: THIS IS A PARTIAL P&ID TO BE USED FOR DEMONSTRATION PURPOSES ONLY. ADDITIONAL EQUIPMENT & FIELD DEVICES MAY BE REQUIRED.

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SYMBOLS LEGEND

3.4MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R–6

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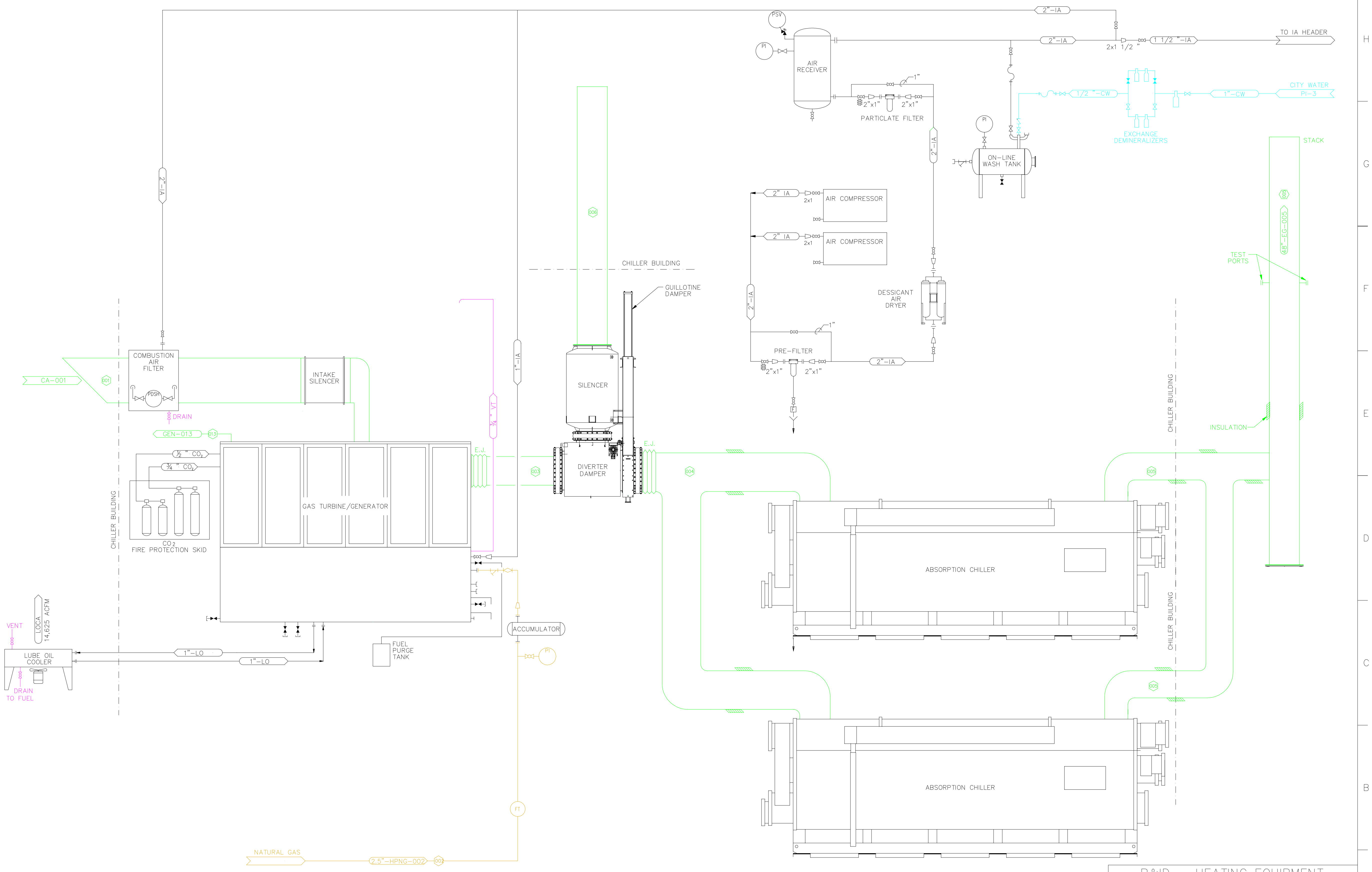

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P&ID – HEATING EQUIPMENT

3.4 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R-6

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DATE BY	Ⓗ	DATE BY	Ⓖ	DATE BY	Ⓕ	DATE BY	Ⓔ	DATE BY	Ⓓ	DATE BY	Ⓒ	DATE BY

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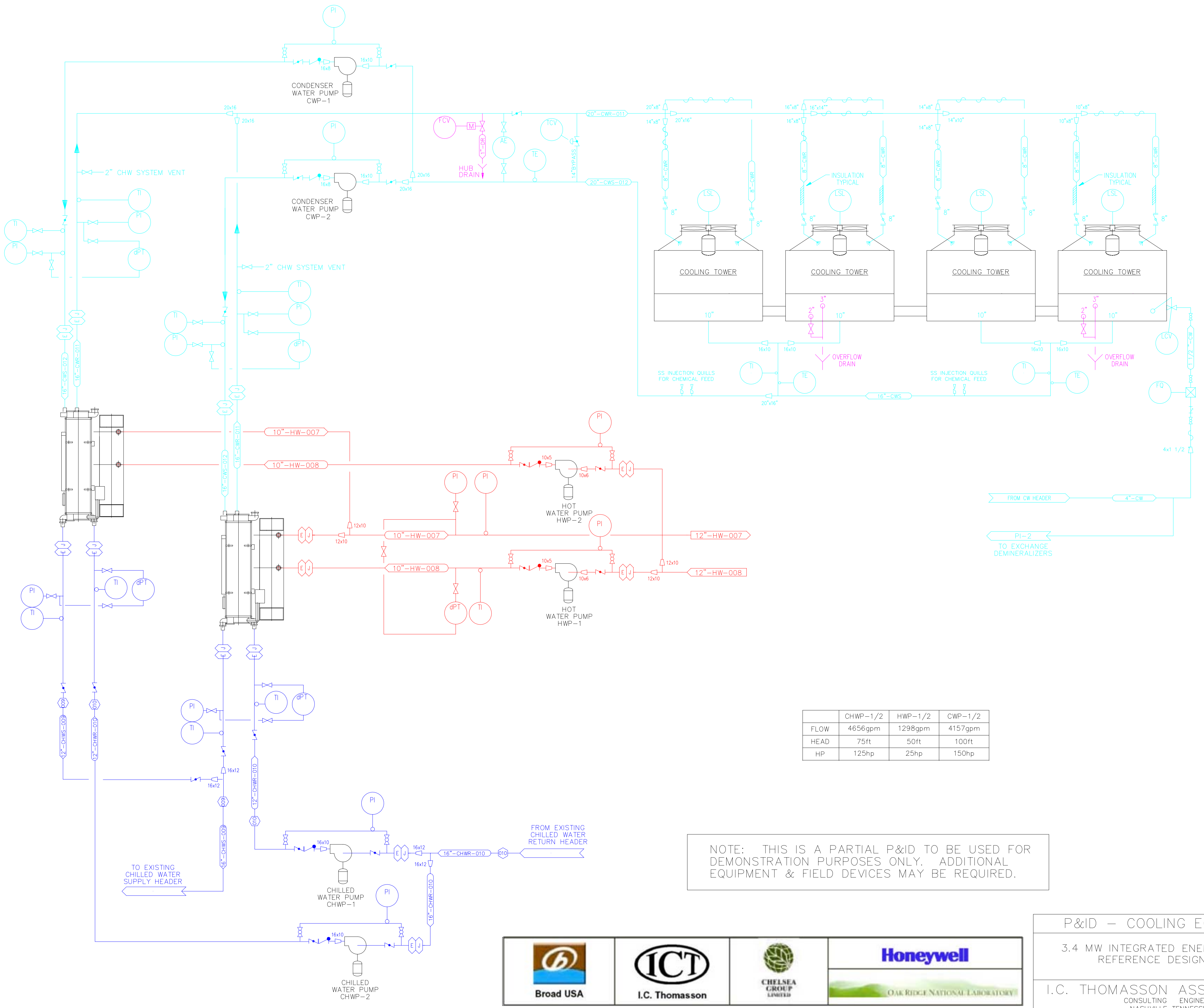

	CHWP-1/2	HWP-1/2	CWP-1/2
FLOW	4656gpm	1298gpm	4157gpm
HEAD	75ft	50ft	100ft
HP	125hp	25hp	150hp

NOTE: THIS IS A PARTIAL P&ID TO BE USED FOR DEMONSTRATION PURPOSES ONLY. ADDITIONAL EQUIPMENT & FIELD DEVICES MAY BE REQUIRED.

Broad USA

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CHELSEA GROUP LIMITED

Honeywell

OAK RIDGE NATIONAL LABORATORY

P&ID – COOLING EQUIPMENT

3.4 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R-6

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

DRAWN BY	BDG	JOB No.	1336.08	SHEET No. R6-PI3
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DATE
BY

90ºF AMBIENT AIR CONDITION
INLET AIR COOLER IN OPERATION
MAXIMUM CHILLED WATER PRODUCTION

MASS BALANCE (90ºF, 60% RH)

PID LOCATION	FLUID/SERVICE	FLOW RATE		TEMP	
CA-001	COMBUSTION AIR TO TURBINE	137,828	PPH	90	°F
2.5"-HPNG-002	NATURAL GAS TO TURBINE	1,897	PPH	NA	
EG-003	TURBINE EXHAUST TOTAL	139,725	PPH	854	°F
54"-EG-004	TURBINE EXHAUST TO CHILLER	139,725	PPH	854	°F
48"-EG-005	CHILLER EXHAUST TO ATMOSPHERE	139,725	PPH	338	°F
54"-EG-006	TURBINE EXHAUST TO ATMOSPHERE	0	PPH	NA	
12"-HWS-007	HOT WATER LEAVING CHILLER	0	GPM	140	°F
12"-HWR-008	HOT WATER TO CHILLERS	0	GPM	125.6	°F
16"-CHWS-009	CHILLED WATER LEAVING CHILLER	4,656	GPM	44	°F
16"-CHWR-010	CHILLED WATER TO CHILLER	4,656	GPM	54	°F
20"-CWR-011	COOLING WATER LEAVING CHILLER	6,683	GPM	96.6	°F
20"-CWS-012	COOLING WATER TO CHILLER	6,683	GPM	84	°F
GEN-013	ELECTRICITY PRODUCED	2,974	KW	NA	

ENERGY CONVERSION CALCULATIONS

PID LOCATION	ENERGY INPUT	ENERGY		
2.5"-HPNG-002	NATURAL GAS TO TURBINE	39,100	MBTU/HR	
	TOTAL ENERGY CONSUMED	39,100	MBTU/HR	
	ELECTRICAL OUTPUT			
GEN-013	ELECTRICITY PRODUCED	10,148	MBTU/HR	
	ENERGY CONVERTED TO ELECTRICAL	26%		
	HEAT RECOVERY			
54"-EG-004	EXHAUST HEAT UTILIZED	19,402	MBTU/HR	
	ENERGY CONVERTED TO HEATING/COOLING	50%		
	COOLING WATER HEAT REJECTION	42,100	MBH	
	COOLING/HEATING OUTPUT			
16"-CHWS-009	CHILLED WATER PRODUCED	1,940	TON	
8"-HWS-007	HOT WATER PRODUCED	0	MBH	
				COP
	SYSTEM USEFUL ENERGY CONVERSION	76%		1.2

60ºF AMBIENT AIR CONDITION
INLET AIR COOLER NOT IN OPERATION
MIXED CHILLED WATER AND HOT WATER PRODUCTION

MASS BALANCE (60ºF, 60% RH)

PID LOCATION	FLUID/SERVICE	FLOW RATE		TEMP	
CA-001	COMBUSTION AIR TO TURBINE	146,862	PPH	60	°F
2.5"-HPNG-002	NATURAL GAS TO TURBINE	2,062	PPH	NA	
EG-003	TURBINE EXHAUST TOTAL	148,924	PPH	836	°F
54"-EG-004	TURBINE EXHAUST TO CHILLER	148,924	PPH	836	°F
48"-EG-005	CHILLER EXHAUST TO ATMOSPHERE	148,924	PPH	338	°F
54"-EG-006	TURBINE EXHAUST TO ATMOSPHERE	0	PPH	NA	
12"-HWS-007	HOT WATER LEAVING CHILLER	1,267	GPM	140	°F
12"-HWR-008	HOT WATER TO CHILLERS	1,267	GPM	125.6	°F
16"-CHWS-009	CHILLED WATER LEAVING CHILLER	2,378	GPM	44	°F
16"-CHWR-010	CHILLED WATER TO CHILLER	2,378	GPM	54	°F
20"-CWR-011	COOLING WATER LEAVING CHILLER	3,492	GPM	96.6	°F
20"-CWS-012	COOLING WATER TO CHILLER	3,492	GPM	84	°F
GEN-013	ELECTRICITY PRODUCED	3,382	KW	NA	

ENERGY CONVERSION CALCULATIONS

PID LOCATION	ENERGY INPUT	ENERGY		
2.5"-HPNG-002	NATURAL GAS TO TURBINE	42,500	MBTU/HR	
	TOTAL ENERGY CONSUMED	42,500	MBTU/HR	
	ELECTRICAL OUTPUT			
GEN-013	ELECTRICITY PRODUCED	11,540	MBTU/HR	
	ENERGY CONVERTED TO ELECTRICAL	27%		
	HEAT RECOVERY			
54"-EG-004	EXHAUST HEAT UTILIZED	19,824	MBTU/HR	
	ENERGY CONVERTED TO HEATING/COOLING	47%		
	COOLING WATER HEAT REJECTION	22,002	MBH	
	COOLING/HEATING OUTPUT			
16"-CHWS-009	CHILLED WATER PRODUCED	991	TON	
8"-HWS-007	HOT WATER PRODUCED	9,119	MBH	
				COP
	SYSTEM USEFUL ENERGY CONVERSION	74%		1.1

30ºF AMBIENT AIR CONDITION
INLET AIR COOLER NOT IN OPERATION
MAXIMUM HOT WATER PRODUCTION

MASS BALANCE (30ºF, 60% RH)

PID LOCATION	FLUID/SERVICE	FLOW RATE		TEMP	
CA-001	COMBUSTION AIR TO TURBINE	156,041	PPH	30	°F
2.5"-HPNG-002	NATURAL GAS TO TURBINE	2,242	PPH	NA	
EG-003	TURBINE EXHAUST TOTAL	158,283	PPH	821	°F
54"-EG-004	TURBINE EXHAUST TO CHILLER	158,283	PPH	821	°F
48"-EG-005	CHILLER EXHAUST TO ATMOSPHERE	158,283	PPH	338	°F
54"-EG-006	TURBINE EXHAUST TO ATMOSPHERE	0	PPH	NA	
12"-HWS-007	HOT WATER LEAVING CHILLER	2,596	GPM	140	°F
12"-HWR-008	HOT WATER TO CHILLERS	2,596	GPM	125.6	°F
16"-CHWS-009	CHILLED WATER LEAVING CHILLER	0	GPM	NA	
16"-CHWR-010	CHILLED WATER TO CHILLER	0	GPM	NA	
20"-CWR-011	COOLING WATER LEAVING CHILLER	0	GPM	NA	
20"-CWS-012	COOLING WATER TO CHILLER	0	GPM	NA	
GEN-013	ELECTRICITY PRODUCED	3,784	KW	NA	

ENERGY CONVERSION CALCULATIONS

PID LOCATION	ENERGY INPUT	ENERGY		
2.5"-HPNG-002	NATURAL GAS TO TURBINE	46,200	MBTU/HR	
	TOTAL ENERGY CONSUMED	46,200	MBTU/HR	
	ELECTRICAL OUTPUT			
GEN-013	ELECTRICITY PRODUCED	12,912	MBTU/HR	
	ENERGY CONVERTED TO ELECTRICAL	28%		
	HEAT RECOVERY			
54"-EG-004	EXHAUST HEAT UTILIZED	20,318	MBTU/HR	
	ENERGY CONVERTED TO HEATING/COOLING	44%		
	COOLING WATER HEAT REJECTION	0	MBH	
	COOLING/HEATING OUTPUT			
16"-CHWS-009	CHILLED WATER PRODUCED	0	TON	
8"-HWS-007	HOT WATER PRODUCED	18,692	MBH	
				COP
	SYSTEM USEFUL ENERGY CONVERSION	72%		0.9

Above Performance information is total of two chillers.

Natural gas LHV = 20,609 Btu/lb.
"Energy Converted" is the percentage of fuel input energy converted into useable energy.
No parasitic losses are included.
SOLAR CENTAUR 40-4700S / BROAD USA 2xBE-400
3% radiation and convection heat loss from chiller.

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PERFORMANCE DATA

3.4 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R-6

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

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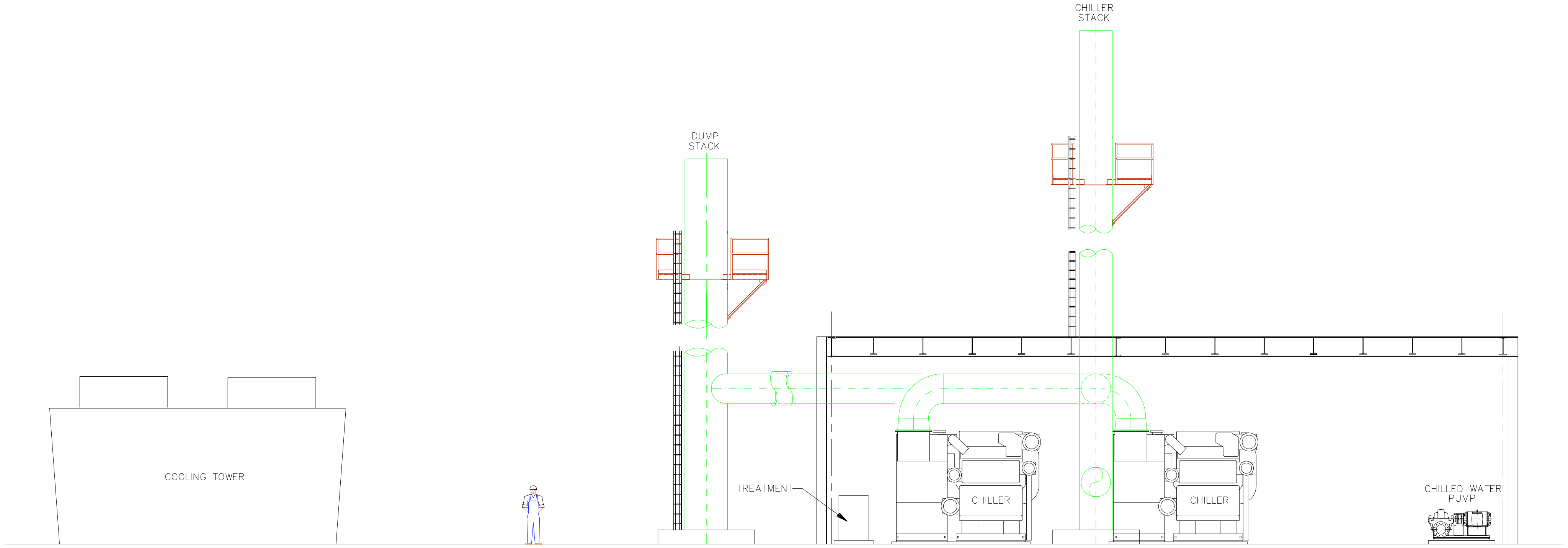

SECTION A S-1

3/16 "=1'-0"

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OAK RIDGE NATIONAL LABORATORY

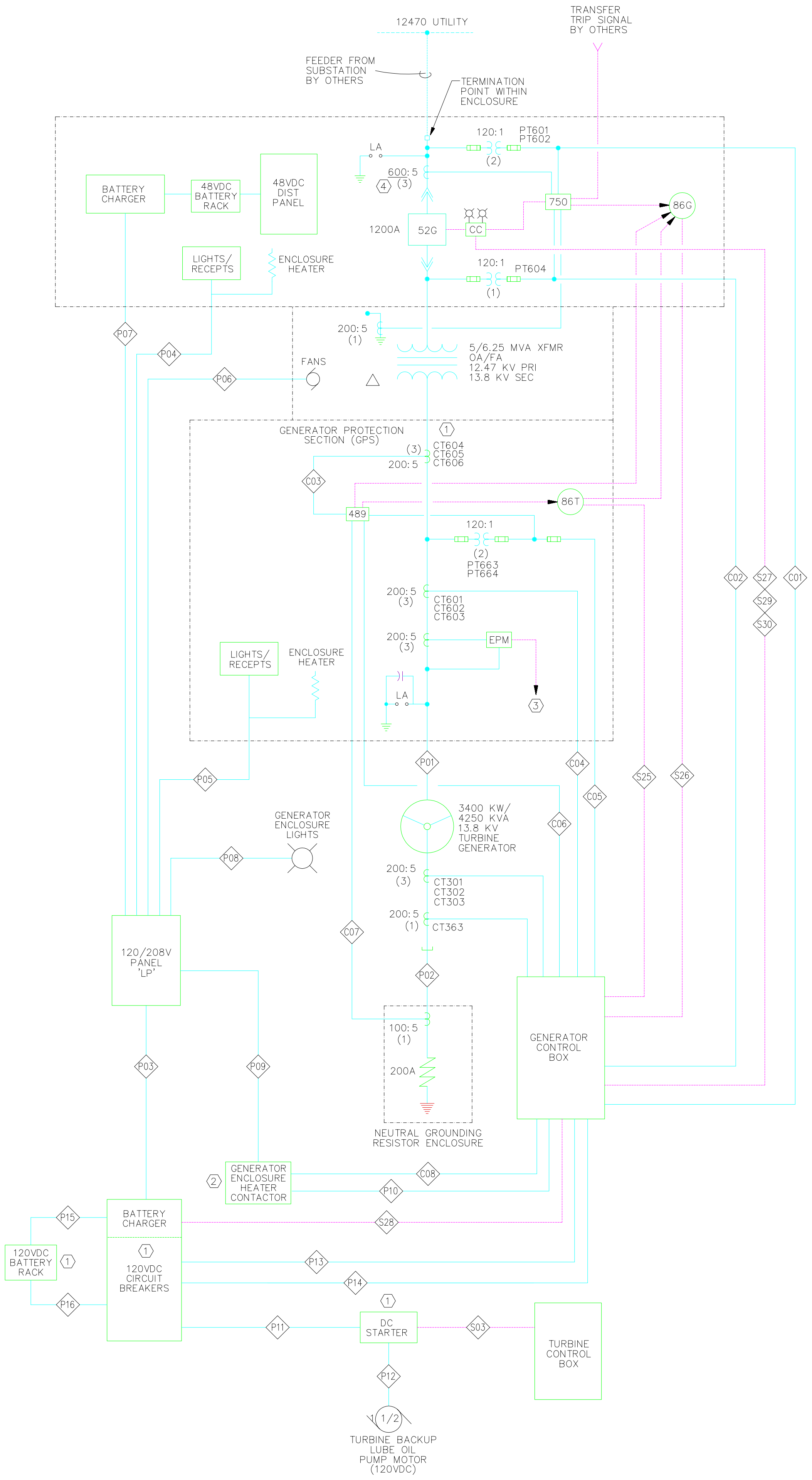
BOILER & TURBINE – EQUIPMENT ELEVATIONS

3.4 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R–6

PROTOTYPE PLANT
FORT BRAGG, N.C.

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

DRAWN BY D. GRIFFITH
CHECKED BY R. BLYTHE
JOB No. 1336.08
ISSUE DATE 04/20/05
SHEET No. R6–M1



CONDUCTOR SCHEDULE

No.	Wire Spec.	Remarks
C01	2– 1/C #14 in 1"C	
C02	2– 1/C #14 (route with C01)	
C03	3–#10 TWISTED PAIRS (JUMPERS)	CT's shipped loose by Solar, installed by contractor
C04	2–#10 TWISTED PAIRS in 1"C	
C05	3– 1/C #14 (route with C04)	
C06	3–#10 TWISTED PAIRS in 1"C	Generator Neutral Side
C07	1–#10 TWISTED PAIR in 3/4"C	
C08	2– 1/C #14 in 1"C	(120VAC)
P01	3–1/C #2/0 & 1–1/C #1/0 Gnd in 4"C	15KV, MV–105, Shielded Cable
P02	1–1/C #2/0 in 2"C	8KV, MV–105, Shielded Cable
P03	2– 1/C #8 & 1–1/C #10 Gnd in 3/4"C	(208V, 1–PH)
P04	3– 1/C #12 & 1–1/C #12 Gnd in 1"C	(120VAC)
P05	3– 1/C #12 & 1–1/C #12 Gnd in 1"C	(120VAC)
P06	3– 1/C #12 & 1–1/C #12 Gnd in 1"C	(208VAC)
P07	2– 1/C #12 & 1–1/C #12 Gnd in 1"C	(120VAC)
P08	2– 1/C #12 & 1–1/C #12 Gnd in 1"C	(120VAC)
P09	2– 1/C #12 & 1–1/C #12 Gnd in 3/4"C	(120VAC)
P10	2– 1/C #12 & 1–1/C #12 Gnd in 1"C	(120VAC)
P11	2– 1/C #6 in 3/4 "C	(120VDC)
P12	2– 1/C #6 in 1"C	(120VDC)
P13	2– 1/C #12 (route with P14)	(120VDC)
P14	2– 1/C #4 in 2"C	(120VDC)
P15	2–1/C #12 in 3/4"C	(120VDC)
P16	2–1/C #2 in 1"C	(120VDC)
S03	2– 1/C #14 in 1"C	(24VDC)
S25	2– 1/C #14 in 1"C	86T trips turbine and generator (24 VDC)
S26	2– 1/C #14 in 1"C	86G trips generator only (24 VDC)
S27	3– 1/C #14 (route with S26)	Breaker position (24 VDC)
S28	2– 1/C #14 in 1"C	(24V DC)
S29	2– 1/C #14 (route with S26)	(48V DC)
S30	2– 1/C #14 (route with S26)	(48V DC)

LEGEND

489 –MULTILIN GENERATOR MANAGEMENT RELAY.
750 –MULTILIN FEEDER MANAGEMENT RELAY.
–CURRENT TRANSFORMERS
–POTENTIAL TRANSFORMERS
86 –LOCK–OUT RELAY. 86T TRIPS TURBINE AND GENERATOR BREAKER. 86G TRIPS GENERATOR BREAKER ONLY.
–SURGE CAPACITOR, ONE–3 PHASE UNIT.
LA –LIGHTNING ARRESTOR, 3 REQUIRED.
(1) – NUMBER = QUANTITY OF DEVICES
– FUSE
CC – CONTROL CIRCUIT WITH INDICATOR LIGHTS
– GROUND
52G – MED/HIGH VOLTAGE GENERATOR SYNCHRONIZING BREAKER
C# – CONDUCTOR RUN DESIGNATOR ('C'= CONTROL, 'P'= POWER, 'S'= SIGNAL). SIGNIFIES CONDUCTORS TO BE INSTALLED BY CONTRACTOR. SEE CONDUCTOR SCHEDULE FOR MORE INFORMATION.
EPM – ELECTRONIC POWER METER

NOTES:

1. EQUIPMENT PROVIDED LOOSE BY SOLAR FOR INSTALLATION BY CONTRACTOR.
2. HEATER CONTACTOR PROVIDED AND INSTALLED BY CONTRACTOR.
3. THIS CONTRACTOR TO INSTALL POWER METER CONDUIT FROM UNIT SUB TO JUNCTION BOX INSIDE NEW CHILLER BUILDING. CONDUIT FROM JUNCTION BOX TO PLANT CONTROL SYSTEM BY OTHERS. METER OUTPUT WIRING INSTALLED BY OTHERS.
4. CURRENT TRANSFORMER SHALL BE OF MULTI–TAP TYPE. USE 200:5 SECONDARY TAP.

Broad USA
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Honeywell
OAK RIDGE NATIONAL LABORATORY

ELECTRICAL ONE–LINE DIAGRAM

3.4MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R–6

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

DRAWN BY CSH
CHECKED BY CSH
JOB No. 1336.08
ISSUE DATE 04/20/05
SHEET No. R6–E1

GENERAL NOTES:

B. THE FOLLOWING MINIMUM WIRING STANDARD WILL BE FOLLOWED IN THE WIRING CONSTRUCTION ON THIS PROJECT–

1. DEFINITION: POWER CONDUCTORS INCLUDE PANEL FEEDERS AND BRANCH CIRCUITS AS WELL AS MOTOR FEEDS FROM THE MOTOR CONTROL CENTER. POWER CONDUCTORS WILL ALSO INCLUDE THOSE CONDUCTORS USED TO POWER FIELD DEVICES.
2. CONTROL CONDUCTORS INCLUDE CONDUCTORS BELOW 300 VOLTS USED IN THE INSTRUMENTATION AND CONTROL OF THE FACILITY.
3. CONTROL POWER CONDUCTORS ARE THOSE USED TO POWER FIELD DEVICES FROM PLC CABINETS, CONTROL POWER TRANSFORMERS IN MCC BUCKETS, OR PANELS DESIGNATED AS CONTROL POWER SOURCES.
4. ALL CONTROL WIRING WILL BE COLOR–CODED. POWER CONDUCTORS, CONTROL POWER CONDUCTORS AND CONTROL CONDUCTORS WILL NOT BE THE SAME COLOR. COLOR CODE AS FOLLOWS:

   120 VAC POWER: BLACK OR RED WITH BLACK STRIPE

   120 VAC POWER NEUTRAL: WHITE

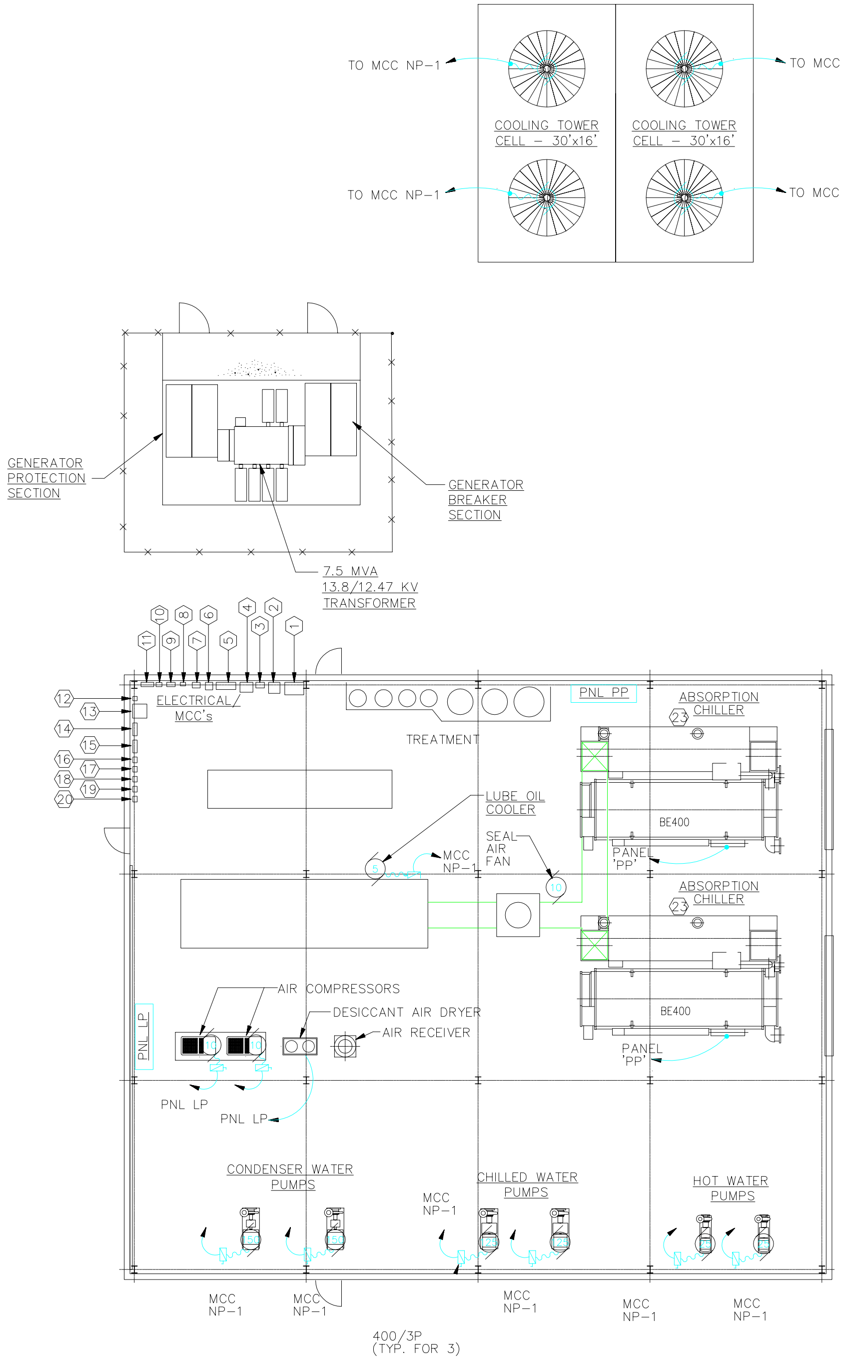
   120 VAC CONTROL: RED

   120 VAC CONTROL NEUTRAL: WHITE OR RED WITH WHITE STRIPE

   24 VDC (+): BLUE

   24 VDC (–): WHITE WITH BLUE STRIPE OR BROWN

5. 120 VAC CONTROL OUTPUTS WILL NOT BOTH BE RED CONDUCTORS. 120 VAC SUPPLY OUTPUT WILL BE RED AND THE RETURN WILL BE A NEUTRAL. THIS MEANS THAT EVERY SOLENOID, ACTUATOR, OR OTHER FIELD DEVICE GETS A WHITE OR WHITE STRIPED WIRE.
6. MULTIPLE FIELD DEVICES REQUIRING A CONTROL POWER SOURCE WILL NOT BE FIELD WIRED IN A DAISY–CHAIN CIRCUIT FROM THE SAME CIRCUIT UNLESS SPECIFICALLY CALLED OUT ON DRAWINGS. WIRING FOR EACH DEVICE MUST BE BROUGHT BACK TO A TERMINAL.
7. CONTROL WIRING WILL BE INTEGRATED INTO THE PROJECT, NOT ADDED AT THE END WHEN EVERYONE IS INVOLVED IN START–UP.
8. CONTROL WIRING WILL NOT SHARE RACEWAYS WITH POWER WIRING, UNLESS SPECIFICALLY INDICATED ON THE DRAWINGS.
9. NO BUTT SPLICES WILL BE USED FOR ANY WIRING. ALL CONNECTIONS WILL BE MADE ON A TERMINAL STRIP.
10. LABELING WILL BE DONE IN A CONSISTENT MANNER WITH THE OTHER END OF THE CONDUCTOR. ALL WIRE NUMBERS WILL BE AS SHOWN ON THE PROJECT CONNECTION DRAWINGS OR LABELED ACCORDING TO THE VENDOR PANEL DESIGNATION IF NOT SHOWN ON THE PROJECT DRAWINGS. FOR EXAMPLE, "BMS#1 TERM 801a", "FAN 12 STARTER CPT–N" (CONTROL POWER NEUTRAL) ETC. FOR VENDOR REQUIRED FIELD WIRING.
11. ALL STARTERS WILL HAVE CONTROL POWER TRANSFORMERS AND THE NEUTRAL SIDE WILL BE GROUNDED, UNLESS SPECIFICALLY NOTED OTHERWISE.
12. ALL FIELD DEVICES WILL BE MOUNTED ABOVE THE ADJACENT JUNCTION BOX TO PREVENT WATER COLLECTION. LIQUID TIGHT FLEX WILL BE USED FOR FIELD DEVICES; GREENFIELD IS NOT ALLOWED.
13. ALL RACEWAYS WILL BE DEPICTED ON THE RECORD DRAWINGS AND THEIR CONTENTS LABELED. SIMPLY SHOWING HOME RUNS FOR CONTROL WIRING IS NOT ACCEPTABLE.
14. EACH CONTROL WIRING RUN WILL INCLUDE AT LEAST ONE SET OF SPARE CONDUCTORS, AND CONDUIT FILL WILL NOT EXCEED 30%. ALL CONTROL POWER RUNS WILL BE PULLED BY HAND.
15. WHERE SWITCH CONTACTS OR LIMITS ARE IN SERIES, BOTH SIDES OF EACH CONTACT WILL BE BROUGHT BACK TO THE CONTROL PANEL TO AID IN TROUBLE SHOOTING.
16. ANALOG SHIELDED CABLE WILL BE DRESSED AT EACH END USING HEAT SHRINK TUBING.



ELECTRICAL POWER PLAN

0 5 10
1/8 "=1'–0"

NOTES:

1. GENERATOR BATTERY RACK
2. GENERATOR BATTERY CHARGER
3. TURBINE BACKUP LUBE OIL PUMP DC STARTER
4. TURBINE AC DIRECT START VFD (MOUNT REACTOR ABOVE VFD)
5. TURBINE AC DIRECT START VFD 600V, 400A, 3–PH, 3–WIRE FUSED DISCONNECT SWITCH. FUSES TO BE 250A TYPE "J" CURRENT LIMITING, DUAL ELEMENT TIME DELAY.
6. TURBINE FUEL PUMP VFD SNUBBER RESISTOR
7. TURBINE FUEL PUMP VFD
8. TURBINE FUEL PUMP VFD 600V, 30A, 3–PH, 3–WIRE NON–FUSED DISCONNECT SWITCH.
9. COAX TAP BOX. FIELD SUPPLY AND INSTALL 12" X 12" (APPROX.) NEMA 1 BOX FOR CONTROLNET TAPS FURNISHED LOOSE BY SOLAR.
10. QUIET GROUND TERMINAL BOX.
11. CHILLER REMOTE CONTROL PANEL
12. GENERATOR ENCLOSURE HEATER CONTACTOR.
13. 480–120/208V, 3–PH, 45 KVA TRANSFORMER 'T–LP'. MOUNT 8'–0" AFF AGAINST COLUMN. BOND SECONDARY NEUTRAL TO COLUMN WITH #4 BARE COPPER WIRE.
14. 120/208V PANEL 'LP'
15. 277/480V PANEL 'PP'
16. LIGHTING CONTACTOR WITH H0A SWITCH.
17. TIMER FOR OUTDOOR LIGHTS.
18. J–BOX FOR OUTDOOR LIGHTS, RECEPTACLES AND HEAT TRACING.
19. J–BOX FOR 120VAC POWER TO BMS AND GAS COMPRESSOR CONTROL PANELS AND UNIT SUB
20. J–BOX FOR FUTURE 120VAC CONTROL TO GENERATOR CONTROL BOX
21. 2–#12 & 1–#12 GND IN 3/4 "C.
22. ROUTE WIRING TO NEW (OR EXISTING SPARE) 1–POLE, 20A CIRCUIT BREAKER IN EXISTING 120/208V PANEL 'NP'.
23. CHILLER SOLUTION PUMP VARIABLE FREQUENCY DRIVE IS SHIPPED LOOSE FOR INSTALLATION ON SKID BY CONTRACTOR.
24. J–BOX FOR WIRING TO UNIT SUB POWER METER.
25. CONTRACTOR TO COORDINATE FINAL LOCATION OF CHEMICAL FEED UNITS AND SWITCHES WITH OWNER.
26. FEED LIGHT WITH TAP FROM NEAREST NEW OUTDOOR 120V RECEPTACLE CIRCUIT. RUN 2–#12 & 1–#12 GND IN 3/4 "C TO J–BOX PROVIDED BY VENDOR ON SIDE OF AIR FILTER. LIGHT IS PRE–WIRED TO J–BOX BY VENDOR.
27. 1–#4/0 INSULATED GROUND WIRE (600V) IN 1" CONDUIT. CONNECT TO GROUND GRID.

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ELECTRICAL POWER PLAN

3.4 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R–6

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

DRAWN BY MGP
CHECKED BY LJS
JOB No. 1336.08
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SHEET No. R6–E2

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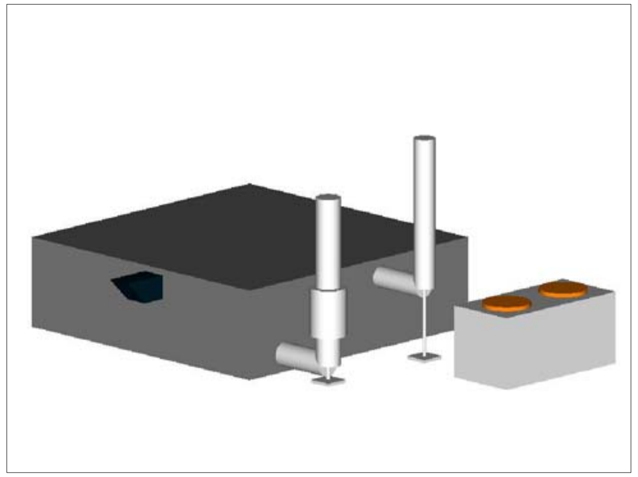
BY

Appendix E

Reference Design R-8, Design Documents

INTEGRATED ENERGY SYSTEM
DESIGN R-8

POWER	CHILLED WATER
1.2 MW	900 TON



SHEET INDEX

COVER	COVER SHEET
R1-PI1	SYMBOLS LEGEND
R1-PI2	P&ID - HEATING EQUIPMENT
R1-PI3	P&ID - COOLING EQUIPMENT
R1-PI4	PERFORMANCE DATA
R1-S1	GENERAL ARRANGEMENT & SITE PLAN
R1-M1	TURBINE - EQUIPMENT ELEVATIONS
R1-E1	ELECTRICAL ONE-LINE DIAGRAM
R1-E2	ELECTRICAL POWER PLAN

REFERENCE DESIGNS

R-1	5.7 MW INTEGRATED ENERGY SYSTEM
R-2	5.3 MW INTEGRATED ENERGY SYSTEM
R-4	4.6 MW INTEGRATED ENERGY SYSTEM
R-6	3.4 MW INTEGRATED ENERGY SYSTEM
R-8	1.2 MW INTEGRATED ENERGY SYSTEM

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COVER SHEET

1.2 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R-8

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

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CHECKED BY	RDB	ISSUE DATE	04/20/05		

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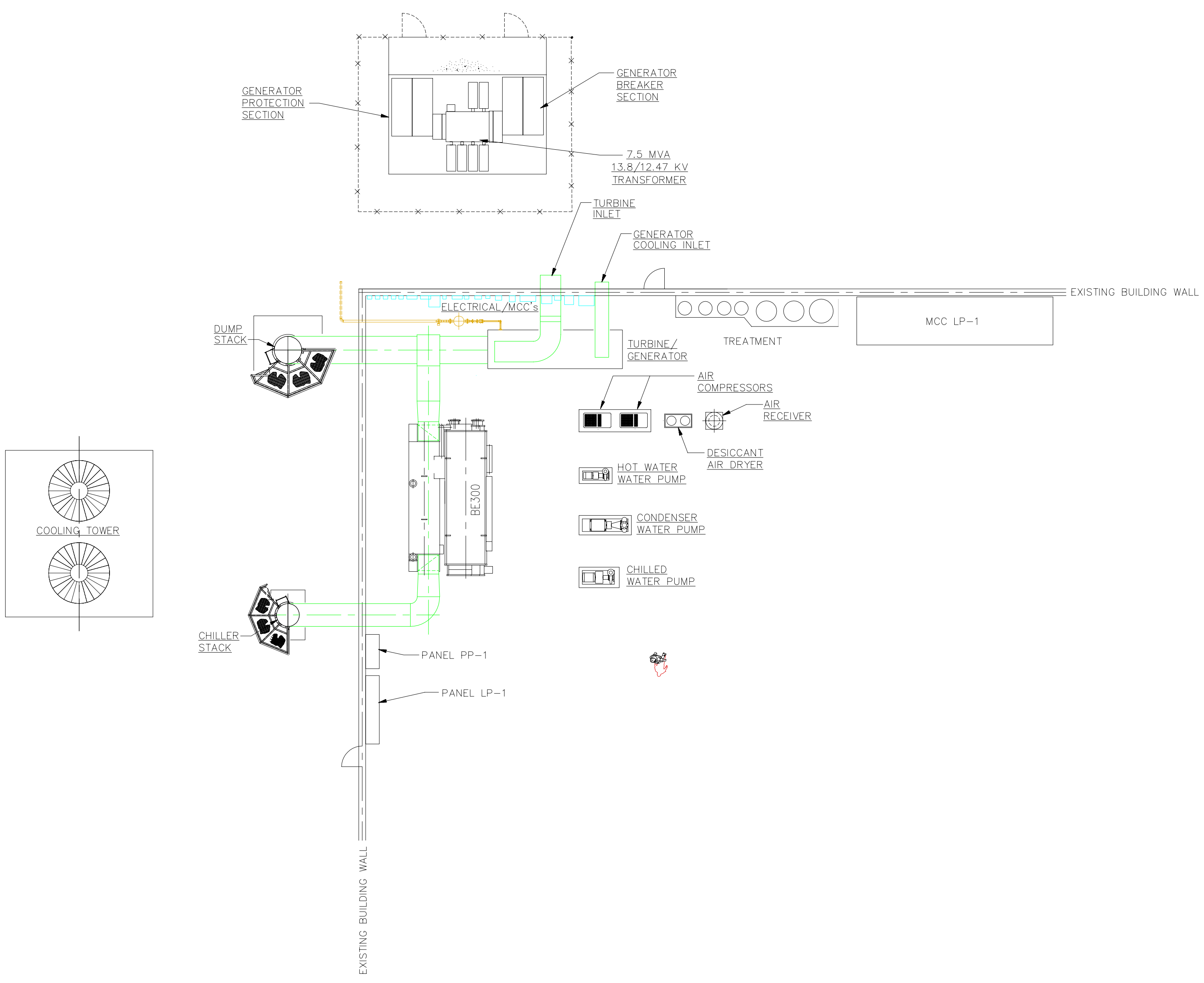

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GENERAL ARRANGEMENT SITE PLAN

0 5 10
1/8 "=1'-0"

Broad USA

ICT
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OAK RIDGE NATIONAL LABORATORY

GENERAL ARRANGEMENT & SITE PLAN

1.2 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R-8

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

DRAWN BY	KER	JOB No.	1336.08	SHEET No.	R8-S1
CHECKED BY	JBD	ISSUE DATE	04/20/05		

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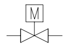
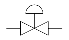
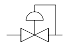
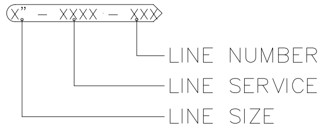
VALVE BODIES

DESCRIPTION	NORMALLY OPEN	NORMALLY CLOSED
GATE		
GLOBE		
BUTTERFLY		
QUICK OPENING		
BALL		
ANGLE		
ANGLE SAFETY OR RELIEF (PRESSURE OR VACUUM)		
CHECK		
PLUG		

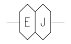
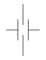
VALVE ACTUATORS

SYMBOL	DESCRIPTION
	MOTORIZED
	DIAPHRAM
	PRESSURE REGULATOR

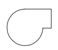
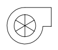
LINE NUMBER LEGEND



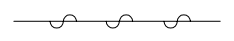
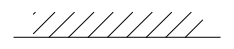
FITTINGS

SYMBOL	DESCRIPTION
	EXPANSION JOINT
	FLOW ELEMENT
	REDUCER
	OPEN DRAIN
	STRAINER
	FLANGE
	FLEX HOSE
	HOSE CONNECTION
	FUNNEL

EQUIPMENT

SYMBOL	DESCRIPTION
	PUMP
	FAN

LINE CONVENTIONS

LINE	DESCRIPTION
	TRACED
	INSULATED VESSEL

LINE SERVICE LEGEND

CA	COMBUSTION AIR
CF	CHEMICAL FEED
CHWR	CHILLED WATER RETURN
CHWS	CHILLED WATER SUPPLY
CWR	COOLING WATER RETURN
CWS	COOLING WATER SUPPLY
CW	CITY WATER
DR	DRAIN
EG	EXHAUST GAS
FOS	FUEL OIL SUPPLY
FOR	FUEL OIL RETURN
HPNG	HIGH PRESSURE NATURAL GAS
IA	INSTRUMENT AIR
LO	LUBE OIL
LOCA	LUBE OIL COOLER AIR
VT	VENT

FIELD DEVICE LEGEND

AE	ANALYZER
dPT	DIFFERENTAL PRESSURE TRANSMITTER
FCV	FLOW CONTROL VALVE
FE	FLOW ELEMENT
FQ	FLOW QUANTITY
FT	FLOW TRANSMITTER
LCV	LEVEL CONTROL VALVE
LT	LEVEL TRANSMITTER
PCV	PRESSURE CONTROL VALVE
PI	PRESSURE INDICATOR
PSH	PRESSURE SWITCH HIGH
PSV	PRESSURE SAFETY VALVE
PT	PRESSURE TRANSMITTER
TCV	TEMPERATURE CONTROL VALVE
TE	TEMPERATURE ELEMENT
TI	TEMPERATURE INDICATOR

NOTE: THIS IS A PARTIAL P&ID TO BE USED FOR DEMONSTRATION PURPOSES ONLY. ADDITIONAL EQUIPMENT & FIELD DEVICES MAY BE REQUIRED.

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Honeywell
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SYMBOLS LEGEND

1.2 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R-8

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

DRAWN BY BDG	JOB No. 1336.08	SHEET No. R8-PI1
CHECKED BY RBD	ISSUE DATE 04/20/05	

DATE BY △F
DATE BY △E
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DATE BY △C
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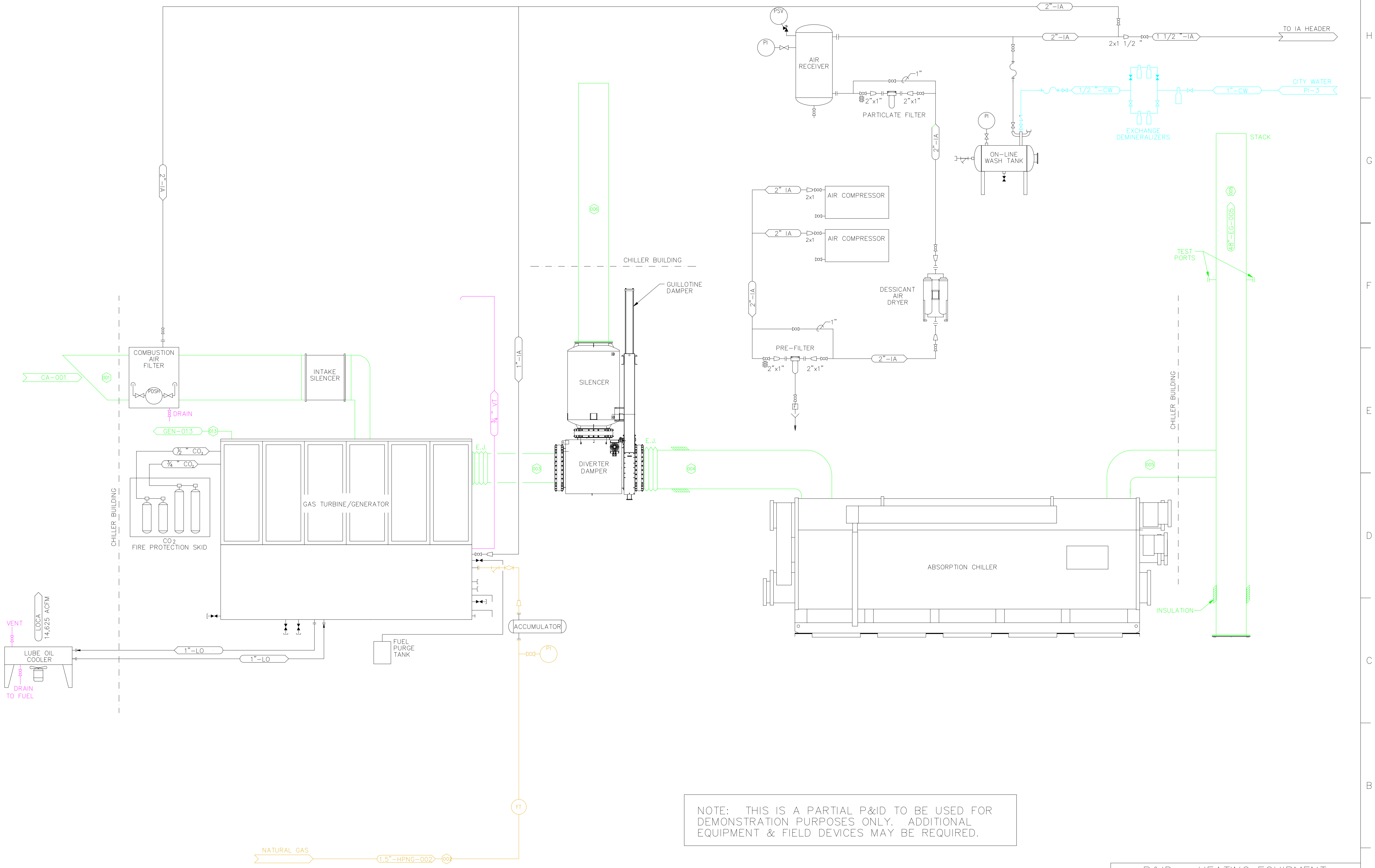

NOTE: THIS IS A PARTIAL P&ID TO BE USED FOR DEMONSTRATION PURPOSES ONLY. ADDITIONAL EQUIPMENT & FIELD DEVICES MAY BE REQUIRED.

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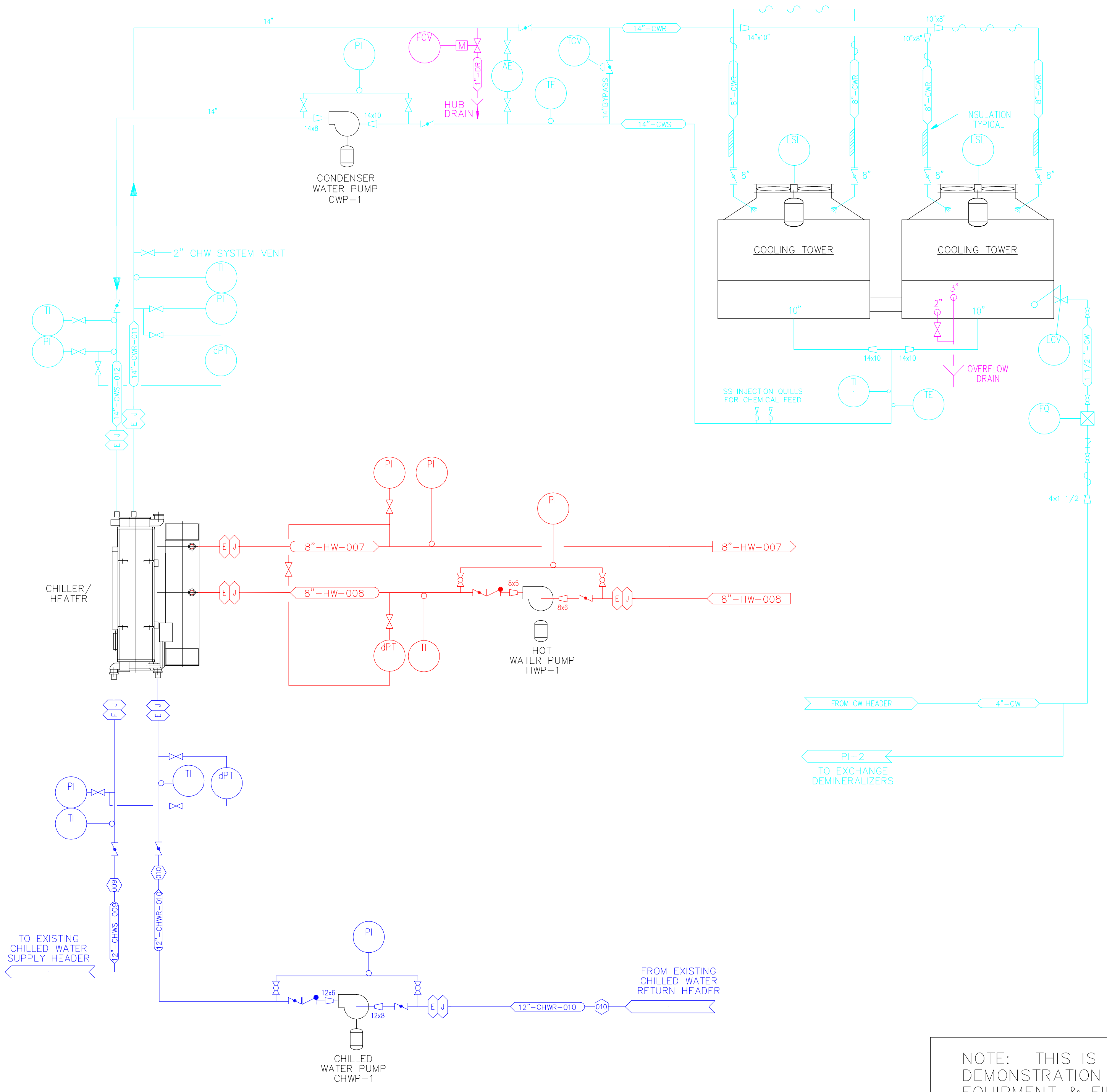
P&ID – HEATING EQUIPMENT

1.2 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R–8

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

DRAWN BY	JWY	JOB No.	1336.08	SHEET No. R8–PI2
CHECKED BY	RDB	ISSUE DATE	04/20/05	



	CHWP-1	HWP-1	CWP-1
FLOW	2148gpm	920gpm	3118gpm
HEAD	75ft	50ft	150ft
HP	50hp	15hp	200hp

NOTE: THIS IS A PARTIAL P&ID TO BE USED FOR DEMONSTRATION PURPOSES ONLY. ADDITIONAL EQUIPMENT & FIELD DEVICES MAY BE REQUIRED.

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P&ID – COOLING EQUIPMENT

1.2 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R-8

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

DRAWN BY	BDG	JOB No.	1336.08	SHEET No.	R8-PI3
CHECKED BY	RDB	ISSUE DATE	04/20/05		

90ºF AMBIENT AIR CONDITION
INLET AIR COOLER IN OPERATION
MAXIMUM CHILLED WATER PRODUCTION

MASS BALANCE (90ºF, 60% RH)

PID LOCATION	FLUID/SERVICE	FLOW RATE		TEMP	
CA-001	COMBUSTION AIR TO TURBINE	47,399	PPH	90	°F
1.5"-HPNG-002	NATURAL GAS TO TURBINE	757	PPH	NA	
EG-003	TURBINE EXHAUST TOTAL	48,156	PPH	997	°F
36"-EG-004	TURBINE EXHAUST TO CHILLER	48,156	PPH	997	°F
30"-EG-005	CHILLER EXHAUST TO ATMOSPHERE	48,156	PPH	338	°F
36"-EG-006	TURBINE EXHAUST TO ATMOSPHERE	0	PPH	NA	
8"-HWS-007	HOT WATER LEAVING CHILLER	0	GPM	140	°F
8"-HWR-008	HOT WATER TO CHILLER	0	GPM	125.6	°F
12"-CHWS-009	CHILLED WATER LEAVING CHILLER	2,148	GPM	44	°F
12"-CHWR-010	CHILLED WATER TO CHILLER	2,148	GPM	54	°F
14"-CWR-011	COOLING WATER LEAVING CHILLER	3,082	GPM	96.6	°F
14"-CWS-012	COOLING WATER TO CHILLER	3,082	GPM	84	°F
GEN-013	ELECTRICITY PRODUCED	1,047	KW	NA	

ENERGY CONVERSION CALCULATIONS

PID LOCATION		ENERGY		
	ENERGY INPUT			
1.5"-HPNG-002	NATURAL GAS TO TURBINE	15,600	MBTU/HR	
	TOTAL ENERGY CONSUMED	15,600	MBTU/HR	
	ELECTRICAL OUTPUT			
GEN-013	ELECTRICITY PRODUCED	3,573	MBTU/HR	
	ENERGY CONVERTED TO ELECTRICAL	23%		
	HEAT RECOVERY			
36"-EG-004	EXHAUST HEAT UTILIZED	8,948	MBTU/HR	
	ENERGY CONVERTED TO HEATING/COOLING	57%		
	COOLING WATER HEAT REJECTION	19,420	MBH	
	COOLING/HEATING OUTPUT			
12"-CHWS-009	CHILLED WATER PRODUCED	895	TON	
8"-HWS-007	HOT WATER PRODUCED	0	MBH	
				COP
	SYSTEM USEFUL ENERGY CONVERSION	80%		1.2

60ºF AMBIENT AIR CONDITION
INLET AIR COOLER NOT IN OPERATION
MIXED CHILLED WATER AND HOT WATER PRODUCTION

MASS BALANCE (60ºF, 60% RH)

PID LOCATION	FLUID/SERVICE	FLOW RATE		TEMP	
CA-001	COMBUSTION AIR TO TURBINE	50,487	PPH	60	°F
1.5"-HPNG-002	NATURAL GAS TO TURBINE	810	PPH	NA	
EG-003	TURBINE EXHAUST TOTAL	51,297	PPH	954	°F
36"-EG-004	TURBINE EXHAUST TO CHILLER	51,297	PPH	954	°F
30"-EG-005	CHILLER EXHAUST TO ATMOSPHERE	51,297	PPH	338	°F
36"-EG-006	TURBINE EXHAUST TO ATMOSPHERE	0	PPH	NA	
8"-HWS-007	HOT WATER LEAVING CHILLER	562	GPM	140	°F
8"-HWR-008	HOT WATER TO CHILLER	562	GPM	125.6	°F
12"-CHWS-009	CHILLED WATER LEAVING CHILLER	1,056	GPM	44	°F
12"-CHWR-010	CHILLED WATER TO CHILLER	1,056	GPM	54	°F
14"-CWR-011	COOLING WATER LEAVING CHILLER	1,550	GPM	96.6	°F
14"-CWS-012	COOLING WATER TO CHILLER	1,550	GPM	84	°F
GEN-013	ELECTRICITY PRODUCED	1,162	KW	NA	

ENERGY CONVERSION CALCULATIONS

PID LOCATION		ENERGY		
	ENERGY INPUT			
1.5"-HPNG-002	NATURAL GAS TO TURBINE	16,700	MBTU/HR	
	TOTAL ENERGY CONSUMED	16,700	MBTU/HR	
	ELECTRICAL OUTPUT			
GEN-013	ELECTRICITY PRODUCED	3,965	MBTU/HR	
	ENERGY CONVERTED TO ELECTRICAL	24%		
	HEAT RECOVERY			
36"-EG-004	EXHAUST HEAT UTILIZED	8,794	MBTU/HR	
	ENERGY CONVERTED TO HEATING/COOLING	53%		
	COOLING WATER HEAT REJECTION	9,765	MBH	
	COOLING/HEATING OUTPUT			
12"-CHWS-009	CHILLED WATER PRODUCED	440	TON	
8"-HWS-007	HOT WATER PRODUCED	4,045	MBH	
				COP
	SYSTEM USEFUL ENERGY CONVERSION	76%		1.1

30ºF AMBIENT AIR CONDITION
INLET AIR COOLER NOT IN OPERATION
MAXIMUM HOT WATER PRODUCTION

MASS BALANCE (30ºF, 60% RH)

PID LOCATION	FLUID/SERVICE	FLOW RATE		TEMP	
CA-001	COMBUSTION AIR TO TURBINE	52,743	PPH	30	°F
1.5"-HPNG-002	NATURAL GAS TO TURBINE	810	PPH	NA	
EG-003	TURBINE EXHAUST TOTAL	53,553	PPH	960	°F
36"-EG-004	TURBINE EXHAUST TO CHILLER	53,553	PPH	840	°F
30"-EG-005	CHILLER EXHAUST TO ATMOSPHERE	53,553	PPH	840	°F
36"-EG-006	TURBINE EXHAUST TO ATMOSPHERE	0	PPH	NA	
8"-HWS-007	HOT WATER LEAVING CHILLER	920	GPM	140	°F
8"-HWR-008	HOT WATER TO CHILLER	920	GPM	125.6	°F
12"-CHWS-009	CHILLED WATER LEAVING CHILLER	0	GPM	NA	
12"-CHWR-010	CHILLED WATER TO CHILLER	0	GPM	NA	
14"-CWR-011	COOLING WATER LEAVING CHILLER	0	GPM	NA	
14"-CWS-012	COOLING WATER TO CHILLER	0	GPM	NA	
GEN-013	ELECTRICITY PRODUCED	1,163	KW	NA	

ENERGY CONVERSION CALCULATIONS

PID LOCATION		ENERGY		
	ENERGY INPUT			
1.5"-HPNG-002	NATURAL GAS TO TURBINE	16,700	MBTU/HR	
	TOTAL ENERGY CONSUMED	16,700	MBTU/HR	
	ELECTRICAL OUTPUT			
GEN-013	ELECTRICITY PRODUCED	3,968	MBTU/HR	
	ENERGY CONVERTED TO ELECTRICAL	24%		
	HEAT RECOVERY			
36"-EG-004	EXHAUST HEAT UTILIZED	7,197	MBTU/HR	
	ENERGY CONVERTED TO HEATING/COOLING	43%		
	COOLING WATER HEAT REJECTION	0	MBH	
	COOLING/HEATING OUTPUT			
12"-CHWS-009	CHILLED WATER PRODUCED	0	TON	
8"-HWS-007	HOT WATER PRODUCED	6,621	MBH	
				COP
	SYSTEM USEFUL ENERGY CONVERSION	67%		0.9

Natural gas LHV = 20,609 Btu/lb.
"Energy Converted" is the percentage of fuel input energy converted into useable energy.
No parasitic losses are included.
SOLAR SATURN 20 / BROAD USA BE-300
3% radiation and convection heat loss from chiller.

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PERFORMANCE DATA

1.2 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R-8

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

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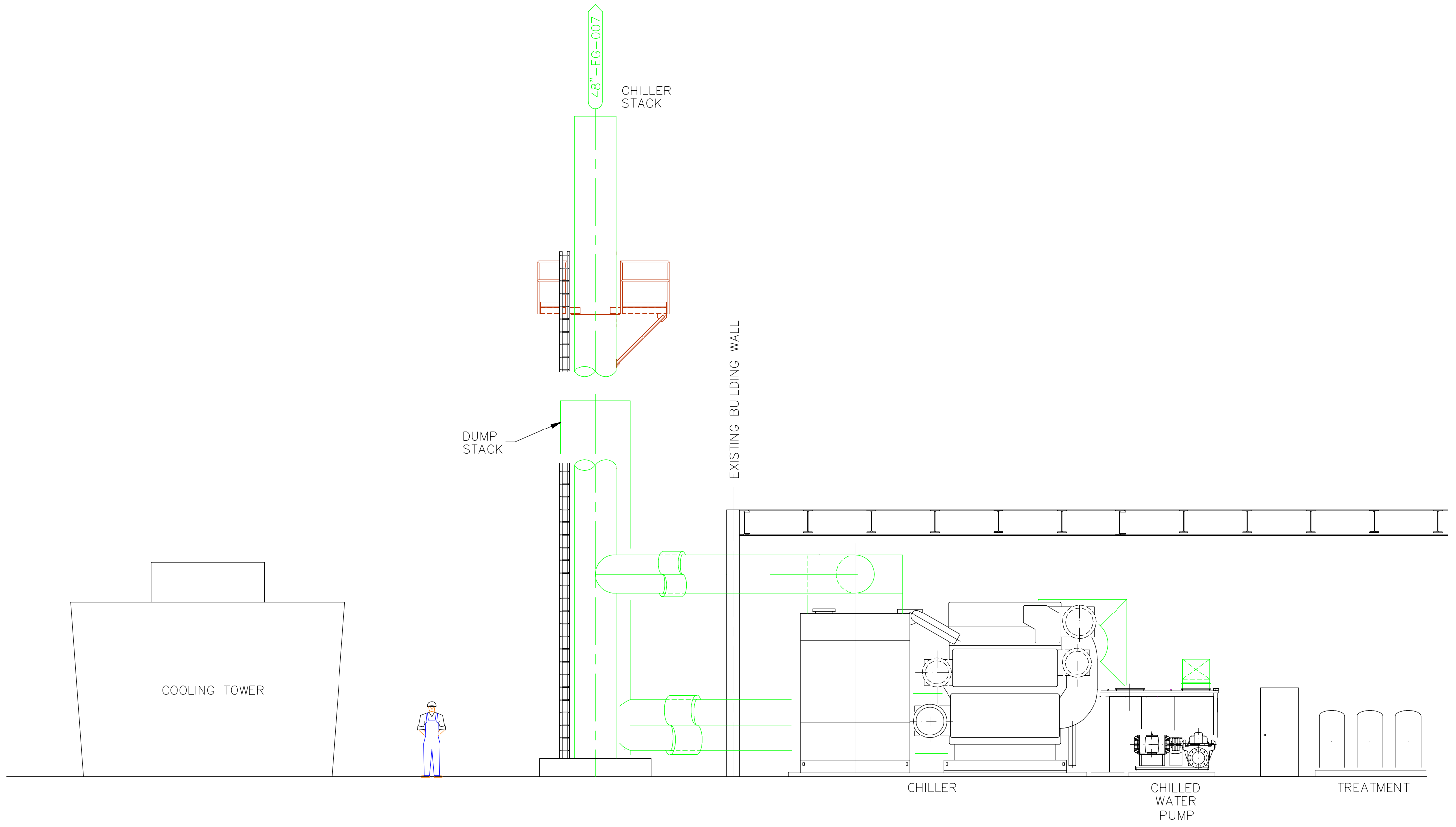
CHECKED BY	RBD	ISSUE DATE	04/20/05		



BOILER & TURBINE – PIPING SECTION

0 5 10
3/16 "=1'-0"

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BOILER & TURBINE – EQUIPMENT ELEVATIONS

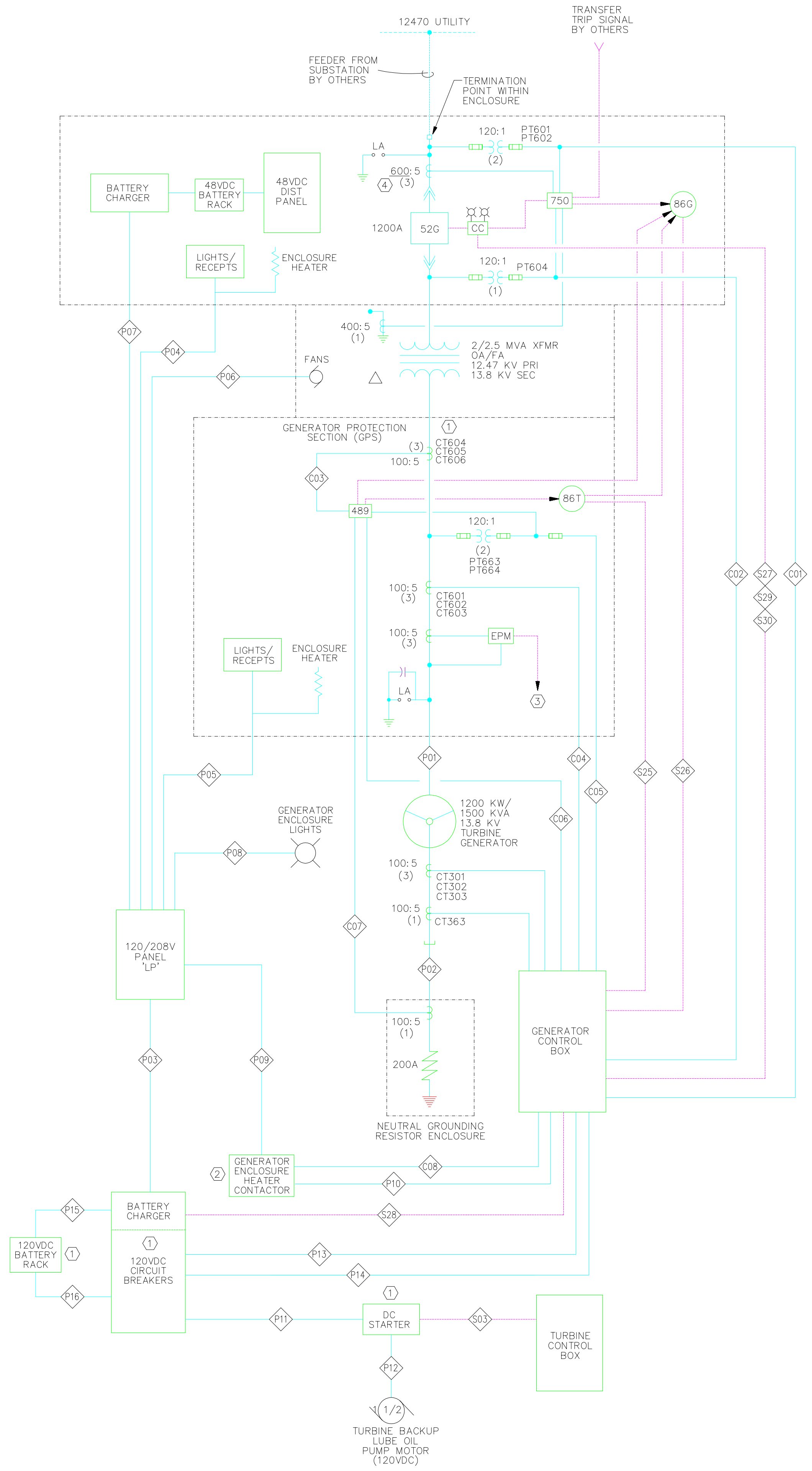
1.2 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R-8

PROTOTYPE PLANT

FORT BRAGG, N.C.

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

DRAWN BY D. GRIFFITH	JOB No. 1336.08	SHEET No. R8–M1
CHECKED BY R. BLYTHE	ISSUE DATE 04/20/05	



CONDUCTOR SCHEDULE

No.	Wire Spec.	Remarks
C01	2– 1/C #14 in 1"C	
C02	2– 1/C #14 (route with C01)	
C03	3–#10 TWISTED PAIRS (JUMPERS)	CT's shipped loose by Solar, installed by contractor
C04	2–#10 TWISTED PAIRS in 1"C	
C05	3– 1/C #14 (route with C04)	
C06	3–#10 TWISTED PAIRS in 1"C	Generator Neutral Side
C07	1–#10 TWISTED PAIR in 3/4"C	
C08	2– 1/C #14 in 1"C	(120VAC)
P01	3–1/C #2 & 1–1/C #1/0 Gnd in 3"C	15KV, MV–105, Shielded Cable
P02	1–1/C #2/0 in 2"C	8KV, MV–105, Shielded Cable
P03	2– 1/C #8 & 1–1/C #10 Gnd in 3/4"C	(208V, 1–PH)
P04	3– 1/C #12 & 1–1/C #12 Gnd in 1"C	(120VAC)
P05	3– 1/C #12 & 1–1/C #12 Gnd in 1"C	(120VAC)
P06	3– 1/C #12 & 1–1/C #12 Gnd in 1"C	(208VAC)
P07	2– 1/C #12 & 1–1/C #12 Gnd in 1"C	(120VAC)
P08	2– 1/C #12 & 1–1/C #12 Gnd in 1"C	(120VAC)
P09	2– 1/C #12 & 1–1/C #12 Gnd in 3/4"C	(120VAC)
P10	2– 1/C #12 & 1–1/C #12 Gnd in 1"C	(120VAC)
P11	2– 1/C #6 in 3/4 "C	(120VDC)
P12	2– 1/C #6 in 1"C	(120VDC)
P13	2– 1/C #12 (route with P14)	(120VDC)
P14	2– 1/C #4 in 2"C	(120VDC)
P15	2–1/C #12 in 3/4"C	(120VDC)
P16	2–1/C #2 in 1"C	(120VDC)
S03	2– 1/C #14 in 1"C	(24VDC)
S25	2– 1/C #14 in 1"C	86T trips turbine and generator (24 VDC)
S26	2– 1/C #14 in 1"C	86G trips generator only (24 VDC)
S27	3– 1/C #14 (route with S26)	Breaker position (24 VDC)
S28	2– 1/C #14 in 1"C	(24V DC)
S29	2– 1/C #14 (route with S26)	(48V DC)
S30	2– 1/C #14 (route with S26)	(48V DC)

LEGEND

489	–MULTILIN GENERATOR MANAGEMENT RELAY.
750	–MULTILIN FEEDER MANAGEMENT RELAY.
	–CURRENT TRANSFORMERS
	–POTENTIAL TRANSFORMERS
86	–LOCK–OUT RELAY. 86T TRIPS TURBINE AND GENERATOR BREAKER. 86G TRIPS GENERATOR BREAKER ONLY.
	–SURGE CAPACITOR, ONE–3 PHASE UNIT.
LA	–LIGHTNING ARRESTOR, 3 REQUIRED.
(1)	– NUMBER = QUANTITY OF DEVICES
	– FUSE
CC	– CONTROL CIRCUIT WITH INDICATOR LIGHTS
	– GROUND
52G	– MED/HIGH VOLTAGE GENERATOR SYNCHRONIZING BREAKER
C#	– CONDUCTOR RUN DESIGNATOR ('C'= CONTROL, 'P'= POWER, 'S'= SIGNAL). SIGNIFIES CONDUCTORS TO BE INSTALLED BY CONTRACTOR. SEE CONDUCTOR SCHEDULE FOR MORE INFORMATION.
EPM	– ELECTRONIC POWER METER

NOTES:

1. EQUIPMENT PROVIDED LOOSE BY SOLAR FOR INSTALLATION BY CONTRACTOR.
2. HEATER CONTACTOR PROVIDED AND INSTALLED BY CONTRACTOR.
3. THIS CONTRACTOR TO INSTALL POWER METER CONDUIT FROM UNIT SUB TO JUNCTION BOX INSIDE NEW CHILLER BUILDING. CONDUIT FROM JUNCTION BOX TO PLANT CONTROL SYSTEM BY OTHERS. METER OUTPUT WIRING INSTALLED BY OTHERS.
4. CURRENT TRANSFORMER SHALL BE OF MULTI–TAP TYPE. USE 100:5 SECONDARY TAP.

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OAK RIDGE NATIONAL LABORATORY

ELECTRICAL ONE–LINE DIAGRAM

1.2 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R–8

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

DRAWN BY	CSH	JOB No.	1336.08	SHEET No. R8–E1
CHECKED BY	CSH	ISSUE DATE	04/20/05	

GENERAL NOTES:

B. THE FOLLOWING MINIMUM WIRING STANDARD WILL BE FOLLOWED IN THE WIRING CONSTRUCTION ON THIS PROJECT–

1. DEFINITION: POWER CONDUCTORS INCLUDE PANEL FEEDERS AND BRANCH CIRCUITS AS WELL AS MOTOR FEEDS FROM THE MOTOR CONTROL CENTER. POWER CONDUCTORS WILL ALSO INCLUDE THOSE CONDUCTORS USED TO POWER FIELD DEVICES.
2. CONTROL CONDUCTORS INCLUDE CONDUCTORS BELOW 300 VOLTS USED IN THE INSTRUMENTATION AND CONTROL OF THE FACILITY.
3. CONTROL POWER CONDUCTORS ARE THOSE USED TO POWER FIELD DEVICES FROM PLC CABINETS, CONTROL POWER TRANSFORMERS IN MCC BUCKETS, OR PANELS DESIGNATED AS CONTROL POWER SOURCES.
4. ALL CONTROL WIRING WILL BE COLOR–CODED. POWER CONDUCTORS, CONTROL POWER CONDUCTORS AND CONTROL CONDUCTORS WILL NOT BE THE SAME COLOR. COLOR CODE AS FOLLOWS:

   120 VAC POWER: BLACK OR RED WITH BLACK STRIPE

   120 VAC POWER NEUTRAL: WHITE

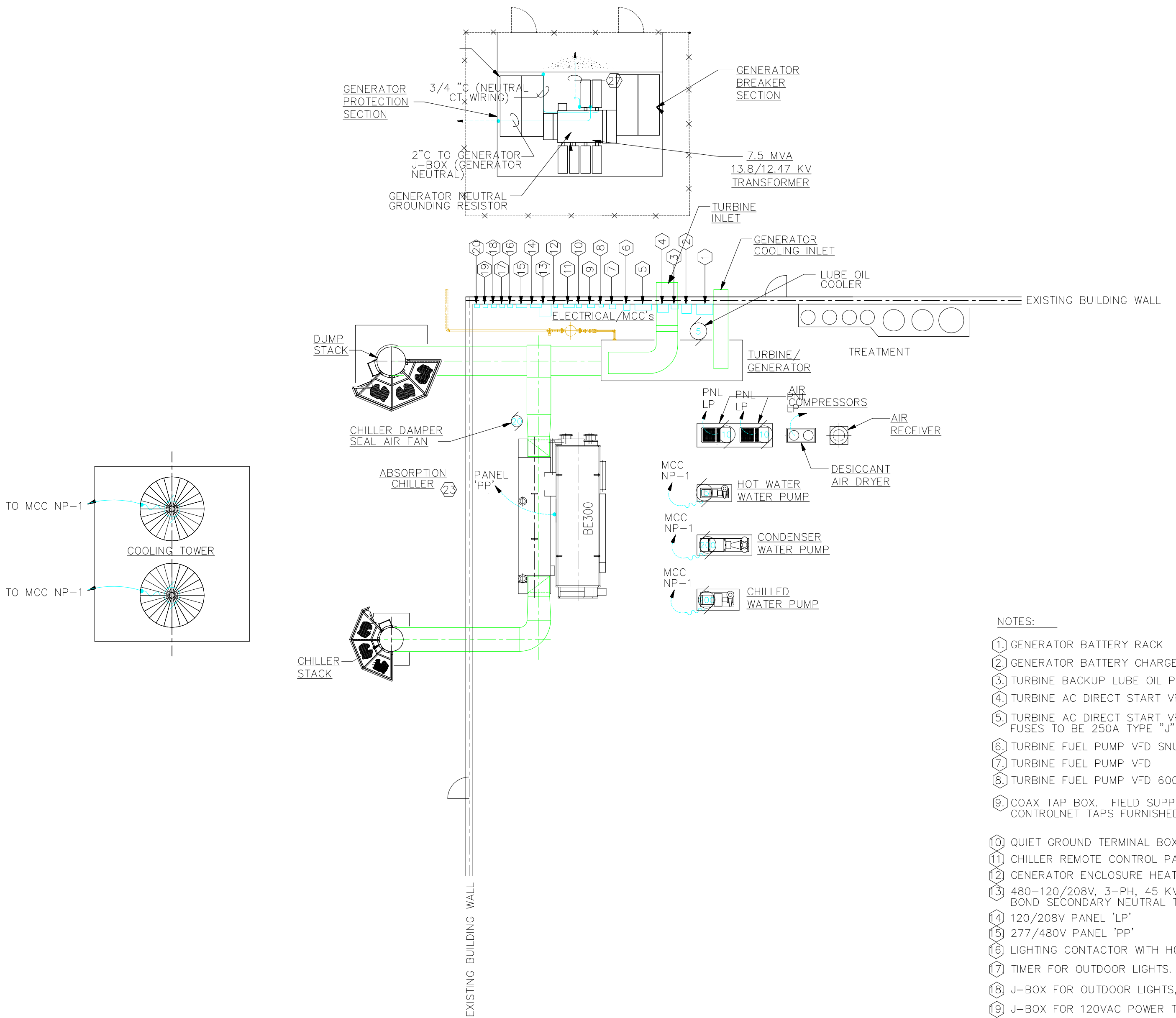
   120 VAC CONTROL: RED

   120 VAC CONTROL NEUTRAL: WHITE OR RED WITH WHITE STRIPE

   24 VDC (+): BLUE

   24 VDC (–): WHITE WITH BLUE STRIPE OR BROWN

5. 120 VAC CONTROL OUTPUTS WILL NOT BOTH BE RED CONDUCTORS. 120 VAC SUPPLY OUTPUT WILL BE RED AND THE RETURN WILL BE A NEUTRAL. THIS MEANS THAT EVERY SOLENOID, ACTUATOR, OR OTHER FIELD DEVICE GETS A WHITE OR WHITE STRIPED WIRE.
6. MULTIPLE FIELD DEVICES REQUIRING A CONTROL POWER SOURCE WILL NOT BE FIELD WIRED IN A DAISY–CHAIN CIRCUIT FROM THE SAME CIRCUIT UNLESS SPECIFICALLY CALLED OUT ON DRAWINGS. WIRING FOR EACH DEVICE MUST BE BROUGHT BACK TO A TERMINAL.
7. CONTROL WIRING WILL BE INTEGRATED INTO THE PROJECT, NOT ADDED AT THE END WHEN EVERYONE IS INVOLVED IN START–UP.
8. CONTROL WIRING WILL NOT SHARE RACEWAYS WITH POWER WIRING, UNLESS SPECIFICALLY INDICATED ON THE DRAWINGS.
9. NO BUTT SPLICES WILL BE USED FOR ANY WIRING. ALL CONNECTIONS WILL BE MADE ON A TERMINAL STRIP.
10. LABELING WILL BE DONE IN A CONSISTENT MANNER WITH THE OTHER END OF THE CONDUCTOR. ALL WIRE NUMBERS WILL BE AS SHOWN ON THE PROJECT CONNECTION DRAWINGS OR LABELED ACCORDING TO THE VENDOR PANEL DESIGNATION IF NOT SHOWN ON THE PROJECT DRAWINGS. FOR EXAMPLE, "BMS#1 TERM 801a", "FAN 12 STARTER CPT–N" (CONTROL POWER NEUTRAL) ETC. FOR VENDOR REQUIRED FIELD WIRING.
11. ALL STARTERS WILL HAVE CONTROL POWER TRANSFORMERS AND THE NEUTRAL SIDE WILL BE GROUNDED, UNLESS SPECIFICALLY NOTED OTHERWISE.
12. ALL FIELD DEVICES WILL BE MOUNTED ABOVE THE ADJACENT JUNCTION BOX TO PREVENT WATER COLLECTION. LIQUID TIGHT FLEX WILL BE USED FOR FIELD DEVICES; GREENFIELD IS NOT ALLOWED.
13. ALL RACEWAYS WILL BE DEPICTED ON THE RECORD DRAWINGS AND THEIR CONTENTS LABELED. SIMPLY SHOWING HOME RUNS FOR CONTROL WIRING IS NOT ACCEPTABLE.
14. EACH CONTROL WIRING RUN WILL INCLUDE AT LEAST ONE SET OF SPARE CONDUCTORS, AND CONDUIT FILL WILL NOT EXCEED 30%. ALL CONTROL POWER RUNS WILL BE PULLED BY HAND.
15. WHERE SWITCH CONTACTS OR LIMITS ARE IN SERIES, BOTH SIDES OF EACH CONTACT WILL BE BROUGHT BACK TO THE CONTROL PANEL TO AID IN TROUBLE SHOOTING.
16. ANALOG SHIELDED CABLE WILL BE DRESSED AT EACH END USING HEAT SHRINK TUBING.



ELECTRICAL POWER PLAN

0 5 10
1/8"=1'-0"

NOTES:

1. GENERATOR BATTERY RACK
2. GENERATOR BATTERY CHARGER
3. TURBINE BACKUP LUBE OIL PUMP DC STARTER
4. TURBINE AC DIRECT START VFD (MOUNT REACTOR ABOVE VFD)
5. TURBINE AC DIRECT START VFD 600V, 400A, 3–PH, 3–WIRE FUSED DISCONNECT SWITCH. FUSES TO BE 250A TYPE "J" CURRENT LIMITING, DUAL ELEMENT TIME DELAY.
6. TURBINE FUEL PUMP VFD SNUBBER RESISTOR
7. TURBINE FUEL PUMP VFD
8. TURBINE FUEL PUMP VFD 600V, 30A, 3–PH, 3–WIRE NON–FUSED DISCONNECT SWITCH.
9. COAX TAP BOX. FIELD SUPPLY AND INSTALL 12" X 12" (APPROX.) NEMA 1 BOX FOR CONTROLNET TAPS FURNISHED LOOSE BY SOLAR.
10. QUIET GROUND TERMINAL BOX.
11. CHILLER REMOTE CONTROL PANEL
12. GENERATOR ENCLOSURE HEATER CONTACTOR.
13. 480–120/208V, 3–PH, 45 KVA TRANSFORMER 'T–LP'. MOUNT 8'–0" AFF AGAINST COLUMN. BOND SECONDARY NEUTRAL TO COLUMN WITH #4 BARE COPPER WIRE.
14. 120/208V PANEL 'LP'
15. 277/480V PANEL 'PP'
16. LIGHTING CONTACTOR WITH HOA SWITCH.
17. TIMER FOR OUTDOOR LIGHTS.
18. J–BOX FOR OUTDOOR LIGHTS, RECEPTACLES AND HEAT TRACING.
19. J–BOX FOR 120VAC POWER TO BMS AND GAS COMPRESSOR CONTROL PANELS AND UNIT SUB
20. J–BOX FOR FUTURE 120VAC CONTROL TO GENERATOR CONTROL BOX
21. 2–#12 & 1–#12 GND IN 3/4 "C.
22. ROUTE WIRING TO NEW (OR EXISTING SPARE) 1–POLE, 20A CIRCUIT BREAKER IN EXISTING 120/208V PANEL 'NP'.
23. CHILLER SOLUTION PUMP VARIABLE FREQUENCY DRIVE IS SHIPPED LOOSE FOR INSTALLATION ON SKID BY CONTRACTOR.
24. J–BOX FOR WIRING TO UNIT SUB POWER METER.
25. CONTRACTOR TO COORDINATE FINAL LOCATION OF CHEMICAL FEED UNITS AND SWITCHES WITH OWNER.
26. FEED LIGHT WITH TAP FROM NEAREST NEW OUTDOOR 120V RECEPTACLE CIRCUIT. RUN 2–#12 & 1–#12 GND IN 3/4 "C TO J–BOX PROVIDED BY VENDOR ON SIDE OF AIR FILTER. LIGHT IS PRE–WIRED TO J–BOX BY VENDOR.
27. 1–#4/0 INSULATED GROUND WIRE (600V) IN 1" CONDUIT. CONNECT TO GROUND GRID.

Broad USA | I.C. Thomasson | CHELSEA GROUP LIMITED | Honeywell | OAK RIDGE NATIONAL LABORATORY

ELECTRICAL POWER PLAN

1.2 MW INTEGRATED ENERGY SYSTEM
REFERENCE DESIGN R–8

I.C. THOMASSON ASSOCIATES,INC.
CONSULTING ENGINEERS
NASHVILLE TENNESSEE

DRAWN BY MGP
CHECKED BY LJS
JOB No. 1336.08
ISSUE DATE 04/20/05
SHEET No. R8–E2

Appendix F

Major Equipment (for design R-1)

Solar Turbines

Solar Turbines
A Caterpillar Company

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Home About Solar Oil & Gas Industry Power Gen Industry Customer Support

Power Gen Industry > Generator Set Packages > **Taurus 60**

- Specify A Project
- Industry Solutions
- Combined Cycle/STAC
- Generator Set Packages
- Saturn 20
- Centaur 40
- Centaur 50
- Mercury 50
- **Taurus 60**
  - Package Layout
  - Combined Cycle/STAC
- Taurus 70
- Mars 90
- Mars 100
- Titan 130
- Environmental Information
- Financial Services
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- Customer Services
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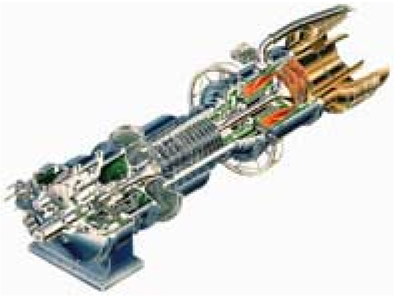
- Industry Links
- Library
- Worldwide Locations
- Toolbox

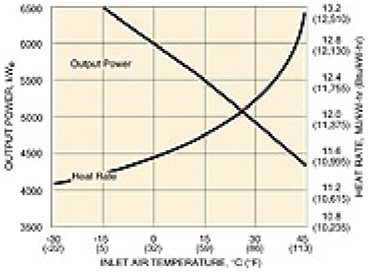
Taurus 60 PG - Generator Set

The family of Taurus™ gas turbines represents years of intensive development by the engineering and manufacturing groups at Solar and offers many advanced features.



sAvailable Power

Iso Conditions



Click for Larger Image

iISO Performance/Specifications

Taurus 60 PG	Metric	English
Power	5500 kWe	5.5 MWe
Heat Rate	11 840 kJ/kW-hr	11,225 Btu/kW-hr
Exhaust Flow	78 820 kg/hr	173,770 lb/hr
Exhaust Temperature	510 C	950 F
Steam Production	11.6-56.9 tonnes/hr	25.5-125.4 klb/hr
Axial Exhaust	Yes	Yes
SoLoNOx	Yes	Yes
Package Length	8750 mm	28' 9"
Package Width	2440 mm	8' 0"
Package Height	2130 mm	7' 0"
Approximate Weight	30 454 kg	67,140 lbs

Related Information

Brochures

- Turbotronic 4 Control System - PG (2.1mb)
- Gas Turbine Generator Systems (2.8mb)

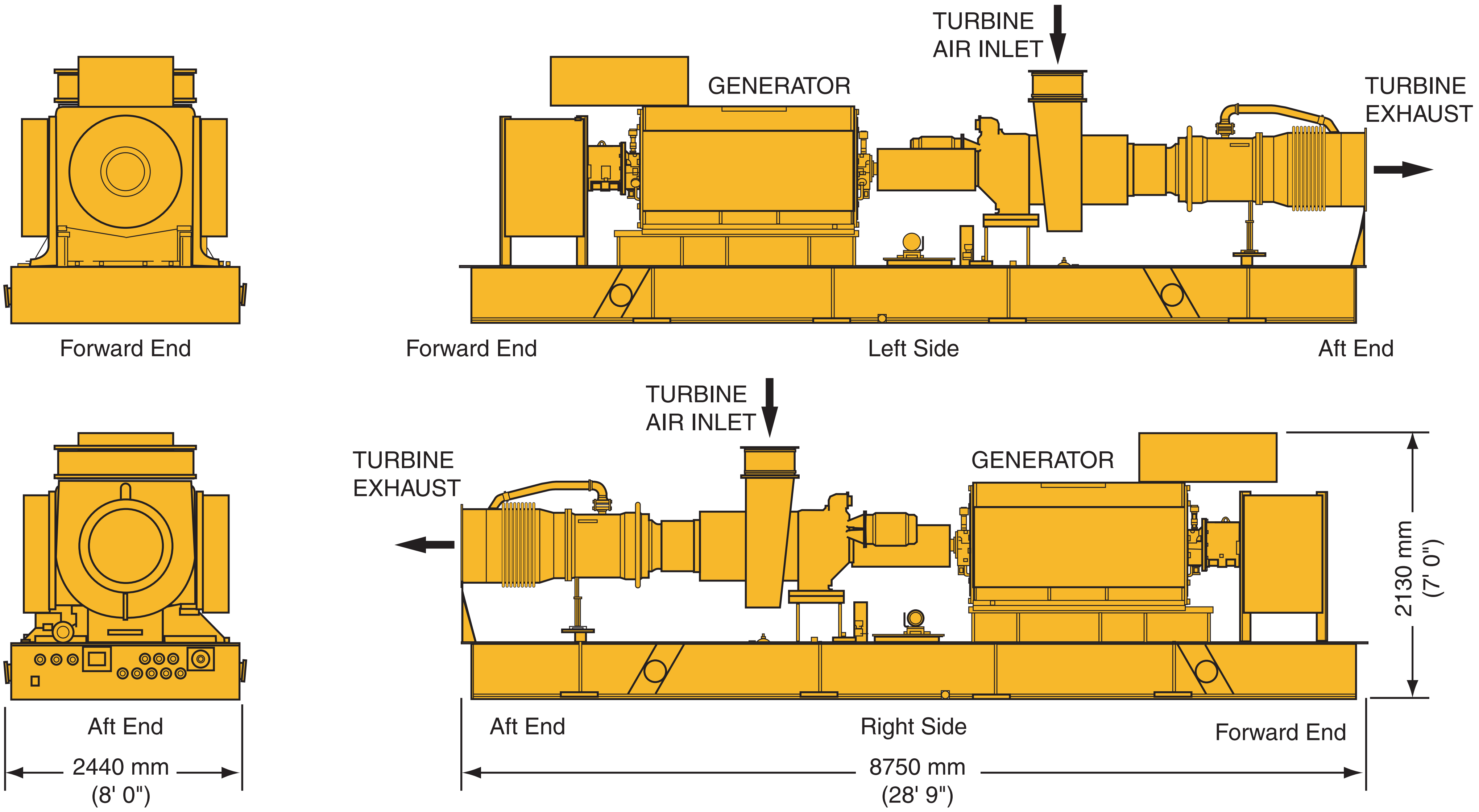
Case Studies

- Cogeneration Project - San Diego State University (150kb)
- Asset Management Services - Congress Energy Recovery (140kb)
- (More...)

Datasheets

- Taurus 60 Generator Set Industrial/Utility Grade - 5200 (52kb)
- Taurus 60-7800 Engine Uprate (100kb)
- (More...)

| Legal Notices | Privacy Policy (System Requirements)



Typical Weight: 30 454 kg (67,140 lb)

FORWARD END
1. Oil Drain from Generator Drip Pan
2. Ground, Package Frame

LEFT SIDE
1. Lube Oil Filter Drain
2. Lube Oil Tank Drain
3. Lube Oil to Cooler
4. Lube Oil from Cooler
5. Lube Oil Tank Vent
6. Lube Oil Cooler Vent
7. AC Power, Lube Oil Tank Heater
8. DC Power, Backup Lube Oil Pump Motor
9. Turbine Air Inlet Flange
10. Turbine Control Box
11. Package Lifting Bollards (Two)

RIGHT SIDE
1. AC Power, Starter Motor
2. Generator Control Box
3. Package Lifting Bollards (Two)

AFT END
1. Turbine Exhaust Diffuser and Combustor Drain
2. Natural Gas Fuel Inlet
3. Turbine Air Inlet Duct Drain
4. Pilot Valves, Air/Gas Vent
5. Liquid Fuel Inlet
6. Liquid Fuel Atomizing Air Inlet
7. Liquid Fuel Drain
8. Compressor Air for Self-Cleaning Filters
9. On-line Cleaning Fluid Inlet
10. On-Crank Cleaning Fluid Inlet
11. Oil Drain from Drip Pan
12. Gas Fuel Filter Drain
13. AC Power, Pre/Post Lube Oil Pump Motor
14. AC Power, Liquid Fuel Primary Pump Motor
15. Ground, Package Frame
16. Gas Fuel Filter Coalescer Purge Inlet

60PG_pl

Broad USA

索拉燃气轮机与远大吸收式冷温水机配套的 BCHP 系统

YKN02101516

Honeywell-DOE Project

1. BCHP system parameters

Revision 1

2. Gas turbine parameters (ambient temp.59°F, elevation is below 100 m)

1	Name 名称		索拉 Taurus 60 燃气轮机
2	Model 型号		Taurus 60
3	Output power 发电量	KW	5250
4	电压 V、相数		3300～13800 V；3 Phases 相
5	Output frequency 输出频率	Hz	60
6	Rotation speed 转速	Rpm	14950
7	Compression ratio 压缩比		12：1
8	Fuel 燃料名称		天然气 natural gas
9	Air consumption 空气耗量	cfm	35892
10	Heat rate 热耗	Btu/kW·hr	11499
11	efficiency 效率	%	29.7
12	Exhaust temp.烟气温度	°F	959
13	Exhaust flowrate 烟气流量	Lb/h	168824 (~~65631~~ 69235 for chiller)
14	Unit weight 机组重量	lb	64595
15	Start-up method 启动方式		Cell

Factory did not calculate the exhaust heat loss in the pipes (radiation loss), hence the exhaust flow rate has changed to account this.

3.2 配套的高温烟气型冷温水机 Chiller (high temp. exhaust type)

1	Name 名称		高温烟气型溴化锂吸收式冷温水机 chiller (high temp. exhaust type)
2	Model 型号		~~BS300N515/180-300~~ BS300N522
3	Cooling capacity 制冷量	kW	3489
5	Chilled water flowrate 冷水流量	GPM	2405
6	Pressure drop 压力损失	ftWC	26.2
7	Cooling water flowrate 冷却水流量	GPM	~~4220~~ 4251
8	Pressure drop 压力损失	FtWC	~~39.4~~ 59.1

9	Exhaust heat utilization amount (cooling) 余热利用量（制冷）	MBH	9914
10	Estimated Pressure Drop in the Exhaust	inWC	~~6.1~~ 7.87
11	Electric consumption 配电量	kW	8.8
12	Main shell ship. weight 主体运输重量	Lb	~~40785~~ 40885 (not including LiBr solution)
13	Operation Weight	Lbs	109,837

通用额定参数 General conditions

1. 冷水额定出口/入口温度 Chilled water outlet/inlet temp.: 44° F/54° F
2. 冷却水额定出口/入口温度 Cooling water outlet/inlet temp.: 95.2° F/85° F
3. 冷水允许最低出口温度 Lowest permitted outlet temperature for chilled water: 41° F
4. 冷水、冷却水压力限制 Pressure limit for chilled, cooling water: 171 Psig(special order)
5. 冷水、冷却水污垢系数 Fouling factor for chilled water: 0.018 m^2 • K/kW
6. Fouling factor for cooling water: 0.044 m^2 • K/kW
7. 机房环境标准 Machine room temperature: 温度 41°F～110°F; 湿度 humidity ≤85%
8. Rated exhaust outlet temp. : 356° F.
9. 冷水允许流量调节范围 Adjustable chilled water flowrate: 50～120%
10. 冷却水允许流量调节范围 Adjustable cooling water flowrate: 20˜ 120%

Fire tubes are G20 Steel, with 1 ½” OD, 014” thickness.

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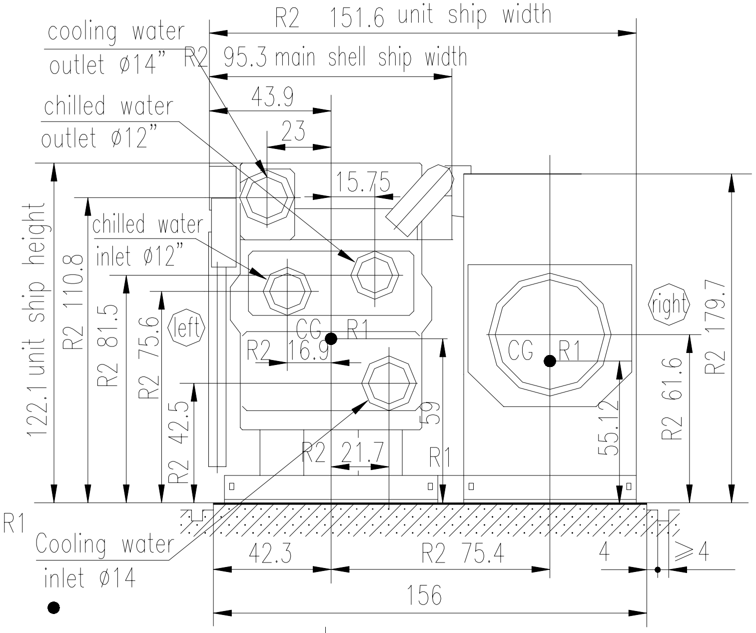
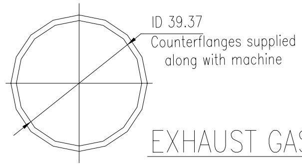
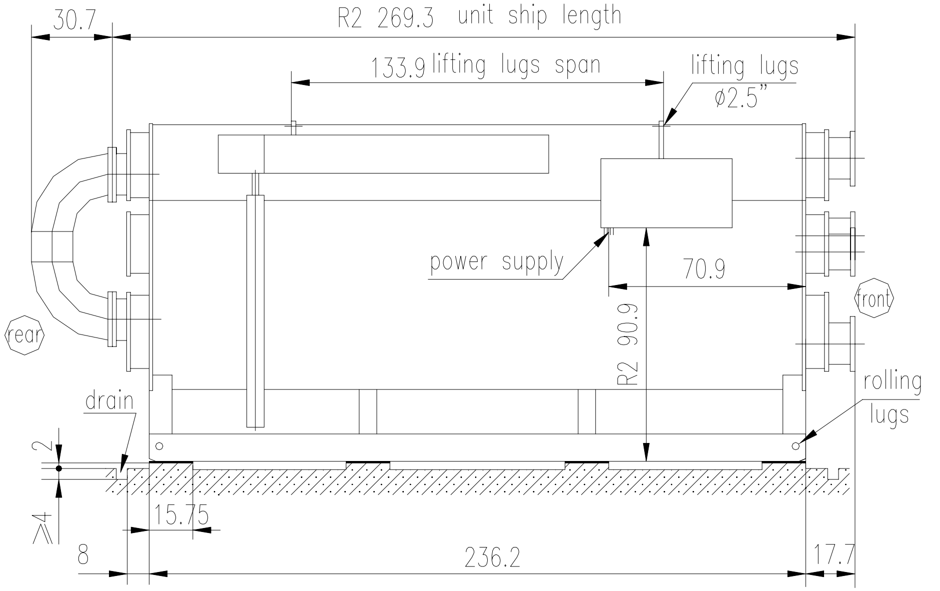
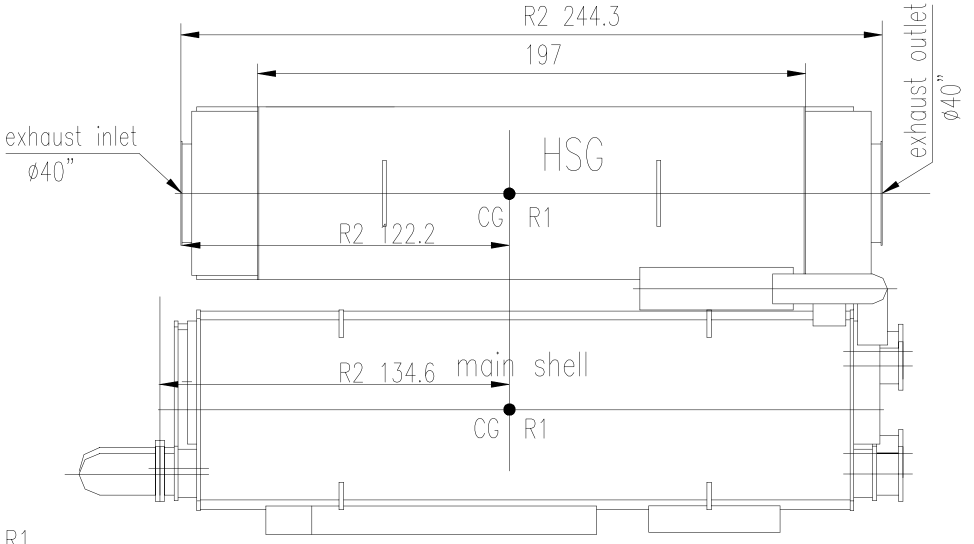
R1





EXHAUST GAS FLANGE





R2	As built dimensions corrected on the drawing	06/05/2003
R1	Corrected Cooling water, added CG and general layout	02/05/2003
Revision #	Description	Date

Product	BS300N522 DIMENSIONS			
Title	WXT-BS300N522			
Drawing No	ZQG300-021116S	Q.A		
Drawn By		Scale	1:1	Page 1 of 1
Checked By		BROAD AIR CONDITIONING Changsha, Hunan, CHINA		
Approved By				
Date	11/21/2002			

R1 ALL DIMENSIONS IN INCHES UNLESS SPECIFIED.

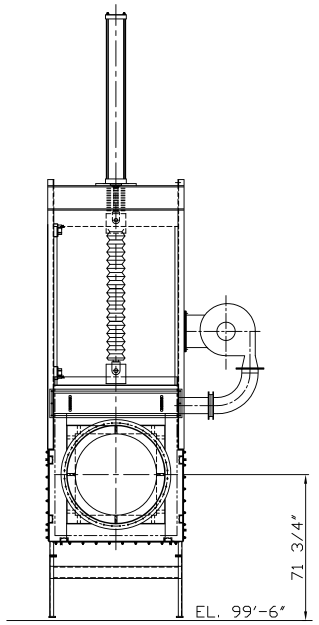
Rentech Boiler Systems

RENTECH BOILER SYSTEMS, INC.

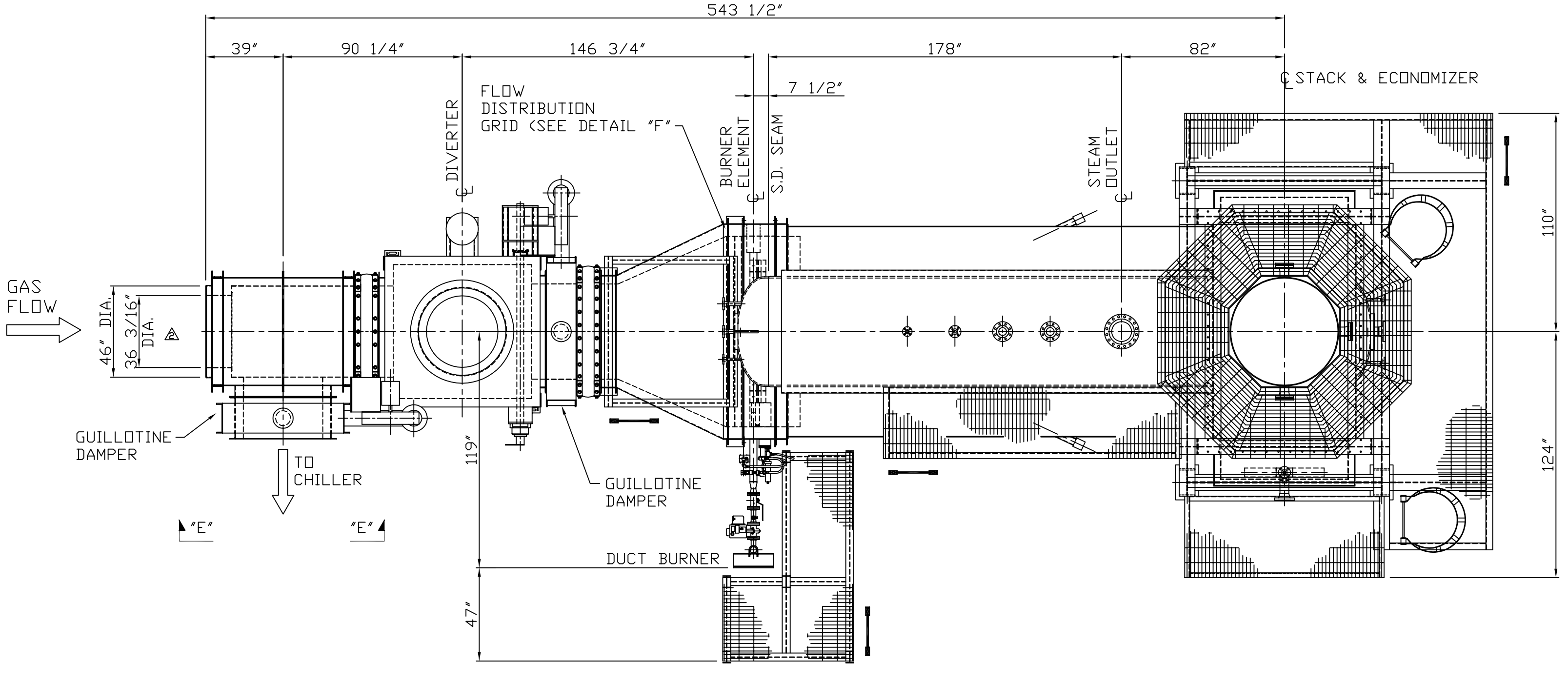
SAFETY AND SAFETY RELIEF VALVE CAPACITY CALCULATIONS

G	1		Customer	
E	2		Job No.	
N	3		Plant Site	
E	4		Calculations By	
R	5		Date	
A	6		Rev. No.	
L	7		Sheet No.	
	8		Boiler Design Pressure, psig	250
P	9		Boiler (Drum) Oper. Pressure, psig	130
R	10		Boiler Saturated Temperature, F	356
O	11		Boiler Steam Flow, lb/hr	**80,000.0**
C	12		Number of Boiler PSV's	2
E	13		Superheater Design Pressure, psig	0
S	14		Superheater Outlet Oper. Pressure, psig	0
S	15		Superheater Outlet Oper. Temperature, F	0
	16		Number of Superheater PSV's	0
D	17		Economizer Design Pressure, psig	300
A	18		Economizer Oper. Pressure, psig	145
T	19		Economizer in Oper. Temperature, F	228
A	20		Economizer Duty, mmBtu/hr	5.453
	21		Number of Economizer PSV's	0
	22		**Total Reqd Relieving Capacity, lb/hr**	**80,000.0**
	23		Minimum Required Boiler PSV's Capacity	80,000.0
	24		Required SH PSV Capacity, lb/hr	0.0
	25		Required Econo. PSV Capacity, lb/hr	0.0
	26		Manufacturer of PSV's	Consolidated
R	27		Steam Drum PSV #1 Set Pressure, psig	160.0
E	28		Model No. of Drum PSV #1	1511N
S	29		Steam Drum PSV #2 Set Pressure, psig	165.0
U	30		Model No. of Drum PSV #2	1511P
L	31		SH PSV Set Pressure, psig	0.0
T	32		Model No. of SH PSV	None
S	33		**Actual Relieving Capacity Boiler PSV's, lb/hr**	**88,362.9**
	34		Economizer PSV Set Pressure, psig	0.0
	35		Model No. of Econ. PSV	None

REV	DATE	DESCRIPTION	CALC. BY/APPD BY



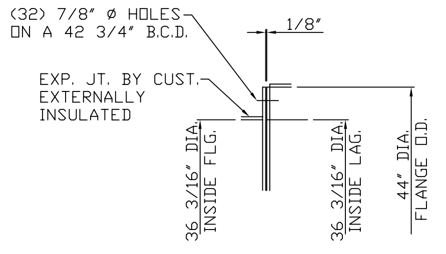
SECTION "E-E"



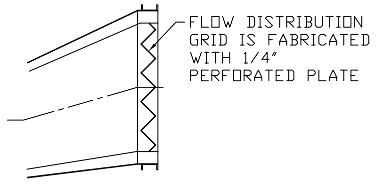
PLAN VIEW

DESIGN NOTES:

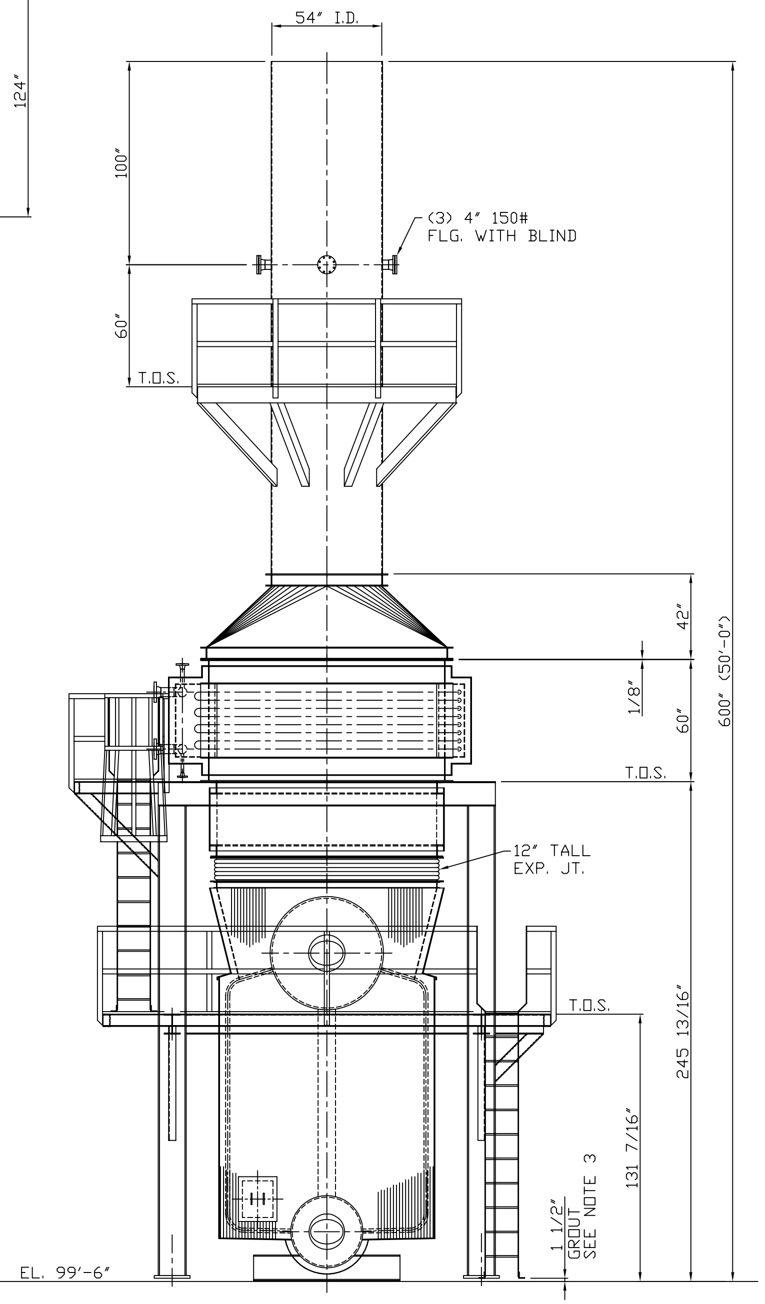
1. GAS DUCTS UPSTREAM OF THE BOILER ARE TO DESIGNED WITH 3/16" MINIMUM C.S. CASING, INTERNALLY INSULATED AND 12 GA. FLOATING A-242 CORTEN LINER.
2. GAS DUCTS DOWNSTREAM OF THE BOILER AND ECONOMIZER ARE TO BE DESIGNED WITH 3/16" MINIMUM C.S. CASING, EXTERNALLY INSULATED WITH CORRUGATED ALUMINUM LAGGING.
3. ALL EQUIPMENT, SUPPORT LEGS, LADDERS AND COLUMNS SUPPORTED FROM TOP OF CONCRETE SHALL HAVE 1 1/2" OF GROUT, EXCEPT BOILER.
4. ALL GAS SIDE FLANGES ARE DESIGNED FOR A BOLTED TYPE CONNECTION WITH AN 1/8" GAP FOR GASKET MATERIAL.
5. REFER TO EFFOX DRAWINGS FOR SPECIFIC INFORMATION FOR THE DIVERTER, GUILLOTINES AND EXP. JOINTS.



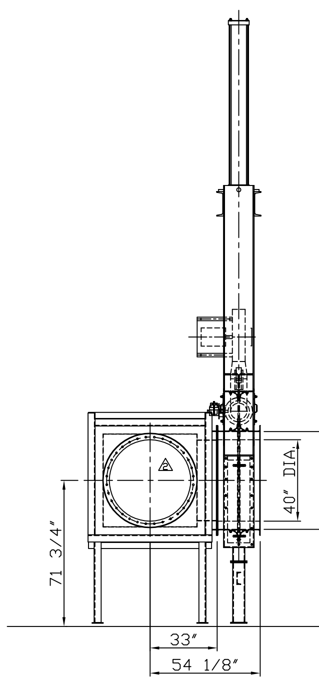
DETAIL "D"



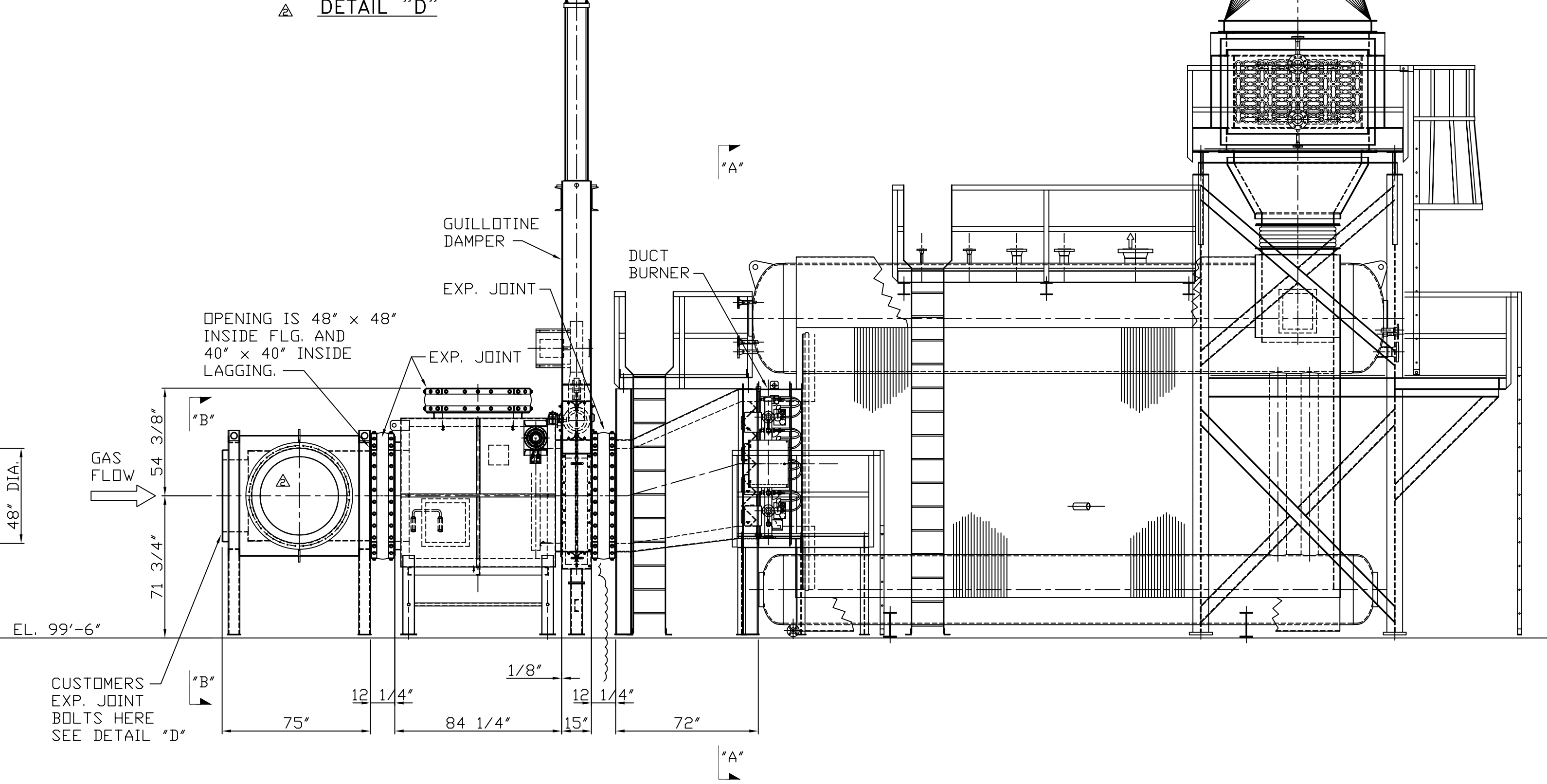
DETAIL "F"
ELEVATION VIEW



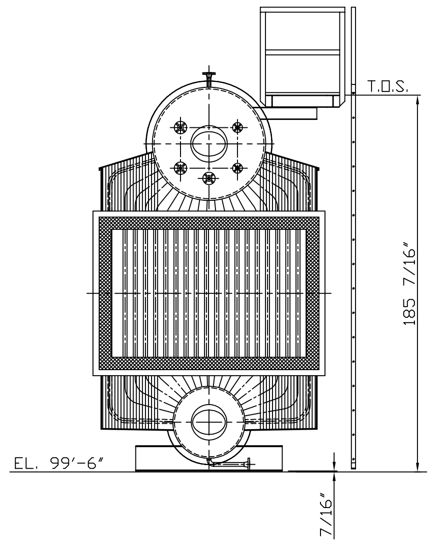
OUTLET END VIEW



SECTION "B-B"
LOOKING AT INLET



SIDE VIEW



SECTION "A-A"

NO.	DATE	DESCRIPTION	BY	APPR
3	·	·	·	·
2	08/18/03	GENERAL REVISION	RD	WEW
1	3-20-03	GENERAL REVISION	WEW	WEW

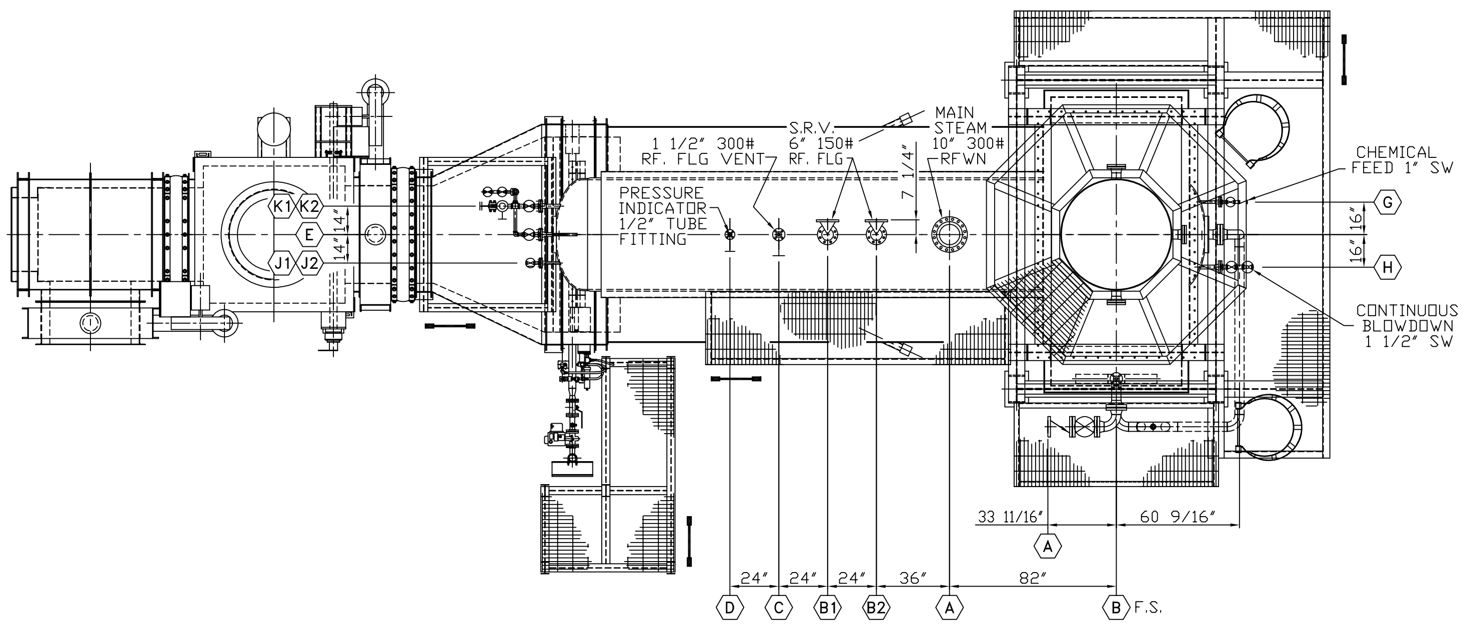
REVISIONS

RENTECH
Boiler Systems, Inc.
"RENTECH *boilers for people who know and care*"™

DESCRIPTION
SYSTEM ARRANGEMENT

CUSTOMER
P.O. # 30200003
STANLEY JONES CORPORATION

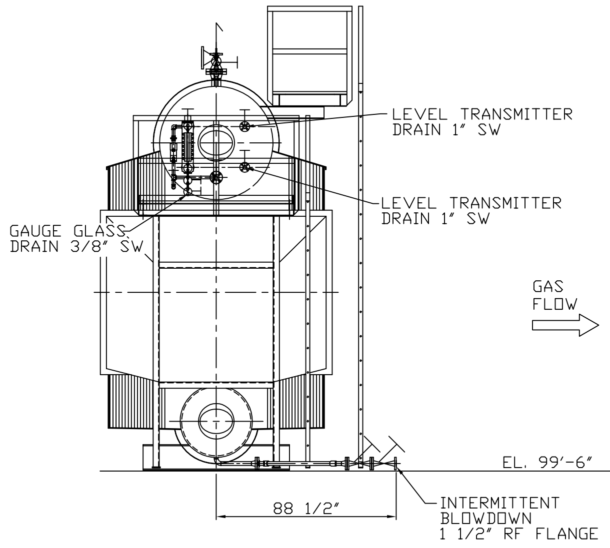
SCALE: 1/4" = 1'-0"
DRAWN BY: WEW
DRAWING NUMBER 02-66,67-1
REV. 2
DATE: 2-4-03
APPR. BY: WEW



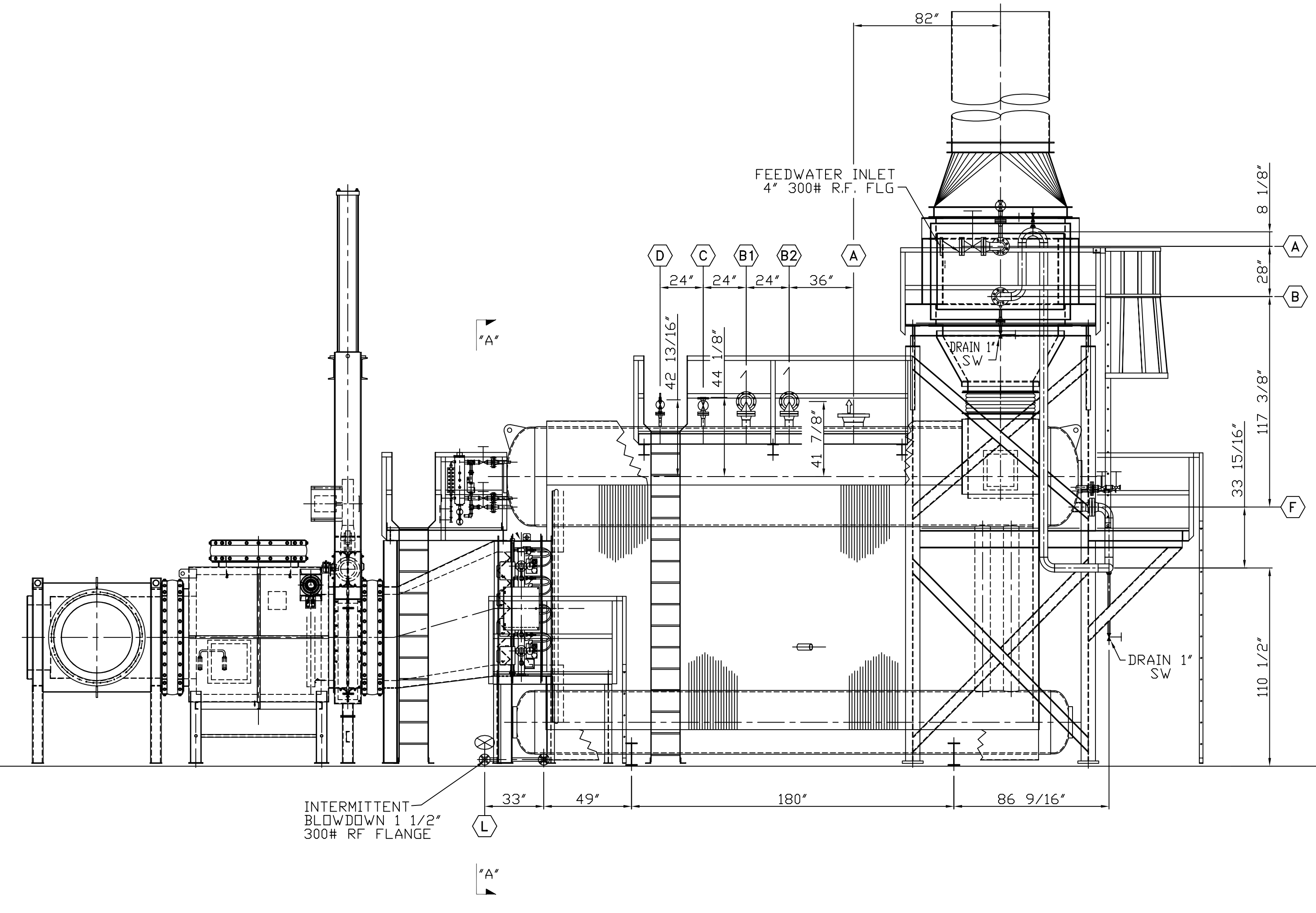
PLAN VIEW

NOTES:

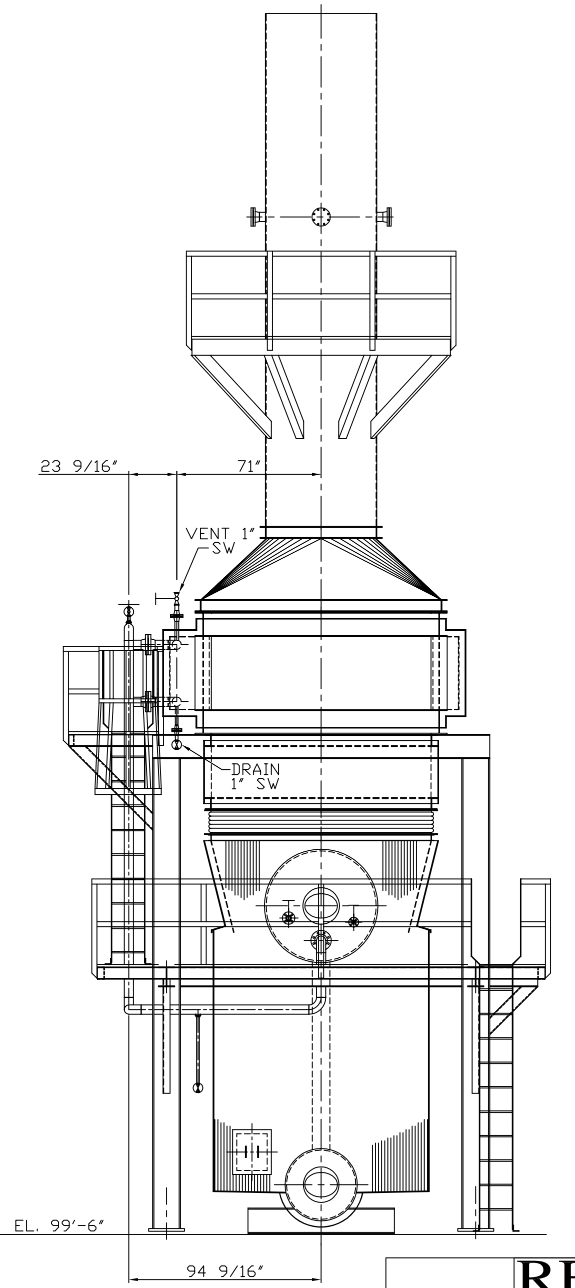
1. REFER TO 02-66,67-1 FOR SYSTEM ARRANGEMENT.
2. REFER TO 02-66,67-10 FOR WATERTUBE BOILER ARRANGEMENT.
3. REFER TO 02-66,67-11 FOR ECONOMIZER ARRANGEMENT.
4. ALL PIPE SUPPORTS FROM TOP OF CONCRETE SHALL HAVE 1 1/2" OF GROUT.
5. AN ADDITIONAL 3" WILL BE ADDED TO PIPE LENGTHS AT FIELD WELDS FOR ADJUSTMENT IN THE FIELD. CUT AND PREP. AS REQUIRED.



SECTION "A–A"



SIDE VIEW



OUTLET END VIEW

RENTECH
Boiler Systems, Inc.
"RENTECH *boilers for people who know and care*"™

DESCRIPTION
PIPING ARRANGEMENT

CUSTOMER
P.O. # 30200003
STANLEY JONES CORPORATION

NO.	DATE	DESCRIPTION	BY	APPR
3	·	·	·	·
2	·	·	·	·
1	8-19-03	GENERAL REVISION	AGF	TDL

REVISIONS

SCALE: 1/4" = 1'-0"
DRAWN BY: WLN
DATE: 3-06-03
APPR. BY: TDL
DRAWING NUMBER 02-66,67-50
REV. 1

Appendix G

Site Interface Resources

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News & Events
General Public
Technical Professionals
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Benefits
Technology Status
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Application Manual
Design Tips
Market Potential
Emissions
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Financial Institutions
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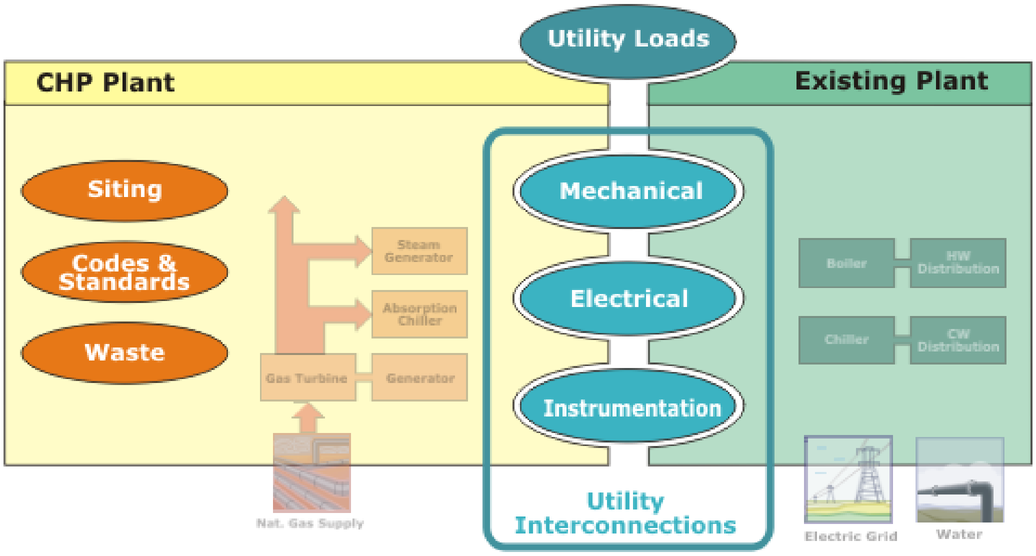
Design Tips - Building and Site Requirements

This section describes the requirements involved in interfacing modular integrated energy systems (IES) with conventional building systems. This document is not intended to be a design guide for these building and site interfaces (which is the responsibility of the cognizant design engineer who is applying a Reference Design to a particular building). The Reference Designs are based on approximately 1MW to 5MW Solar gas/diesel turbine generators, heat recovery boiler(s) with duct firing, and Broad USA heater/chiller(s) serving a variety of load scenarios and generic facilities. As such, the focus of this document is on identifying the kinds of conventional systems that are compatible with the Reference Designs, and provides a list of design resources that practitioners can use in applying modular IES technology. An illustration of key building interfaces is shown below. Additional discussion is presented in each section.



- Background
- Codes and Standards
- Electrical Interconnections
- Instrumentation
- Mechanical Interconnections
- Siting
- Utility Loads
- Waste
- Additional Information

Background

Introduction

The information presented here is the results of technical work being performed for developing packaged system designs for large (in the range of 1MW to 5 MW) building cooling, heating, and power (BCHP) Systems, also known as Integrated Energy Systems (IES). This work is funded by the U.S. Department of Energy and is being administered by

Oak Ridge National Laboratory (ORNL Subcontract 4000011476). Honeywell and its team members, Broad USA, I.C. Thomasson, and the Chelsea Group, are developing a set of CAD-based packaged IES system designs and a supervisory control and optimization capability for these systems. This section covers the work performed under Task 2.1: Building & Site Requirements.

Project Overview

The objective of the program that developed the information in this section was to develop large (in the range of 1MW to 5 MW) BCHP packaging technologies and field-test a prototype system. These technologies include a set of "reference" CAD designs and an optimizing supervisory control system. Installation scenarios for these systems can vary widely, so packaging is dependent on modularity, namely, the ability to construct a system by choosing from a selection of compatible components with standardized interfaces. This is especially important for larger BCHP systems, where the physical size of the equipment prohibits the manufacture and shipment of the entire system in one enclosure. Packaging in this way still simplifies the design and installation process by reducing the amount of site-specific engineering and site preparation required.

This project was focused on BCHP packaged systems in the 1- to 5-MW size range, with 900 to 2000 tons of cooling, intended for central plant and district energy applications serving multiple buildings. The major modules are a turbine-generator, a heat recovery steam generator, and an absorption chiller. The set of "reference" packaged designs to be developed will allow these modules to be applied to a variety of customer sites.

Back To Top

Codes and Standards

The purpose of this section is to provide the reader with a overview of the codes and standards that will generally apply to a CHP plant. By no means is this list comprehensive.

1. **Building Codes**
    - International Building Code (IBC), developed as a model code for model code organizations:BOCA, UBC, SBC
    - State & local codes
2. **Mechanical Codes & Standards**
    - **2.1 ANSI Standards**
        - Flanges and piping B16.5, B16.1, B16.47, etc.
    - **2.2 ASHRAE Standards**
        - Guideline 1-1996 The HVAC Commissioning Process
        - Std 15-2001 Safety Standard for Refrigeration Systems
        - Std 62-2001 Ventilation for Acceptable Indoor Air Quality
        - Std 114-1986 Energy Management Control Systems Instrumentation
        - Std 135-2001 BACnet - A Data Communication Protocol for Building Automation and Control Networks
        - Std 147-2002 Reducing the Release of Halogenated Refrigerants from Refrigerating and Air-Conditioning Equipment and Systems
    - **2.3 ASME Standards**
        - Boiler Power Piping 31.1
        - Chemical Process Piping 31.3
        - Boiler and Pressure Vessel Code
        - Pipe Flanges and Flange Fittings B16.5
    - **2.4 ASTM Standards**

      These are generally equipment standards and pertain to individual components of the CHP system
    - **2.5 UL Standards**
    - **2.6 State & Local Code**

      A number of large municipalities (Chicago, New York City) maintain their own codes
3. **Electrical Codes & Standards**
    - **3.1 IEEE**

- Interconnection Standard 1547
- DG Standard 1589
- IEEE Standards 519-1992, 929-2000, 84 (Harmonic Limits and Voltage Fluctuations, Waveform)

3.2 National Electric Code (NEC)

3.3 ASTM Standards

These are generally equipment standards and pertain to individual components of the CHP system

3.4 UL Standards

3.5 State & Local Codes

A number of large municipalities (Chicago, New York City) maintain their own codes

3.6 State & Local Codes

4. National Fire Protection Agency (NFPA) Codes

- Gas-Fired Equipment Code 8501
- Oil/Diesel-Fired Eqipment Code 31
- National Gas Fuel Code (NFPA 54)
- Liquid Fuel Storage Tanks Code (NFPA 30)

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Electrical Interconnections

The electrical equipment of the CHP facility, though not the most expensive part of the construction, is vital in the operating success of the facility, and is probably the most complicated and diverse part of the design. In most facilities there are two major areas of focus, the utility interface point and the CHP construction itself. We will consider these two points as separate parts of the design and in many cases may be remote from each other by a substantial distance.

1.Utility Interface Point

The interface point is usually located close to or within the distribution substation for the facility. The following upgrades are usually considered in the design of this point of intersection.

2.Low-Med Voltage/Station Power Capacity

The CHP facility consumes power itself to operate. Although supplied by the CHP equipment itself through transformers, often an additional feed is used to provide this power from the utility during startup. A new standby generator may also be used.

3.High Voltage-Substation

The CHP plant connects to the grid at the substation; sufficient space must be present for the switchgear and transformers required.

3.1 Over / Under Voltage Protection

It is usually critical for the cogeneration facility. The utility normal mode of design is to avoid voltage drop so they operate their distribution system at a higher than nominal level so that nominal levels can be maintained on the extended reaches of the distribution system. Cogeneration equipment removes load or may even export power removing voltage drop or creating voltage rise thereby driving the site into higher than normal voltage levels. Some utilities take an unrealistic, bureaucratic approach with mandatory trip requirements while operating at very high voltage levels. To avoid nuisance tripping of the interface breaker a fast acting, over voltage relay (ANSI Device 59) is required.

3.2 Under Voltage Relaying

Under voltage relaying (ANSI Device 27) also required is usually not as critical as over voltage control.

3.3 Out of Frequency - Over/Under Frequency Protection

Out of frequency / over/under frequency protection (ANSI Device 81 O/U) is also important. The first signs of system instability occur in the system operating frequency. For a cogeneration plant operating in parallel the frequency is set by the utility. The system frequency protection should be set outside the utility trip points and set for on site equipment protection only. In the unlikely event of utility grid instability the cogeneration equipment should stay on line to avoid placing the facility load on a utility tending toward instability. Utility guidelines may be obtained to assist in making these determinations.

3.4 Out of Step Protection

Normally any breaker interfacing between the utility and the cogeneration must be equipped with a Sync-check relay, (ANSI Device 25). This relay will be capable of monitoring the voltage via potential transformers (PT) on the line and load side of the device. The protective relay will prevent closing the breaker unless the voltages levels are the same and the both systems are in phase. If the co generation plant were accidentally connected to the utility out of phase, the two systems would attempt to instantly align themselves with other. This would cause major stress on the mechanical and electrical equipment operating on the site.

3.5 Reverse Power Protection

Reverse power protection may be required on facilities, which have not negotiated a power sell agreement with the utility. The reverse power relay (ANSI Device 32) monitors the direction of power flow and will, after a time delay, initiate a trip when power flows from the site to the utility grid. There is an option to either trip the site-interconnecting breaker or trip the generating equipment causing the reverse power. It is usually less disruptive to trip the generating equipment and suffering the impact of the increased power use penalties from the utility than to take the entire site off line. This however is not always the case, and must be analyzed for each site.

3.6 Detecting Unintentional Island Operation

The condition of unintentional island operation may occur when the facility load is approximately equal to the output of the cogeneration equipment. Under this condition, if a utility breaker upstream opens it may be difficult for the relaying at the interface point to detect that the utility is no longer connected. As long as the load is closely matched to the generators output the facility will continue to operate until a load change pushed the generator voltage or frequency out of the protection zone provided by the interconnecting relaying. Under this condition the facility may remain energized for several minutes creating the possibility of the upstream breaker reclosing on the facility out of phase or a possibly unsafe condition for utility maintenance workers. This condition does not occur during a fault since the fault energy would pull the generation equipment down, taking the CHP off line.

3.7 Power Import / Export Power Control

One feature that becomes vital in cogeneration facilities is the use of feed back control to limit the amount of power purchased from the utility. This is accomplished by sending a signal from the utility interface breaker to the CHP. Based on this feed back signal the turbine controls continually adjust the governor to maintain a fixed amount of power flowing through the utility interconnect breaker. This is modified only by the limits of the CHP generator.

3.8 Reactive Power Import / Export Power Control

A similar control function may be accomplished by monitoring the amount of reactive power purchased from the utility. The feed back signal from the interface breaker to the CHP allows the voltage regulator to be continuously adjusted to maintain a constant power factor across the utility main breaker. Protective features must be supplied for the generator controls to prevent over exciting the generator. The additional cost for this control feature may be recovered from utility charges against reactive power purchases.

4. The CHP Electrical Design Considerations

4.1 Distribution System Configuration

The first consideration for a new CHP is the configuration of the distribution system to which it is connected. The presence or absence of a neutral in the distribution system will determine how the cogeneration equipment is connected to the system. Another consideration is to whether the system will be operated as an island or not. The presence of a neutral indicated that transformers are connected wye on the primary side. If this is the case an Isolating transformer will be required since the generator is not a good source for generating neutral currents.

4.2 The Isolating Transformer

The isolating transformer for the CHP cogeneration equipment allows an exact match between the site distribution and the generator output. It also provides a level of isolation between the generator and exposed distribution. Typically the wye connection faces the distribution system to supply ground faults and neutral currents, and the delta faces the generators to provide isolation. The generator is typically connected wye and grounded through a reactor or resistor that establishes the ground reference on the generator side.

4.3 Generator Bus

The generator can operate on an electrically isolated bus or can supply auxiliary CHP loads. If the generator bus is used to supply other loads a grounding bank to establish the generator bus ground reference must be installed for those situations when the CHP auxiliary loads are operating and the turbine generator is not in operation.

4.4 Underground Distribution System

If the cogeneration equipment is connected to an underground distribution system, not exposed to lightning flash over events, and the system has no neutral the turbine generator can be connected to the distribution system without an isolating transformer. When this is the design care must be taken to properly ground the generator or specify the proper generator construction to avoid harmonic currents circulating between the distribution system and the utility distribution system. The pitch of the generator windings must match those of the utility system, typically 2/3. This type of construction is more expensive for this size alternator. Another option is to purchase a standard alternator and mitigate the harmonic currents that can result by increasing the impedance in the generator neutral connection. This should be carefully considered since the installation can impact the performance of lightning arresters in the distribution system.

4.5 Synchronizing Switchgear Requirements

4.5.1 Synchronizing Switchgear

Synchronizing switchgear is a piece of electrical switchgear constructed in such a manner to interface the generation equipment to the electrical distribution system. This gear contains the synchronizing breaker and all of the protective relaying required for protecting the alternator from electrical disturbances that occur on the distribution system. The location of this equipment in the electrical configuration for the CHP is between the generator and the first distribution bus upstream. In some cases the isolating transformer cam be placed between the synchronizing breaker and the alternator.

4.5.2 Synchronizing

Synchronizing is the operation of adjusting the generator voltage to match the line voltage, aligning the generator phase angle to match the utility and closing the synchronizing breaker. The turbine control equipment performs this operation automatically. Provision is also provided for manual override in the event that the automatic system fails. The manual system consist of volt meters with selection for line and generator voltage comparison; sync-scope for monitoring each system phase relationship; sync-lights which are not illuminated when the two systems are in phase; manual voltage and speed switches, raise and lower; and a manual switch to close the synchronizing breaker.

4.5.3 Protective Relaying

Protective relaying for the typical generator protection package may consist of the following. Presently many of these functions are housed in a multifunction, microprocessor protective relay.

4.5.3.1 Sync-check relay

Sync-check relay, (ANSI Device 25). This relay will be capable of monitoring the voltage on the line and load side of the device. The protective relay will prevent closing the breaker unless the voltages levels are the same and the both systems are in phase.

4.5.3.2 Voltage restrained overcurrent (ANSI Device 50/51V)

This feature protects against generator overload and faults in the generator and the distribution system. If the voltage in the generator collapses during a fault the voltage restrained feature decreases the trip point value by seventy five percent.

4.5.3.3 Ground overcurrent (ANSI Device 50/51G)

This feature protects against ground faults in the generator and the distribution system.

4.5.3.4 Differential overcurrent protection (ANSI Device 87)

Current transformers (CT) monitor the currents entering and leaving the zone of protection and trips if the values differ more than the set point value. CTs are located on the load side of the synchronizing breaker and the neutral side of the alternator.

4.5.3.5 Reverse power (ANSI Device 32)

This device monitors the direction of power flow and will, after a time delay, initiate a trip when power flows from the distribution system to the generator.

4.5.3.6 Over / under frequency protection (ANSI Device 81 O/U)

This function trips if the generator frequency is outside the relay set point range of protection.

4.5.3.7 Over under voltage protection (ANSI Device 27 / 59)

This function trips if the generator voltage is outside the relay set point range of protection.

4.5.3.8 Loss of excitation (ANSI Device 40)

This function trips if the generator power factor is outside the relay set point range of protection.

4.5.3.9 Volts / hertz protection (ANSI Device 24) and inadvertent generator energization (ANSI Device 50 / 27)

These features provide off line protection features that protect against generator voltage regulator malfunction with the generator running but not synchronized to the utility.

5.Possible Utility Power Requirements

- IEEE 519-1992, 929-2000, 84 (Harmonic Limits and Voltage Fluctuations, Waveform)
- Power Factor, Voltage, Frequency, Harmonic Distortion, Voltage Flicker, Waveform Distortion, Phase Imbalance Limitations
- IEEE 1547 Standards for DC Injection, Immunity Protection, Surge Capability

6.Island Mode

The installation of an on-site electric generating facility requires an interconnection agreement between the facility operator and the local electric utility before a generator can be connected with the electrical service. When electric power from the on-site facility is substantial enough, the interconnection facility and supporting agreement may enable the operator to function in “island mode”, delivering a number of significant advantages. Island mode involves removing a piece of equipment or the entire facility’s electrical load from the electrical grid and serving it directly from the engine-generator, with no interconnection or ability to take power from the electric utility. This is vital when the industrial facility or commercial/institutional operation cannot afford even momentary outages, or when it requires exceptionally high-quality electric power. Firms engaged in high-quality electro-plating, for example, may require an hour or more downtime before production can resume after a power outage of just a few seconds duration. For them, island operation represents insurance against unforeseen and expensive production downtime. At its most basic, island mode requires no interconnection equipment or switchgear to access the power grid. This is rarely a practical option, however, since power from the utility must be available when the engine generator is down for maintenance or when the facility’s load exceeds that produced by the generator. An improperly sized engine-generator, for example, may be unable to handle demand spikes caused by certain types of equipment such as motors that can draw three times their rated electrical demand during startup. While reliability and power quality are primary drivers in selecting a natural gas-fueled electric generating or CHP (Combined Heat & Power) installation, sufficient bottom-line savings may add to the appeal and reduce the payback time

7.Black Start

Black start is the procedure for recovery from total or partial shutdown of electrical supplies throughout the country’s national transmission system or supplier distribution network. A little additional outlay on capital cost to ensure back-up for potential systems failure can prove to be a time and money-saving option. All power stations, with the possible exception of small hydro-electric generating stations, need an electrical supply to start up. To be able to black start, a station must have some form of independent auxiliary supply with sufficient capacity to supply the unit auxiliaries while a main generator is prepared for operation. This additional power source is usually provided by a smaller peripheral black start generating plant, which is started from a battery or other energy storage device. Once operational, the power plant can then be used to energize part of its local network, providing supplies for other plant within the area to enable them to start-up. For partial or total shutdown of the transmission system, the general principle of recovery includes re-establishment of isolated power stations to provide “power islands”; these are then integrated into larger sub-systems eventually allowing the re-instatement of the whole national grid system. By having this capability at a number of strategically located sites, electrical supplies can be rapidly restored. Back-up diesel or turbine sets for black starting the main generating plant used to be a common occurrence at power stations. The reasons for the lack of these facilities at most modern plants can be technical, but more often than not they are commercial - the extra capital costs for black starting can be prohibitive. Plant and grid failures are few but power companies and plant managers need to bear in mind that accidents and systems failures do occur. Without black starting, re-establishing the supply system can be difficult, severely delayed and therefore costly. Investing in a secure back-up is essential to minimize the consequences of system failure.

8. **Meeting Local Utility Standards**
   Every local power utility has their own set of interconnection requirements which must be researched and met. While utilities are currently developing uniform standards to guide CHP interconnection (California rule 21 for example), facilities currently must design unique equipment scenarios for each plant. Major power utility requirements include grid connection, condition of power, switchgear and transformer access, and meter access.

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Instrumentation

1. **Supervisory Control**
   Evaluate existing control system for ability to expand and supervise new equipment packages. Data links may be established to new controls furnished with packaged system for data acquisition and supervisory set points.
2. **Possible New Plant Steam Master for Brownfield Sites**

   For plants with existing steam producing boilers, consider integrating the new HRSG into existing coordinated boiler control strategies. Coordination of some type will be required to allow the units to share steam loads without causing instability between the units.

   Option No. 1 – Expand existing controls to include new requirements including steam master and new balance of plant (BOP) auxiliaries

   Option No. 2 – Replace all plant controls if outdated

   Option No. 3 – Relatively few interconnect points required for coordinated control. Hardwire necessary interconnections.

   Option No. 4 – For coordinated control and more extensive data acquisition, investigate options and implement communication interface.
3. **Major Control Components**
   Major equipment is normally furnished with controls as part of the package including:
   - Burner Management (NFPA required compliance) if supplemental firing
   - Gas turbine and generator control
   - Gas Compressor (if required)
   - Chiller

   HRSG, Chiller, and BOP equipment controls
   - Feed water control to HRSG
   - Management of Diverter (if equipped)
   - Supplemental firing rate of HRSG (if burner equipped)
   - Chiller start/stop operation
   - Chilled water set point and load management
   - Operation of various pumps, makeup water systems, cooling towers and other plant auxiliaries
   - Plant water chemistry measurement and control for cooling tower and boiler system
4. **Remote Monitoring**
5. **Safety**
   - Gas Leak Detection Interrupt
   - Start building exhaust fans
   - Provide visual and audible alarms in building and at every entrance
6. **Emission and Environmental Monitoring**
   - CEM as required by local or federal regulation. Blowdown monitoring as required by local authority
   - Blowdown monitoring as required by local authority

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Mechanical Interconnections

Mechanical interfaces represent the bulk of the connections required with turbine generator-based CHP systems.

1. **Natural Gas**

Turbine generators may operate on a variety of fuels: natural gas, diesel or distillate oil, landfill or waste gas, hybrid fuels, bio-fuel and high hydrocarbon fuel, are among the most prevalent.

1.1 Natural Gas Specification

Many CHP equipment manufactures provide a natural gas specification. Performance may only be guaranteed if the specification criteria are met. A gas analysis, usually obtained from the natural gas utility, should be compared with the specification. Additional equipment may be required to meet the utility's gas specification requirements. For example, a pressure reducing station may be required to lower the gas pressure, and heaters may be required to remove any non-condensable particulate formed by this temperature drop and pressure reduction

1.2 Gas Compressors

Turbine generator sets in the size range between 1 MW and 5 MW typically require medium to high pressure gas (175 psi to 325 psi) for operation. If proper gas pressure is not available locally, a new high pressure line(s) may be run from the gas utility. If this new gas line is cost prohibitive, gas compressor(s) may be installed. Redundant gas compressors and associated maintenance may be a costly item, and should be evaluated on a site by site basis. Multiple smaller gas turbine generator units which require lower gas pressure may indeed be a better investment in place of a new high pressure gas line or installing several gas compressors.

1.3 Leak Detection

Many regulations, and good engineering practice, dictate that natural gas leak detection be utilized when working with high pressure gas systems. The leak detection system is typically tied in with the plant control system, and will automatically close the gas shut off valve in the event that gas is detected.

2. Diesel

Diesel and natural gas are by far the two most common fuels for turbine generator CHP systems. Higher emissions and diesel fuel cost usually prescribe natural gas as the fuel of choice, but diesel burning capability may allow a facility to leverage natural gas by buying from cheaper interruptible tariffs. A second fuel capability will further provide a solid back up fuel option incase a primary fuel is unavailable or not economical. On site diesel fuel will require storage tanks and any associated air/groundwater permitting. Secondary containment will need to be addressed if required, as well as the filing of any storm water pollution prevention plan (SWP3) or spill prevention control and countermeasure (SPCC) plans required by the regulator. Proper siting is required for filling access by the diesel supplier. Many turbine manufactures require an additional air compressor to start a turbine on diesel.

3. Chilled / Hot Water

The Broad USA unit converts hot gas exhaust from the gas turbine into chilled or hot water. The interface to these systems is typically a simple welded pipe connection. Hot tapping may be utilized to avoid interruption of an existing system. Additional control devices may be required if the new CHP equipment works alongside existing chilling and/or heating equipment. Chilled water systems will require cooling water systems, which include cooling towers, city water makeup, chemical treatment, blowdown, and freeze protection. Hot water systems also have simple chemical treatment.

4. Steam

CHP equipment can often be integrated into an existing plant with no additional requirement for steam auxiliaries. Typical steam auxiliaries include condensate storage tanks, condensate return pumps, water treatment equipment, deaerator, blowdown and boiler feed pumps. If the CHP steam production is similar to the existing plant's steam production, most of these auxiliaries may continue to be used.

5. City Water

Existing heating plants probably use city water for makeup, and treat the water with additional chemicals and equipment accordingly. Turbine compressor blades foul after a certain operational time, and require washing at regular intervals. Washing may be on-line or offline, and requires a specific water quality. Additional equipment may be required to remove impurities and/or hardness of the city water supply, and additional pumps may be required to increase water pressure.

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Siting

1. Permiting

Permits for construction and operation of a CHP facility will be required from federal, state, and local jurisdictions. The following list (adopted from Spiewak) represents a good starting point.

1.1 Federal

- Federal Aviation Administration Notification of Proposed Construction
- NEPA Certification
- U.S. Army Corps of Engineers Section 10 Permit
- U.S. Army Corps of Engineers Section 404 Permit
- U.S. EPA NPDES Permit

1.2 State

- Coastal zone management certificate of consistency
- Cross connection permit
- Environmental impact statement
- Floodplain development
- Gas pipeline approval
- Groundwater discharge permit
- Historical Commission approval
- Industrial user discharge permit
- Oil storage tank construction permit
- PSD/air plans review
- Sewer extension/connection permit
- Siting approval
- Solid waste facility operating permit
- Solid waste facility site assignment
- Surface water discharge permit (with NPDES)
- Water quality certification
- Water withdrawal permit
- Wetlands approval of local order of conditions

1.3 Local

- Board of Health
- Building Inspector
- Conservation Commission
- Department of Public Works
- Fire Department
- Historical Society
- Planning Board
- Water Department/Sewer Commission
- Zoning Board of Appeals

2. Utility Tie-ins

Ideally, the new CHP plant is close to the existing powerhouse, switchgear, site distribution systems, and fuel supply lines. This allows for easy integration with existing utilities. The turbine/generator set of the Reference Designs can be located next to the existing power plant in a weatherized enclosure.

3. Interior Siting

If the new CHP plant is integrated into an existing plant structure, the older structure may need to undergo a number of modifications including

- Overcoming space limitations that may limit access to all components of the CHP plant
- Upgrade of the existing chilled or hot water or steam piping
- Upgrade of the existing power lines
- Structural upgrades to accommodate the weight of the new equipment
- Upgrade of the existing ventilation system

Independently if the CHP plant is located in an existing or a new building, at a minimum consideration should be given to the following.

- Access to equipment
- Fire code requirements
- Maintenance access
- Structural Consideration
- Ventilation
- Vibration isolation

4. Exterior Siting

Considerations with regard to the exterior siting of an CHP system are very similar to that of the interior siting. Of particular concern are:

- Access to equipment
- Aesthetics of the overall installation
- Maintenance access
- Noise
- Soil &Structural Consideration

5. Noise

By their very design, combustion turbines are relatively quiet and vibration free. In general, they produce noise at high frequencies that easily can be attenuated. Following points may be considered to control the noise emissions of the CHP plant.

- Attenuated turbine enclosure
- Gas compressor noise suppression
- Gas turbine exhaust stack muffler
- Intake air attenuation
- Plant wall soundproffing
- Sound proof roll up doors and windows
- Turbine enclosure ventilation

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Utility Loads

Utility loads are patterns of usage of electrical and thermal energy requirements by the facility. They vary with the time of day and the seasons. The sucess of a CHP installation depends on the ability of the CHP plant to have all of its electrical **and** thermal output be continuously used by the facility, i.e., the CHP plant energy output profile should closely match the utility loads of the facility.

The CHP system is commonly used to baseload a facility’s thermal and electrical utility loads; small portions of utilities continue to be purchased through existing means. CHP may also be used to peak shave a facility’s electrical load; however total cycle performance decreases as heat recovery may not be fully utilized.

1. Electrical Demand / Usage

A large portion of the cost-of-energy savings recovered by a CHP project is produced by generating electric power with the CHP equipment and offsetting electrical power normally purchased from the local utility. In some instances a CHP facility may be designed to also sell excess power to the utility grid. This, however, is rare in CHP facilities of this size.

1.1 Site Load Control

Site load control is normally accomplished by operating the generator equipment in parallel with the utility grid and the existing site distribution system.

1.2 Electrical Generator Sizing

The CHP electrical generator is normally sized to produce approximately enough electrical power to offset the minimum electrical demand that the facility consumes. A major focus on the initial CHP study is to determine the minimum electrical loading. This is often difficult to determine since most facilities record the maximum electrical demand and not the minimum. If the CHP electrical generation equipment is too large the facility will export power to the utility during minimum demand times. For the normal CHP facility of this magnitude this is usually not desirable.

1.3 Utility Buy-Back

CHP facilities can sell power to the utility. This may be to dispose of large amounts of excess power produced at low usage times or may be negotiated so that large variations in the steam distribution system can be managed without loosing the turbine. The reason that selling power to the utility is usually not feasible is due to the discrepancy between the utilities sell price and their purchase price. Normally what utilities are willing to pay for power will not offset the cost of operation for the CHP equipment.

2. Utility Tariffs

Charges levied against the CHP are as varied as the number of utilities involved. To date there is no standard formula for determining the cost of utility charges so each case must be analyzed on its own merits. Charges from the utilities that may be anticipated are outlined below.

2.1 Cost of Utility Interconnection

Most utilities will expect the CHP budget to pay for the cost of inter connect. This usually will encompass the following.

2.1.1 Interconnect Study

The first step in utility negotiations is to obtain a copy of their interconnect requirements. Some utilities require that an interconnect study be performed to set forth the specifications for the specific interconnect site. The cost of this study will be paid for by the CHP budget.

2.1.2 Substation Cost

If the site substation is owned by the utility, it is commonly expected that the substation be purchased from the utility.

2.1.3 Metering Cost

Since the average CHP site is not metered to accommodate cogeneration most utility interconnect agreements will include this charge.

2.1.4 System Control and Data Acquisition (SCADA) Installation

Some utilities require the installation of SCADA equipment. SCADA will definitely be required in those facilities selling power to the utility. If required, this installation will be paid by the CHP budget.

2.1.5 Protective Relaying Improvements

Cost of protective relaying improvements required to protect the cogeneration equipment will be paid by the CHP budget.

2.1.6 Standby Charges

Utilities will usually have some method or recouping the cost of standby power. Standby power is the power that is required when the CHP facility is down for maintenance or for the excess power purchased from the utility above that produced by the CHP. This tariff can be a negotiated firm demand with severe penalties for exceeding the negotiated amount, or it could also be a ratcheting demand where the facility pays a demand charge based on the largest demand set over the past twelve months. This charge is also different for each utility.

2.2 Other Charges

Other charges to be expected is a service charge for each metering point, a cost of energy charge, a cost of demand charge

2.2.1 Demand Charges

Demand charges are based on the largest demand measured in kilowatts or kilovolt-amperes required by the site during a fifteen-minute, or thirty-minute period of time depending on the utility.

2.2.2 Power Factor

A penalty for poor power factor or excess reactive power purchased is usually levied against the facility.

2.2.3 Energy Charge

A cost of energy charge for each kilowatt-hour consumed by the site will also be levied.

2.2.4 Time of Day / Time of Year Charges

These rates may differ for times of the year or even times of the day in which the energy is purchased. These billing rated are usually on peak and off peak with the on peak being the more expensive. For this reason maintenance on the CHP should be scheduled during off peak hours. Off peak hours are determined from the utility rate structure.

3. Thermal Demand/Usage

Turbine exhaust energy is converted or extracted through heat recovery equipment.

3.1 Steam

Steam is probably the most common method of thermal energy produced by a CHP system. A heat recovery boiler is typically used to generate steam with the turbine exhaust. Supplemental gas may be consumed in a duct burner to increase the amount of steam generated. The upper limit of steam production is related to the amount of free oxygen (O2) in the turbine exhaust stream.

3.2 Chilled/Hot Water

Chilled water typically peaks in the warmer summer months, and hot water (if used primarily for heating) peaks in the winter months. A portion of hot water may be used year round for domestic purposes. The Broad USA unit is able to produce chilled water and hot water simultaneously, recovering energy in the turbine exhaust continuously.

3.3 Process Heating

There are a variety of process heating uses: drying operations, kilns, stripping, direct heating, etc. The exhaust ductwork may be directly tied into such a system, but typically requires a healthy bit of additional engineering effort. Care must be taken to not exceed the turbine manufacturer's exhaust static pressure limitation.

3.4 Desiccant Dehumdification

Recovered heat can also be used to regenerate an active desiccant systems. This may particularly be beneficial in facilities that require tight humidity control, are located in a hot and humid climate, or require high outdoor air intakes. Pretreating the outdoor air with actively regenerated desiccant systems can also reduce the required chiller capacity.

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Waste

Several waste products are generated from a CHP facility, some of which require treatment before disposal through sanitary or storm sewers. Most facilities choose to use an off site disposal service in place of installing, operating, and maintaining waste treatment equipment.

Typical sources of waste requiring disposal may include:

- Blowdown coolers
- Gas compressors
- Additives and chemicals used for treatment
- Lube oil

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Additional Information Resources

Codes & Standards

Building Codes

First Source maintains detailed information on building codes for all 50 states, major cities, and some counties. The site offfers information on codes and amendments as well as contact information for up to 17 authorities having jurisdiction (AHJs) in each market.

The International Code Council has developed a single set of comprehensive and coordinated national model construction codes. The ICC website offers information on which states and jurisdictions have adopted one or all of the international model codes.

Mechanical Codes & Standards

ANSI - American National Standards Institute

ASHRAE - American Society of Heating, Refrigerating and Air-Conditioning Engineers

ASME - American Society of Mechanical Engineers

ASTM

UL - Underwriters Laboratories

Electrical Codes & Standards

IEEE

Pacific Gas & Electric -- This site provides information on Rule 21 generators

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CHP Information Sources

Combined Heat and Power (CHP) Program -- The Department of Energy's Office of Energy Efficiency and Renewable Energy is working on a number of fronts to support increased use of CHP technologies. This site provides information about the CHP Initiative, BCHP Initiative, Combustion Program, Steam Challenge Program, and the Federal Energy Management Program.

DOE BCHP Initiative -- The objective of this site is to provide you with information on CHP systems to facilitate your decisions relating to these systems.

EPA's CHP Partnership -- The CHP Partnership is a voluntary program that seeks to reduce the environmental impact of power generation by fostering the use of CHP. The Partnership works closely with the CHP industry, state and local governments, and other stakeholders to develop tools and services to support the development of new projects and promote their energy, environmental, and economic benefits.

California Distributed Energy Resources Guide -- The California Distributed Energy Resources Guide is a public benefit site containing a wealth of information regarding distributed energy resources (DER).

Midwest CHP Information Center -- The Midwest CHP Application Center was established in March 2001 for the U.S. Department of Energy (DOE) at the University of Illinois at Chicago (UIC) Energy Resources Center (ERC). The Center is a partnership between UIC/ERC and the Gas Technology Institute (GTI). Its mission is to provide application assistance, technology information, and educational support in the eight Midwest states of Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin.

The Midwest Cogeneration Association (MCA) promotes a greater public understanding of cogeneration, independent power production, and distributed generation. In addition, MCA works to improve general business conditions of the industry. The non-profit organization provides pertinent information for its members to conduct research, publish reports, and hold various seminars and workshops with the goal to advance the concept of cogeneration throughout the Midwest

The U.S. Combined Heat and Power Association (USCHPA) brings together diverse market interests to promote the growth of clean, efficient CHP in the United States. It is a private, non-profit association, formed in 1999 to promote the merits of CHP and achieve public policy support.

California Alliance for Distributed Energy Resources (CADER) is a voluntary collaborative committed to facilitating the successful deployment of highly efficient and environmentally responsible distributed energy resources into competitive energy markets.

CHP -- This site gives you information about combined heat and power production (CHP) and district heating and cooling (DHC). The website provides you with information on combined heat and power (CHP) and district heating and cooling (DHC) from a technical, market and political point of view. The web site includes both general and country specific information about CHP and DHC in Europe.

The Combined Heat and Power Association (of Great Britain) works to promote the wider use of combined heat and power and community heating

Cogen Europe is the European Trade Association for the promotion of cogeneration. Its principal goal is to work towards the wider use of cogeneration in Europe for a sustainable energy future.

Honeywell BCHP Project

Honeywell

Honeywell T.E.A.M. Services (for the Federal Government)

This site contains a link to the Ft. Bragg BCHP project.

Honeywell Enterprise Building Integrator (EBI). This site prodes information the EBI technology, a scaleable system that pulls together all core building systems and integrates information from many different enterprise subsystems, including environmental controls.

BCHP Team Members

Broad USA -- Broad Air Conditioning is the world’s largest manufacturer of two-stage absorbers, selling approximately 500,000 tons of absorption cooling annually. Broad USA provided the absorption chiller for the project.

Chelsea Group Ltd -- Chelsea Group. is a leading consultant to the indoor environment industry headquartered in Itasca, IL. With a specific focus on indoor air quality, Chelsea Group, provides strategic, technical, and marketing consulting to businesses that create products and provide services used to create resilient, productive indoor environments and to maximize asset value.

I.C. Thomasson (ICT). ICT is a multidisciplinary engineering and consulting firm established in 1942 in Nashville, TN and currently has branch offices in Knoxville, TN, Tampa, FL, and an affiliated office in Brookhaven, MS. The company is licensed in 43 states and has completed more than 12,000 projects valued in excess of $18 billion. ICT provides engineering services to sports, medical, commercial, industrial, institutional, and military facilities throughout the United States and abroad.

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Appendix H

Sequence of Operations (for design R-1)

FORT BRAGG
HRSG AND BALANCE OF PLANT EQUIPMENT
OPERATING SEQUENCE

ENGINEER

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ICT PROJECT NO. 201337.02

SEQUENCE OF OPERATIONS

December 10, 2003

ABBREVIATIONS

Plant Control System: PCS
Burner Management System: BMS
Turbine Control System: TCS
Heat Recovery Steam Generator: HRSG
HMI: Human Machine Interface
PID: Proportional, Integral, and Derivative Control Calculation (Note: Configure to avoid reset windup).
PV: Process Variable
VFD: Variable Frequency Drive

GENERAL DATA SETUP INFORMATION

Hardwired I/O inputs should be configured to scan continuously. If selectable, control loop execution times should be set up to operate at a 250 millisecond or faster scan rate. All analog points should be set up for archiving. Data archive rate should be at least once per minute or more often if the data changes by greater than 2% of the scaled range. All flow readings are to be totalized and the totalized values archived.

GENERAL DISPLAY INFORMATION

Graphic displays showing general system and major component information should be developed for the HMI. P&ID drawing should provide the basis for the system flow paths and major equipment. It is anticipated that analog control loops will be show on these primary displays with pop-up type faceplates to allow “Auto / Manual” selection, adjustment of output in “Manual” and adjust of setpoint in “Auto.” Similar pop-up displays should be provided for “Start /Stop” control of motors. It is anticipated that the following primary displays will be required.

- Overall plant display showing “Running” or “Stopped” condition of major equipment. Also display major flow parameters, chilled water temperature and steam pressure.
- Display showing the Chiller Guillotine, Chiller, Box Damper, and ID Fan. NOTE: BROAD has primary chiller control, but PCS has status information for display concerning this equipment. Additionally, the MODBUS interface can provide information about the chiller. Information to be gathered via MODBUS relates primarily to chiller performance and is not covered in this document. Refer to Honeywell for specific guidance on parameters expected from the MODBUS connection. Provide operating capability for control loops via pop-ups from this graphic.
- Display showing the Turbine, HRSG Guillotine, Diverter Damper, and HRSG. Display operating parameters associated with this equipment including steam flows, fuel flows, drum level, and equipment positions. Provide operating capability for control loops via pop-ups from this graphic.

- Display showing the Condenser Water System including Cooling Towers and associated controls. Provide operating capability for control loops via pop-ups from this graphic.

NOTE: All references to operator adjustments are assumed to be performed from the PCS computer interface or HMI. All setpoints for alarms and automatic control points may be adjusted during startup commissioning. These values are not normal operator functions, but should be configured as a tuning adjustment for final settings to be established during startup.

V. CONDENSER WATER TEMPERATURE CONTROL

A. Control Modes

1. Auto/Manual selection from the HMI.

   a. Auto allows PID control operation of the speed of the 2 cooling tower VFD's from the PCS to achieve the desired setpoint of condenser water temperature.
   b. Manual allows the operator to manipulate the speed demand under all conditions.
   c. Provide Start / Stop control of each tower fan via an operator selection from the HMI. The PCS will control the start stop of the fan when the MCC selector switch is in the "Remote" position. Both fans normally operate in parallel with the same speed demand. Provide selections where the Operator may select either fan to run alone, but still in speed control based upon condenser water temperature.

2. Setpoint adjustment is manual from HMI. Limit setpoint adjustment by the operator between the following points.

   a. No setpoint limit
   b. No Setpoint tracking.

B. Permissives

1. No permissives required for Auto or Manual operation of PID loop.

2. Local MCC handswitch must be in "Remote" for PCS control of the VFD.

C. Alarms, Interlocks and Trips

1. High temperature alarm at 92 degrees F.

2. Low temperature alarm at 65 degrees F.

3. Alarm if a tower fan is commanded to run from the PCS and the run confirm signal is not received within 5 seconds of a start or thereafter, signal a tower fan malfunction alarm.

4. If the "Fault" indication is received from the VFD, signal a tower fan malfunction alarm.

D. Related Field Devices

1. Temperature transmitter TT-601-A2
2. Cooling tower fan VFD’s. Reference drawing E-1.03.

VI. HRSG STEAM DRUM LEVEL CONTROL

A. Control Modes

1. Auto/Manual selection from the HMI.

    a. Auto allows PID control operation of the HRSG FEEDWATER supply valve from the PCS to achieve the desired setpoint.
    b. Manual allows the operator to manipulate the control valve position under all conditions.
    c. 2 - Element Control uses measured drum level and steam flow to continuously set the valve demand in Auto. Measured drum level is input to a PID control calculation and compared with an operator input setpoint to generate a level demand. Steam flow is summed with the level demand to provide a feed-forward signal for faster response and a final demand output to the feedwater valve.
    d. For proper response from the steam flow signal provide a multiplier on the steam flow signal. Initial setting for the multiplier to be set to 0.4 prior to being added to the demand from the PID algorithm from the drum level.

2. Setpoint adjustment is manual from HMI. Limit setpoint adjustment by the operator between the following points.

    a. High Setpoint Limit = +3 inches of water level.
    b. Normal Setpoint = 0 inches of water level.
    c. Low Setpoint Limit = - 3 of water level.
    d. No Setpoint tracking.

B. Permissives

1. No permissives required for Auto or Manual operation.

C. Alarms, Interlocks and Trips

1. None from control loop. High and low level alarms generated from level switches associated with drum level read from BMS level switches.

2. Low level alarm = -4 inches of water.

3. High level alarm = +4 inches of water.

4. Low water level trips are generated from switches associated with the BMS.

5. Low level trip = -5 inches of water.

6. Auxiliary low level trip = -6 inches of water.

D. Related Field Devices

1. Level Transmitter = LT-201-A1. LT range = -10 to +10 inches of water level.

2. Level Control Valve (with I/P positioner) = LCV-201-A1. Valve fails closed. Set valve to stroke for 0 to 100% open for 4 to 20 mA.

3. HRSG No. 1 Steam Flow Transmitter = FT-302-A1 FT range = 0 to 85,000 pph.

4. HRSG Burner management PLC Low Water Contact Output from LSL-201-A1.

5. HRSG Burner management PLC Low Low Water Contact Output from LSLL-201-A1.

6. HRSG Burner management PLC Auxiliary Low Water Contact Output from LSLL-201-B1.

7. HRSG Burner management PLC High Water Contact Output from LSH-201-A1.

VII. PLANT STEAM MASTER BOILER CONTROL

NOTE: It was originally discussed that both the No. 5 package boiler and the new HRSG would follow the same master firing rate demand signal. Further discussion and review indicate that it *may* be possible to send the No. 5 boiler a new remote firing rate signal, but sufficient status information about this boiler cannot be found from the Hays Republic system to automate the firing rate control of this boiler from the PCS. Therefore, the new HRSG will follow the new boiler header pressure steam demand. The No. 5 boiler controls must be further investigated to determine the possible interconnection of a manually set firing rate demand from the PCS; however, the general operation for 2 units in service will be for one unit to be placed in "Manual" and the other to operate in "Automatic" to load follow.

A. This steam master control is related to control of the steam header pressure. Normally a master demand signal would be generated from this logic to control the firing rate of both the HRSG and No. 5 boiler from a header pressure PID control calculation. As discussed previously, each boiler will stand alone in this function with the Hays Republic system remaining in place and the HRSG firing rate set by the PCS. In effect, each unit will have a boiler master firing rate control, but no header pressure master. (Refer to the Burner Firing Rate Control - Boiler Master section of this document for additional information).

B. The operator will determine when to bring another boiler online and when to remove a boiler from operation.

C. The steam header vent valve will act to limit any high pressure conditions in the steam header. It will be controlled as follows.

   1. Automatic operation allows the steam valve to modulate open on rising header pressure. The PCS must perform a curve fit of "Steam Pressure" vs. "Vent Valve Open Demand" based upon the following points. Header setpoint for this calculation is determined by low selection of the 2 setpoints for the HRSG boiler master. i*.e*. Burner firing rate control and diverter control. (Refer to descriptions for the HRSG burner control and diverter control).
      a. Header Pressure < Setpoint then Vent Valve Output = 0%
      b. Header Pressure = Setpoint + 3 psig then Vent Valve Output = 2%
      c. Header Pressure = Setpoint + 5 psig then Vent Valve Output = 10%
      d. Header Pressure = Setpoint + 8 psig then Vent Valve Output = 50%
      e. Header Pressure = Setpoint + 12 psig then Vent Valve Output = 100%.

   2. Manual operation allows the operator to adjust the valve open position from 0 to 100%.

D. Permissives

1. Purge complete logic must be satisfied for the HRSG to allow Manual or Automatic positioning of the diverter.

E. Alarms, Interlocks and Trips

1. High Header Pressure alarm = 135 psig.

2. Low Pressure alarm = 95 psig.

F. Related Field Devices

1. Pressure Transmitter = PT-301-A0. PT range = 0 to 200 psig.

2. Hays Republic Control System for No. 5 Package Boiler

    a. Interface burner master firing rate demand to No. 5 Analog Input point for “Master Loading Signal input.” Field verify input point for signal can be input at No. 5 package boiler input board –B22 terminals 2 & 4 with field installed 250 ohm precision resistor.
    b. Install field switch to transfer control between the existing Master Loading Signal and the new loading signal to be manually set from the HMI for No. 5 boiler.

    NOTE: Available Hays Republic system information indicates that the installation may use fabricated ribbon cables for connection to these boards. It is important to verify that the new No. 5 boiler loading signal can physically connect to the existing controls without interrupting other connections are required to remain.

3. Main steam header vent valve PCV-301-B1.

VIII. DIVERTER DAMPER CONTROL

A. Control Modes

1. The diverter will normally either be full open or full closed. The diverter full closed bypasses the HRSG. Open sends the exhaust to the HRSG for heat recovery. When the HRSG is in operation, the diverter is to be normally opened completely to the HRSG. Boiler shutdown means that the diverter is to be completely closed to the HRSG. Overrides will force diverter to positions for purge or trip condition as described below. However, it is possible for the operator to select Manual mode of operation if no override condition is present. In the manual mode, the operator may position the diverter at some midpoint position. Note that burner management interlocks will turn off the burner if the diverter is not fully open to the HRSG. Therefore, the partial closing of the HRSG should only be operated with the burner off.

2. Automatic operation will modulate the diverter based upon an operator selected setpoint for steam header pressure. This mode of operation may be useful for warming up the unit using turbine exhaust gas, or when operating at reduced loads below the minimum firing rate of the burner.

   NOTE: Operating in this mode should only be attempted at low loads where the burner on the HRSG is not required. The control characteristics of the diverter are coarse and do not represent a fine level of control at a fixed setpoint. Cycling of the diverter to hold approximate steam pressure is to be expected due to both process dead-time associated with the diverter and the control characteristics of the diverter.

3. Setpoint adjustment is manual from HMI. Limit setpoint adjustment by the operator between the following points. **NOTE**: If the diverter is to be left in Auto mode with either the supplemental HRSG burner operating or with the No. 5 package boiler operating, then the diverter setpoint should be adjusted 5 to 6 psig higher than the firing rate setpoint to assure that the diverter remains completely open.

   a. High Setpoint Limit = 130 psig.
   b. Normal Setpoint = 125 psig.
   c. Low Setpoint Limit = 100 psig.
   d. No Setpoint tracking.

4. Manual operation allows the operator to select the output of the diverter to any position.

NOTE: It is IMPORTANT to understand that positioning the diverter in any position other than full open to the HRSG will prevent the burner from operating.

B. Permissives and Overrides

1. In order to enable the diverter to open to the HRSG, the following conditions must be true.

2. No boiler trip present.

3. HRSG Guillotine damper must be open.

4. The diverter damper safety solenoid is fed a signal from the BMS, wired in series with guillotine damper switch, such that the diverter damper is held closed if the switch contact is not closed verifying that the guillotine is fully open.

5. The unit must be purged before admitting hot gas or initiating the burner. Normally this will be performed during the turbine start sequence so that the turbine purge and the HRSG purge occur at the same time. The operator must initiate the Purge for the HRSG from the HMI. Refer to the description on purging.

6. The gas turbine may be operated without the HRSG in service. The diverter must be closed and the inlet guillotine damper should be manually closed locally at the HRSG.

C. Alarms, Interlocks, and Trips

1. Boiler trip condition signal from the BMS must force the demand to the diverter to 0% and close the diverter to the HRSG.

2. Boiler trip condition and diverter not verified closed to the boiler within 60 seconds initiates a “Malfunction Summary Shutdown Contact” output to the turbine.

3. Turbine running AND chiller guillotine damper is not closed initiates a “Malfunction Summary Shutdown Contact” output to the turbine.

4. Turbine running AND HRSG guillotine damper is not full open AND diverter not full open to Bypass Stack initiates a “Malfunction Summary Shutdown Contact” output to the turbine.

NOTE: This shutdown contact is held closed for normal operation and opened to cause a shutdown of the turbine. This is a single output that is opened for any of the above conditions described.

D. Related Field Instruments

1. Boiler Guillotine Damper FCV-503-A2.
2. Boiler Guillotine Damper limit switches ZSL-503-A1 and ZSH-503-A1.
3. Diverter Damper FCV-301-A1.
4. Diverter limit switches ZSL-301-A1 and ZSH-301-A1.
5. BMS Boiler Trip Signal
6. Summary Shutdown to the TCS

IX. BURNER FIRING RATE CONTROL – BOILER MASTER

NOTE: The diverter damper controls the amount of exhaust gas going to the furnace from the turbine. Operation of the diverter is described previously. This description relates to the burner load control that provides the majority of the heat input for steam production.

A. HRSG Operating Modes

1. Waste Heat Only Mode. The diverter is positioned to allow exhaust gas from the turbine to provide a source of heat to the HRSG for steam generation. The exhaust gas from the gas turbine provides a heat source capable of making approximately 20 to 25 % of the HRSG steam load.

2. The operation of the HRSG is only supplemental firing turbine exhaust gas (TEG) mode. No fresh air is available to fire the burner. When the burner is placed into operation from the COEN BMS panel, then supplemental firing of the burner brings the HRSG up to its full steam generation capacity. **NOTE**: Refer to the COEN descriptions for operation of the BMS controls.

3. In the event of a burner trip, the unit may continue to operate on waste heat. However, in order to maintain plant header pressure, it may be necessary to adjust the firing rate of No. 5 package boiler to make up any steam that the HRSG cannot deliver without supplemental burner firing.

B. No. 5 Package Boiler Operating Modes

1. This boiler only produces steam base upon its burner firing rate. Presently, this unit is completely controlled by the Hays Republic system, which adjusts the firing rate to satisfy a measured steam demand signal.

2. This project should add a manually operated switch to allow the “Master Loading Signal” used by the Hays Republic system to be transferred between the present control mode and a manually set signal. The manual signal should be a 4 to 20 mA signal generated by the PCS with an operator setting the firing rated demand in 0 to 100% from the HMI.

C. HRSG Control Modes

1. Each boiler's master control acts to automatically follow the steam load measured for control of that unit. The PCS must perform a PID calculation to generate a firing rate signal based upon measured steam header pressure compared to an operator setpoint. (The No. 5 boiler control performs similar functions within the existing controls).

2. Auto allows the output from the boiler master loop calculation to pass to the firing rate to the burner's gas valve.

3. Manual allows the operator to manipulate the gas control valve position when permitted by BMS permissives without other regard for the steam header pressure.

4. The PCS must not allow positioning of the gas valve above 0% output from either Manual or Auto unless a contact closure is received from the BMS signaling, "Release to Modulate."

5. Limit setpoint adjustment by the operator between the following points.

   a. High Setpoint Limit = 130 psig.
   b. Normal Setpoint = 125 psig.
   c. Low Setpoint Limit = 100 psig.
   d. No Setpoint tracking.

6. With HRSG steam flow less than 40,000 pph for 1 minute, close the contact output to signal minimum turndown operation. Verify that the BMS recognizes the signal by reading back a contact input from the BMS to the PCS for burner at minimum.

   a. The HRSG burner is designed to operate in a minimum turndown mode or in a high load firing mode. A contact closure signal from the PCS must switch between the 2 conditions.
   b. With HRSG steam flow greater than 42,000 pph for 1 minute, open the contact output to signal high load operation. Verify that the BMS recognizes the signal by reading back a contact input from the BMS to the PCS for burner at high load.

7. If the burner is firing, the PCS must signal the BMS when the chiller is to go into service. (NOTE: During the following 2 steps that transition the chiller into service, the burner will go out and re-light. Expect a major steam pressure upset during this period. Also, once the chiller is place into service, the firing rate of the duct burner will be limited to the maximum setting of the minimum turndown firing rate).

   a. The PCS must generate a contact output to the BMS for "Chiller Mode Selected." This signal is to be activated when the operator makes the selection from the HMI to begin chiller operation and the contact from the PCS interlocking the chiller guillotine damper should close to allow the guillotine to open.

b. After a time period of 4 minutes, to allow the burner to cycle and purge, the PCS must generate a second contact output to the BMS signaling that the burner "Chiller Ready / Re-start Duct Burner".

8. From the HMI, provide an operator selected Normal Stop function to turn off that burner. Initiation of this signal will transition the contact output from the PCS wired to "Contact: Remote System Stop" input of the BMS. NOTE: Coordinate with COEN at startup if the condition required of this contact for normal operation. *i.e.* Is this contact required to be opened or closed for the burner to operate?

D. Permissives

1. "Contact: Remote System Stop" contact input to the BMS from the PCS must be in a condition that allows the burner to run.

2. Boiler must be released for modulating operation by the burner management controls for normal modulating operation.

3. For the PCS to signal that the chiller is ready for operation, the ID fan must be verified as running, the guillotine damper verified as open and the chiller purge complete.

E. Alarms, Interlocks and Trips

1. The number of burner elements in service is reported from the BMS to the boiler master by the "High Load or Minimum Turndown" contact closure signals. The maximum output demand is limited based upon the number of elements in service. The output limits will be initially set as follows.
   a. Minimum turndown = 2 elements = 50%
   b. High Load = 4 elements = 100%

2. Output to the burner will be stopped at current demand and limited regardless of the number of elements in service if excess oxygen read in the exhaust from the boiler is less than 2.9%. Release the output if oxygen reading returns to 3.1%.

3. Output to the burner will be limited to the minimum turndown setting whenever the Broad Chiller is in operation.

4. High steam pressure alarms generated from pressure switches associated with drum pressure read from the BMS. High steam pressure causes the burner to recycle. High High pressure causes a boiler trip condition.

5. A low level switch on the boiler drum level will cause an alarm. A low low drum level will cause a boiler trip. Refer to the drum level control description.

6. Other BMS alarms related to safe burner operation may trip the burner. (Refer to the BMS description from COEN for additional information). Provided the boiler trip signals are not present, the burner may turn off and allow heat input to the boiler continue from turbine exhaust gas.

7. Provide a contact output from the PCS that trips the burner as a contact input to the BMS. This output is to be selected by the Operator from the HMI to provide a remote shutdown feature. This contact will open for a shutdown and be closed for normal operation.

8. A boiler recycle at the BMS will shut off the burner but allow it to re-start without operator intervention.

9. A boiler trip condition will shut off the burner and cause the diverter to close. If the diverter is not verified as closed from a field mounted position switch within 60 seconds, then the PCS must generate a contact output for a turbine trip condition causing the gas turbine to shut down. This contact must open to cause the turbine shutdown and held closed normally. Once a boiler trip condition occurs, the operator must reset the BMS system locally at the panel next to the boiler.

10. "Low Fire" is a hardwired signal to PCS from the BMS that forces the controller output to the HRSG burner gas valve to 10%. This provides a minimum gas flow conditions to permit the burner to light.

11. If the “Low Fire” interlock is not present and the HRSG is not released to Auto operation, then the firing rate control to the gas valve output is forced to 0 % from the PCS.

F. Related Field Devices

1. Vendor supplied I/P positioner and gas valve, PCV-301-A1. Positioner fails closed. Set I/P to stroke for 0 to 100% open for 4 to 20 mA.

2. Status inputs hardwired from the BMS including the following. (Reference COEN drawing D: 0681-CC-246 pages 2, 3, 4 and 5 of 5. Refer to the MISCELLANEOUS DISPLAYS, ALARMS, ARCHIVING, AND TRENDS portion of this document for additional points to monitor for status indication from the BMS).
   a. Chiller mode selected.

    b. Chiller Ready / Re-start Duct Burner
    c. Release to Modulate.
    d. Low Fire Requested
    e. Boiler Trip
    f. Duct Burner in Minimum Turndown Operation
    g. Duct Burner in High Load Operation
    h. Duct Burner Remote System Stop.

3. HRSG exhaust oxygen sensor and transmitter AT-504-A1.

4. Plant Steam Header Pressure Transmitter. PT-301-A1. See Plant master control description.

5. Status inputs from the following points.

    a. Chiller purge complete from BROAD
    b. ID fan running status from the VFD

6. Chiller guillotine limit switches ZSH-502-B2 and ZSL-502-B2

X. BURNER MANAGEMENT CONTROLS

A. For detailed instructions for the burner management system refer to burner vendor information provided by COEN.

XI. PURGING THE HRSG AND BROAD CHILLER

NOTE: The NFPA does not specifically address purge requirements related to the chiller. The NFPA does address the requirements for purging an unfired HRSG. The BROAD chiller represents a large volume heat recovery vessel not unlike an unfired HRSG, and so the requirements for purging and unfired HRSG will be described for the chiller.

A. When the turbine is to be brought on line and the operator intends to direct the exhaust through the HRSG or chiller, then all ductwork must be purged prior to any turbine ignition. Management of this function must be performed jointly by the PCS and BROAD Chiller controls and supercedes any other positioning of the dampers.

B. BROAD must provide the following functions for purging the chiller within the chiller control package. If any function cannot be completed, the chiller control package must indicate a "Purge Failed" and halt the sequence requiring reset and re-initiation by the operator once the problem interrupting the sequence is corrected.

1. The operator must determine that the turbine is ready to start and the chiller is ready to be purged. Refer to the chiller purge permissives list for the chiller purge below.

2. The operator must start the ID fan from the PCS or at the MCC and the ID fan be verified running by the chiller controls via an auxiliary contact from the VFD. The ID fan speed is controlled by a 4 to 20 milliamp output from the chiller controls. Prior to starting the ID fan, put the fan speed at minimum from the chiller controls.

3. Provide for an operator to initiate a purge of the chiller via the chiller display or via a handswitch added to the chiller control panel.

4. Set the analog output for the split range control of the Inlet Box Damper and ID fan VFD at a value that fully opens the box damper, but holds the VFD at minimum speed.

5. Verify that the Inlet Box Damper is fully open from its open limit switch.

6. Close a contact output from the chiller controls causing the guillotine damper to come open.

7. Verify that the guillotine damper is fully open from its open limit switch.

8. Ramp up the analog output to the ID fan VFD speed demand to a purge flow point of 35%. (Note: This 35% speed demand value must be a field adjustable setpoint to be finally determined at startup).

9. Once the speed is at 35%, start a 5 minute timer and indicate on the chiller display that a purge is in progress. Note: If any permissive changes, damper changes state, or ID fan stops or speed reduces, during this 5 minutes, then the purge is violated and a failure must be indicated and the purge re-initiated.

10. After the 5 minutes elapses without a permissive interruption, ramp the VFD speed to minimum.

11. Close the guillotine damper and verify its position from its closed limit switch.

12. Read an input from the seal air fan starter auxiliary contact that verifies that the seal air fan inlet to the guillotine damper is running. Indicate on the chiller display that purge is complete and close a contact output indicating that the purge is complete. If this auxiliary contact opens prior to the turbine starting or if the guillotine closed limit switch opens prior to the turbine starting, then indicate that a purge is again required on the chiller control display and open the contact output indicating that the purge is complete.

13. Read a contact input indicating that the turbine is running. Once the turbine is successfully started and running, then either the turbine running signal must be present or the input from the seal air fan auxiliary contact must be closed and the guillotine closed in order for the purge complete condition to be maintained. At least one of these two conditions must be true or it is required that the chiller be purged again and must be indicated as "Purge Required" on the chiller display. The "Purge Complete" contact output must be opened when a purge is required.

14. If the turbine is detected as running and the purge of the chiller has not been completed, then set flags in the logic that will not allow the guillotine damper to open.

15. Once the purge is completed, if the chiller is not to be brought on line, then the operator should manually turn off the ID fan either from the HMI if in remote control or at the MCC handswitch if in local control.

C. Once the chiller contact closure indicating "Purge Complete" is detected as an input to the PCS, then the turbine may begin a start cycle and the HRSG may be purged during the turbine starting sequence. Within the PCS provide the necessary logic to achieve this purge sequence. Also within the PCS, provide HMI graphics to allow the operator to start and observe operation of the purge functions for HRSG

1. The operator must determine that the turbine is ready to start and bring on line and that the PCS displays “Purge Permitted” at the HMI. Refer to the required permissives list for a HRSG purge below.

2. Provide a setting for the operator to select “Turbine Only” operation from the HMI and bypass the purge of the chiller and HRSG. Provide a second setting for the operator to select “Turbine and HRSG Only” operation from the HMI and bypass the purge of the chiller. Set flags in the PCS logic to prevent subsequent introduction of hot exhaust gas through any path not purged.

   NOTE: If the HRSG or chiller is not purged during an initial turbine startup, it will be necessary to stop the turbine and initiate a purge in order to bring either the HRSG or chiller on line at some later time. The PCS does not control the purging of the chiller or its guillotine damper, but the PCS has a contact input indicating that the chiller purge is complete. Display the condition of the chiller purge on the HMI.

3. From the PCS HMI, the operator will initiate a HRSG Purge Sequence to begin. PCS closes an output contact to the gas turbine for WHRS Start Permissive.

4. Once the purge is started, a 15 minute timer is initiated that provides a time window for the operator to initiate a turbine start and complete the purge for a full system purge. (Note: Timer value to be finally adjusted at startup).

5. If the operator has elected to bypass purging the HRSG and chiller, then a 10-minute timer is initiated that provides a time window for starting the turbine and purging the bypass stack. (Note: Timer value to be finally adjusted at startup).

6. Once the turbine begins starting, it will reach a startup point where sufficient air volume is flowing through the unit to provide adequate purge flow rate. The turbine controls will generate a contact output to be read by the PCS that indicates Purge Flow Established. The HMI for the PCS should indicate “Purge in Progress.” With all other permissives true, another 5-minute timer is started to allow purging of the HRSG bypass ductwork. (Note: Timer value to be finally adjusted at startup).

7. If the operator has elected to bypass the purge of the chiller and HRSG, then the timers and functions described in the next 2 steps are eliminated from the logic sequence. After purging the bypass stack, the PCS generates a contact output to the turbine controls signaling “WHRS Turbine Ignite Permissive.”

8. When the 5-minute timer in the previous step expires, the PCS moves the diverter to full open to the HRSG. Once the position limit switches on the diverter verify this position, a 5-minute timer is started to allow time for purging the HRSG and exhaust stack.

9. When the 5-minute timer in the previous step expires, the PCS HMI indicates "Purge Complete." The PCS generates a contact output to the turbine controls signaling "WHRS Turbine Ignite Permissive."

   NOTE: Following a successful purge sequence that includes the HRSG, the diverter damper should be full open to the HRSG and control mode rejected to Manual. Following purge completion, the diverter may be positioned to any intermediate position in Manual, or it may be placed in Auto. It is recommended that the diverter be left in Manual, particularly if the supplemental burner is to be brought into operation.

D. Chiller Purge Permissives

1. Turbine Not Running.

2. ID fan started and running.

3. Box damper to the ID fan open greater than 5%.

E. HRSG Purge Permissives

1. Turbine Not Running.

2. No boiler trip condition is present.

3. Chiller Purge Complete. (Not required if operator elects to bypass chiller purge because chiller will not be operated).

4. HRSG Guillotine damper to HRSG open.

5. Diverter damper closed to HRSG.

F. Alarms, Interlocks, and Trips

1. Any boiler trip condition must cause a purge failure requiring the condition be cleared and a new purge started.

2. Boiler trip condition and diverter not verified closed to the boiler within 60 seconds initiates a “Malfunction Summary Shutdown Contact” output to the turbine.

3. Turbine running AND chiller guillotine damper is not closed initiates a “Malfunction Summary Shutdown Contact” output to the turbine.

4. Turbine running AND HRSG guillotine damper is not full open AND diverter not full open to Bypass Stack initiates a “Malfunction Summary Shutdown Contact” output to the turbine.

   Note: This shutdown contact is held closed for normal operation and opened to cause a shutdown of the turbine. This is a single output that is opened for any of the above conditions described above. The “Malfunction Summary Shutdown Contact” description is also covered in the diverter control section of this document. It is repeated here for completeness of this section. Only a single shutdown contact output is required from the PCS.

5. An ID fan trip or condition that cause the chiller guillotine to close. (Refer to hardwired logic for chiller guillotine solenoid on drawing E-1.04).

6. If the turbine is started prior to the time required by the purge sequence, then the purge fails and a new purge started.

7. If the purge is not completed within the 15 minute initial timer setting for the HRSG, then the HRSG purge fails and must be restarted.

8. Provide an operator interrupt feature in the chiller controls so that a purge sequence can be manually aborted.

9. Provide alarm message on the chiller display detailing the purge failure.

10. Provide an operator interrupt feature on the PCS HMI so that a purge sequence can be manually aborted.

11. Provide alarm messages on the PCS HMI detailing the purge failure.

12. If the diverter damper closes to a point where the closed limit to the HRSG is detected by the PCS, then the HRSG purge complete is to be reset in the logic, the output demand to the diverter set to 0%, and another purge required prior to allowing the diverter to open to the HRSG.

G. Related Field Devices

1. Chiller guillotine damper FCV-502-A2

2. Chiller guillotine damper limit switches ZSL-502-A2 and ZSH-502-A2 and ZSL-502-B2 and ZSH-502-B2.

3. Diverter damper FCV-301-A1

4. Diverter damper limit switches ZSL-301-A1 and ZSH-301-A1.

5. Chiller purge complete signal from BROAD.

6. Turbine signals to and from the TCS.

   a. WHRS Start Permissive
   b. Purge Flow Established
   c. WHRS Turbine Ignite Permissive
   d. Turbine Running
   e. Turbine Malfunctino Summary Shutdown

XII. HOT SYSTEM PURGE

NOTE: Data about the gas turbine indicates that even at a reduced load, the exhaust gas temperature is above 900 degrees F. To avoid auto ignition of any natural gas, the temperature must be dropped to below 900 degrees F. Therefore, this purge sequence is not feasible unless subsequent data is found to show that a turbine operating mode may be achieved with lower exhaust temperature. In any event, this purge sequence is not recommended, as it requires very coordinated operation of the turbine and other equipment. The only advantage offered is that a purge may be accomplished to avoid shutting down the turbine and re-starting to achieve the cold purge sequence previously described.

A. Since the chiller is not supplemental fired, once purged, it may be isolated with the guillotine and exhaust gas re-admitted if the following conditions are met. The PCS must provide the logic to evaluate the conditions.

   1. Purge completed at turbine start.

   2. No turbine shutdown or trip OR the guillotine damper is maintained closed and the seal air fan runs continuously. (NOTE: BROAD logic verifies this condition).

B. If the HRSG is not purged and started with the turbine or a HRSG trip occurs with turbine running, then the turbine may continue to run with diverter bypassing the HRSG. However, shutdown and re-start of the turbine are required to do an initial HRSG purge.

XIII. ABSORPTION CHILLER INTERFACE AND ID FAN

A. Control Modes

1. Chiller control is completely by BROAD. Interface points exist that allow chiller operation and provide indication to the plant operator.

    a. Monitor the Open / Close status via limit switches of the guillotine damper to the chiller. Provide indication of the position on the HMI.
    b. Provide Start / Stop control of the ID fan via an operator selection from the HMI. The PCS will control the start stop of the fan when the MCC selector switch is in the “Remote: position.

2. No Setpoint adjustment is required to chiller or fan. BROAD will control the speed setpoint to the ID fan VFD and the position of the Box Damper.

3. Honeywell may require additional information monitoring from BROAD via the MODBUS interface for chiller performance. This information is beyond the scope of this document. Consult Honeywell for more information.

B. Permissives

1. The ID fan running and the Box damper on the inlet to the fan are permissives for BROAD to open the diverter damper.

2. The MCC local switch must be in the “Remote” position to allow the PCS to Start / Stop the ID fan. Do not allow an operator to attempt fan start from the HMI if the MCC handswitch is not in the “Remote” position.

C. Alarms, Interlocks and Trips

1. Alarm if the ID fan is commanded to run from the PCS and the run confirm signal is not received within 5 seconds of a start or thereafter, signal an ID fan malfunction alarm.

2. If the “Fault” indication is received from the VFD, signal an ID fan malfunction alarm.

D. Related Field Devices

1. Chiller Guillotine limit switches ZSH-502-B2 and ZSL-502-B2

2. ID fan VFD. Reference drawing E-1.04.

XIV. TURBINE INTERFACE

A. Control Modes

1. Turbine Control is completely by Solar. Interface points exist as described in the boiler and purge control that allow purge and turbine operation when no HRSG trip condition exists. Refer to those sections of this document for a complete description.

2. No Setpoint adjustment is required to the turbine.

3. Via the OPC connection to the turbine controls, read the turbine fuel oil flow value to the turbine in real-time and trend this value. Totalize flow on an hourly, daily and weekly basis and archive this value for emissions reporting.

4. Honeywell may have other data requests from the OPC interface for testing purposes. This information is beyond the scope of this document.

B. Permissives

1. As detailed in the purge and boiler operating descriptions.

C. Alarms, Interlocks and Trips

1. Provide an HMI selection for a normal turbine stop. Tie this to a contact output to be wired to the turbine control box.

D. Related Field Devices

1. Connection to Solar I/O as detailed on Solar drawing 73301-149320 sheet 17 of 57.

2. Connections to Solar I/O as detailed on Solar drawing 73301-149320 sheet 35 of 57.

3. Solar fuel oil flow transmitter TF-586 installed inside the turbine skid and with information reading available via OPC interface.

XV. MISCELLANEOUS DISPLAYS, ALARMS, ARCHIVING, AND TRENDS

A. Control Modes - No control functions. Only display and history functions.

1. Provide real-time indication and historical trends for turbine exhaust gas temperature (TE/TT-500-A1).

2. Provide real-time indication and historical trends for HRSG furnace gas temperature (TE/TT-501-B1).

3. Provide real-time indication and historical trends for turbine inlet natural gas pressure (PT-004-A1).

4. Provide real-time indication and historical trends for HRSG Economizer exhaust temperature (TE/TE-503-A1).

5. Provide real-time indication of turbine natural gas flow with historical trend. Additionally, totalize this value on an hourly, daily and weekly basis for emissions reporting (FT-002-A1).

6. Provide real-time indication of HRSG natural gas flow with historical trend. Additionally, totalize this value on an hourly, daily and weekly basis for emissions reporting (FT-003-A1).

7. Provide real-time indication and historical trends for differential pressure across chilled water inlet and outlet to the BROAD chiller (dPT-715-A2).

8. Provide real-time indication and historical trends for differential pressure across condenser water inlet and outlet to the BROAD chiller (dPT-605-A2).

9. Provide real-time indication and historical trends for differential pressure across exhaust inlet and outlet to the BROAD chiller (dPT-505-A2).

10. Provide real-time indication and historical trends for differential pressure across glycol inlet and outlet to the BROAD chiller (dPT-712-A2).

11. Provide real-time indication and historical trends for glycol temperature entering the turbine inlet air coil (TE/TT-710-A2).

12. Provide real-time indication and historical trends for glycol temperature leaving the turbine inlet air coil (TE/TT-711-A2).

13. Operating status indications for the HRSG burner from the BMS including the following.

    a. Ready to Start
    b. Purge Requested (Burner Purge)
    c. Purge Complete (Burner Purge)
    d. Main Fuel On
    e. Remote Control Selected
    f. Limits Satisfied.

B. Permissives

  1. NONE.

C. Alarms, Interlocks and Trips

  1. High turbine exhaust gas temperature alarm at 1500 degrees F.

  2. Low boiler feedwater header pressure from switch input PSL-201-A1

  3. High gas pressure and low gas pressure alarms set at 45 psig and 30 psig respectively (PT-004-A1).

D. Related Field Devices

  1. Field device listed above in part A of this section.

  2. Burner Management I/O as list in part A of this section.