
Electrical module:

- Generator circuit breaker (GCB) and generator control module (GCM) complete with protective relays, meters, voltage regulator, alarms and controls

HRSG accessory module:

- Feedwater heat exchanger with insulation
- Deaerator unit with level controls, trim and insulation
- Electric motor driven centrifugal boiler feed pumps (2 units at 100% capacity each)
- Three element feedwater controls and control valve assembly with block, bypass and drain
- Main process steam pressure control valve with block, and drain valves
- Injection steam flow control valve with block, and drain valves
- Continuous blowdown system, including conductivity cell, controls, and flash tank
- HRSG control cabinet
- Motor control center with starters, and panels for HRSG and BOP power, lighting and control needs
- Steam traps
- External steam moisture separator located between evaporator and superheater
- Instrumentation as required for control and monitoring
- Chemical feed tanks and pumps

Other equipment shipped loose:

- Intermittent blowdown tank
- Neutral grounding device
- Battery charger and batteries

Control System:

Control of the Series 7 is accomplished through the use of distributed digital control hardware and IPT designed control logic. All system functions are controlled automatically (with manual override available) to ensure safe, economically optimal operation. Plant starting and stopping is accomplished with minimal manual action. All of the turbine starting sequence, through generator synchronization, is pre-programmed in the control logic. Location of the turbine/generator controls on the turbine/generator skid allows shop wiring and testing of the control system, thus significantly reducing field installation expenses.

An important feature of the control system is its ability to control the operating mode based on overall system economics. Optimal economic operation is ensured through the use of a comprehensive set of pre-programmed operating modes. The specific mode of operation at any time is a function of current site energy economics (i.e. fuel cost, electric rates, steam and electric loads).

Operator interaction with the plant occurs through an Operator Interface Unit (OIU). The OIU provides access to all cogeneration plant control, monitoring and alarm functions through a single CRT interface. Control logic developed by IPT is an integral part of the control system. Control of balance of plant systems such as water treatment is configured in the Series 7 control system. The location of the OIU can vary, but it is generally within an existing structure such as the boiler plant control room, or a separately constructed cogeneration plant control room (not included).

The standard control system is comprised of the following elements:

- Genset skid control cabinet located in the genset skid control enclosure
- Genset skid motor control center located in the genset skid control enclosure
- Generator breaker and control module located on the electrical equipment module
- HRSG control cabinet located on the HRSG accessory module
- HRSG motor control center located on the HRSG accessory module
- Duct burner control panel located on the fuel treatment module
- Integrated BOP system controls located on the water treatment, plant air, and fuel treatment modules
- OIU including CRT, keyboard, printer, and disk memory

Startup and Training Services:

A variety of startup and training services are supplied as part of the standard Series 7. These ensure proper startup of the system, and provide the customer with a base of knowledge about operation and maintenance of the Cheng Cycle cogeneration plant.

IPT and **IPT's** subcontractors provide startup and checkout services for the entire plant. This ensures that all components systems are properly installed and fully operational. **IPT** carries full responsibility for coordination of these activities.

The standard training program consists of instruction on Cheng Cycle operating procedures, balance of plant systems, and specific Series 7 components. Training is coordinated by the **IPT** Training Manager. Included with the Series 7 and used as an integral part of this training are five complete sets of operations and maintenance manuals.

Cheng Cycle training is a five day course intended to acquaint the customer's operators and maintenance technicians with the system. Topics include:

- Cheng Cycle technology
- Series 7 functional and operating mode description
- Control system indication and reports
- Description of normal and abnormal operating conditions with required actions

Specific component training consists of representatives from **IPT** suppliers teaching detailed operations and maintenance procedures at the site; this occurs just before plant startup and lasts approximately five days.

Installation Requirements:

The equipment module supply alternative does not include any construction and installation services. These services are offered under the power island and turnkey plant supply alternatives. This section is intended to give an overview of the installation requirements of the equipment modules previously described. Detailed installation instructions and requirements are provided with the equipment and are made available to the plant installers where appropriate to reduce their costs.

The Series 7 is designed to minimize installation complexity and expense. Significant savings are associated with the installation of the Series 7 as compared to installation of a conventional system. These savings are primarily a result of IPT's pre-engineered, standardized modular design, and a philosophy which maximizes factory packaging and testing. Specific areas responsible for savings are:

- The entire plant is pre-engineered, including balance of plant and foundations. Site specific requirements are accommodated through minor changes or additions to a proven standard design.
- The unit is factory wired and tested to the maximum extent possible.
- Piping is pre-fabricated and factory installed with the exception of pre-fabricated interconnect piping between the BOP modules and the HRSG and genset.
- The entire plant control system is pre-engineered.
- The genset is tested at full simple cycle load in the factory with all controls and safety functions proven.
- BOP modules are assembled, and when feasible, mated and/or tested at the factory.
- Plant checkout and startup time is minimized due to factory testing, use of a proven design, and IPT's experienced startup personnel.

Installation of the Series 7 typically requires a) site preparation and foundation/building construction, b) placement, assembly and interconnection of IPT supplied equipment modules, and c) interconnection and interfacing of the power island with existing facilities and electric and gas utilities. The following sections provide an overview of the required activities.

Site Preparation and Foundation/Building Construction:

Unless the cogeneration plant is to be located in an existing building, site preparation and construction of concrete foundations and/or a building will be required. Typical activities might include:

- Clearing and grading
- Excavation
- Placement of forms and rebar
- Concrete pouring and finishing
- Building construction

Placement, Assembly and Interconnection of Equipment Modules:

The following skid-mounted Series 7 components must be placed on foundations. These components are supplied suitably equipped for either outdoor or indoor installation.

- HRSG module
- Deaerator module (Supported by HRSG Module)
- Fuel module
- Compressed air module
- Lube oil cooler module (Supported by compressed air module)
- Combustion turbine generator (genset)
- Exhaust transition
- Superheater
- Duct burner with augmenting air blower and scanner blower (Both supported by duct burner)
- Duct burner firing transition
- HRSG evaporator section and associated platforms and ladders (economizer, and stack are supported by the evaporator)
- Economizer (Supported by Evaporator)
- Static transition and stack (Supported by stack)
- Electrical module
- Water treatment module

The following Series 7 components must be placed on structural supports that are designed and supplied by IPT:

- Combustion air inlet duct
- Combustion air filter and silencer
- Turbine injection steam piping from the superheater to the genset skid

The Series 7 is factory assembled to the optimal extent to achieve lowest total installed cost. Field assembly activities generally involve connection of modules and loose items which are shipped separately. Very little field fabrication of any type is required. Typical assembly requirements include the following:

HRSG and supplemental burner:

- Installation of boiler trim
- Attachment of ladders and platforms that service the HRSG
- Installation of the interconnecting piping between the HRSG and the accessory module
- Placement and installation of gas turbine injection steam piping
- Connection of the fuel module to the genset and supplemental burner
- Connection of supplemental burner augmenting air system components via ductwork

Control system:

- Control system I/O wiring between the HRSG, HRSG motor control center, supplemental burner control panel and the HRSG control cabinet
- Control system plant loop wiring (twinax cables) between various components of the Series 7

Gas turbine generating set:

- Supply and installation of conductors between the genset skid terminals and the generator breaker and control module
- Connection of the battery box to the charger
- Connection of the generator grounding device
- Installation of gas turbine combustion air filtration components and ductwork
- Installation of genset skid cooling air ductwork
- Connection of the turbine fuel to the genset
- Connection of the genset lubrication system with the lube oil cooler
- Installation of the gas turbine exhaust expansion joint
- Installation of motor control and protective relay wiring between the genset and associated off-skid equipment

Balance of Plant Systems and Equipment:

- Interconnection of water treatment modules
- Interconnection of HRSG accessory, fuel treatment, and plant air module integral pipe racks through the use of prefabricated flanges and spool pieces
- Assembly and interconnection of the HRSG module with the deaerator module and plant air module with the lube oil cooler module
- Connection of water treatment module piping with piping on the compressor air module integral pipe rack
- Wiring from MCC on the HRSG accessory module to motors on other modules

Interconnection and Interfacing with Existing Systems:

To be fully operational, the Series 7 power island must be connected to existing facilities and local utilities. The scope of activities associated with this aspect of plant installation varies greatly from site to site. Typically included are:

- Connection of the power island steam, electrical, water, fuel, and waste interfaces with existing site systems
- Electric and gas utility interconnect activities

The Interface Requirements section of this document describes required input conditions at the plant boundary for the various interfaces, and describes conditions at the plant boundary for outputs produced by the Series 7.

4. SCOPE OF SUPPLY ALTERNATIVE TWO - INSTALLED POWER ISLAND

Under this alternative, IPT supplies an installed power island; this allows IPT to utilize its pre-engineered design for the entire power island, including foundations, and to work with an experienced associate engineering and construction company. The result is typically a very cost-effective installation, because the bulk of the engineering work has already been done and because an experienced project and construction management team can be used.

The standard power island design utilizes the configuration described in the Layout section of this document. This design has been developed assuming a clear, flat rectangular site of approximately 100'x100' (the 100'x40' standard plant plot plan, plus 30' construction access on both sides), with sufficient soil bearing capacity to not require pilings. To the extent that some or all of these conditions are not met for a specific project, the standard design can be modified.

Items Included:

Included in the scope of supply under this alternative are all components and services required for an installed, fully equipped power island. The result is essentially an operable cogeneration plant, lacking only interconnection and interfacing with existing systems and utilities. Specifically included are:

- The equipment modules described in Alternative One
- The startup and training services described in Alternative One
- Site preparation and foundation construction as described in the Scope of Supply Alternative One, Installation Requirements section
- Placement, assembly, and interconnection of equipment modules as described in the Scope of Supply Alternative One, Installation Requirements section
- Project and construction management

Interface and Interconnection Requirements:

Interconnection and interfacing of the power island with existing facilities and utilities is not included in this scope of supply. These activities normally include connection of the power island steam, electrical, water, fuel, and waste interfaces with existing systems, as well as electric and gas utility interconnect activities. These services are offered in the turnkey plant alternative discussed in the following section.

IPT offers the standard power island package which does not include these services for two reasons: 1) because of their project specific nature, it is impossible to develop a standard design for interfacing and interconnection, and 2) often the power island is part of a larger construction project being managed by others. Thus, it may often be most effective for IPT to supply a standardized power island, with interconnection and interfacing supplied by another engineering or construction firm.

5. SCOPE OF SUPPLY ALTERNATIVE THREE - TURNKEY PLANT

In many situations, a customer may wish to work with a single party for a complete and fully operable turnkey cogeneration plant. To accommodate this, IPT can expand the scope of construction and installation services offered to include interfacing and interconnection of the power island to existing systems. In addition, IPT and its engineering/construction associates can offer complete architectural treatment of the cogeneration plant and incorporate necessary site energy system upgrades or renovations into the cogeneration project.

Items Included:

The scope of supply associated with the turnkey plant can vary considerably depending on the requirements of the project and the preferences of the customer. The following items will generally always be included:

- Supply and installation of the power island as described in Supply Alternatives One and Two
- Connection of the power island steam, electrical, water, fuel, and waste interfaces with existing site systems
- Electric and gas utility interconnect activities
- Project and construction management services for the entire project

Other services which can be supplied by IPT as part of the turnkey project might include:

- Site steam distribution system expansion or renovation
- Enclosure of the cogeneration plant in a building which is architecturally compatible with its surroundings
- Environmental and other permitting

6. INTERFACE CONDITIONS AND REQUIREMENTS

Complete installation of the Series 7 requires connection with site and utility systems. This section provides information on the types of activities required, and input/output conditions at the boundary of IPT's scope of supply when either the equipment module or power island alternatives are selected. Normally, the turnkey plant scope of supply would include complete interconnection with existing systems, so this scope boundary would not exist.

The standard layout which serves as the basis for both the equipment modules and the power island alternatives has standard interface locations on the plant perimeter for all piping and wiring. All interface piping and wiring from within the power island is led to these standard locations. Connection of the power island to the host facility and local utilities involves running piping and wiring from the standard interface locations to existing host and utility locations. This method preserves the standard design to the maximum extent possible and typically results in the lowest overall installation cost. The following sections describe these interfaces and associated conditions and requirements.

- **Steam Interfaces:**

Process steam is supplied at the end of the HRSG accessory module skid at up to the minimum HRSG operating pressure of 205 psig saturated (higher pressures are available as options). Any required pressure let-down is accomplished by an IPT supplied control valve.

- **Electrical Power Interfaces:**

The power export interface with the Series 7 occurs at the terminals on the generator circuit breaker and generator control module. Power is supplied at 60 Hz, 4160 volts with the standard plant (other voltages are available as options).

Station power at 480 volts must be supplied from an existing facility buss to the cogeneration plant boundary, or may be provided from within the power island through the use of an optional 4160/480 volt transformer.

- **Water Interfaces:**

There are typically four water interfaces at the plant boundary. Flow rates at these interfaces depend on site specific conditions including amount of condensate return and raw water quality. The interfaces are:

- Raw makeup water input for treatment. 50 psi required at the plant boundary with typical maximum flow rate of 90 gpm.
- Output treated water to a condensate and treated water storage tank located external to the power island. 10 psi delivered to the plant boundary with a typical maximum flow rate of 60 gpm.
- Input water to condensate pumps from the condensate and treated water storage tank. 10 psi required at the plant boundary with a typical maximum flow rate of 60 gpm.
- Potable water delivered to the plant boundary at 50 psi and 10 gpm typical maximum flow rate.

- Fuel Interfaces:

Natural gas must be supplied to the power island boundary at 40 psi minimum with maximum flow rate of approximately 1800 scfm.

If dual or liquid only fuel options are used, #2 fuel oil from a storage tank external to the power island must be supplied at 1 psi and 8 gpm maximum flow rate.

- Environmental and Waste Stream Interfaces:

All power island drains are led to a single sewer interface at the plant boundary. Typical maximum flow rates is 120 gpm with a typical maximum temperature of 200 °F. (Lower temperatures require optional blowdown cooling.)

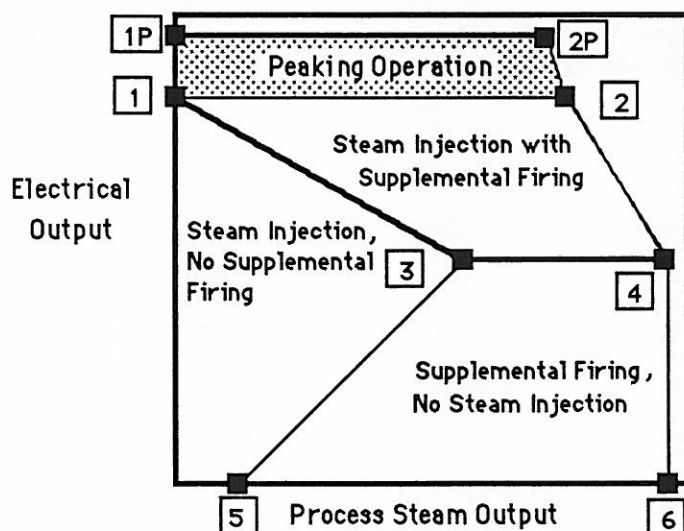
If an optional control room is included with toilet facilities a sanitary sewage interface will also exist at the plant boundary.

** **Note:** Flow rates, pressures, and temperatures are typical, and may vary depending upon site specific characteristics and requirements.

7. SERIES 7-COGEN PERFORMANCE - GAS FIRED

The Cheng Cycle Series 7 is capable of producing up to 5.6 megawatts of electrical power and up to 45,000 lbs/hour of process steam. Actual system output is a function of site energy loads, operating mode, and site ambient conditions such as temperature and altitude. The operating mode at any given point in time is selected by the supervisory control system based on current energy prices. The mode chosen is that which maximizes economic returns. Typical modes are:

- Steam load following - This most common mode consists of operating along line 1-3-4 (see figure on the following page). Process steam demand determines the operating point; steam injection takes place only as necessary to follow steam load fluctuations.
- Maximum power output - Operation occurs along line 1P-2P. This peaking mode is recommended for a maximum of 1250 hours per year, and is typically used during periods of very high electrical rates.
- Steam and electric load following - Site steam and electrical loads are matched by operating anywhere within the operating regime. This type of operation typically occurs when utility buyback rates are very low or when the plant is operating in isolation from the utility grid.



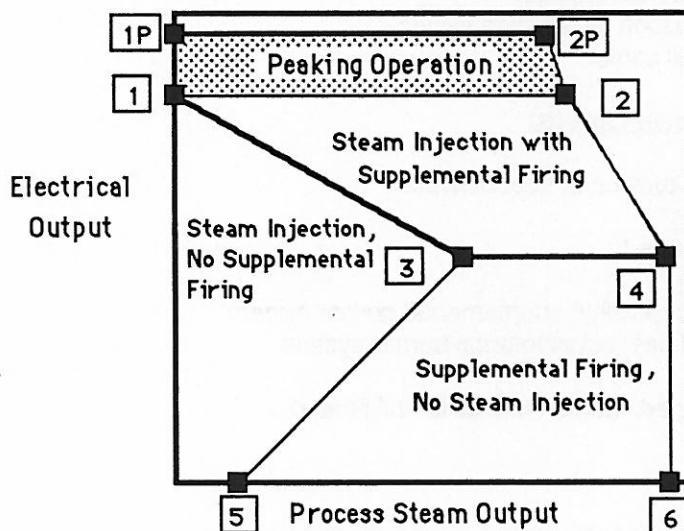
Operating Point:	1	2	3	4	5	6	1P	2P
Power Output (kW at Generator Terminals)	5,362	5,362	3,562	3,562	0	0	5,592	5,592
Process Steam Output (Lbs/Hour)	590	36,704	22,781	43,219	4,621	44,994	1,784	36,539
Turbine Fuel (Gas - MMBtu/Hr LHV)	49.21	49.21	44.81	44.81	14.52	14.52	51.28	51.28
Supplemental Burner Fuel (Gas - MMBtu/Hr LHV)	0	43.19	0	24.49	0	44.75	0	41.68
Injection Steam (Lbs/Hr)	19,800	19,800	0	0	0	0	19,800	19,800

- Notes:**
- 1 Power output levels are based on Allison 501KH nominal specifications, and include provisions for inlet and outlet duct losses.
 - 2 All data is for ISO standard conditions (14.7 psia, 59 degF temperature, 60% relative humidity).
 - 3 Process steam at 205 psig. Figures are typical, based on 100% makeup water at 60 degF.

SERIES 7-COGEN PERFORMANCE - OIL FIRED

The Cheng Cycle Series 7 is capable of producing up to 5.6 megawatts of electrical power and up to 45,000 lbs/hour of process steam. Actual system output is a function of site energy loads, operating mode, and site ambient conditions such as temperature and altitude. The operating mode at any given point in time is selected by the supervisory control system based on current energy prices. The mode chosen is that which maximizes economic returns. Typical modes are:

- Steam load following - This most common mode consists of operating along line 1-3-4 (see figure on the following page). Process steam demand determines the operating point; steam injection takes place only as necessary to follow steam load fluctuations.
- Maximum power output - Operation occurs along line 1P-2P. This peaking mode is recommended for a maximum of 1250 hours per year, and is typically used during periods of very high electrical rates.
- Steam and electric load following - Site steam and electrical loads are matched by operating anywhere within the operating regime. This type of operation typically occurs when utility buyback rates are very low or when the plant is operating in isolation from the utility grid.



<u>Operating Point:</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>1P</u>	<u>2P</u>
Power Output (kW at Generator Terminals)	5,221	5,221	3,419	3,419	0	0	5,444	5,444
Process Steam Output (Lbs/Hour)	660	37,048	22,876	43,520	4,621	44,994	1,850	36,891
Turbine Fuel (Oil - MMBtu/Hr)	48.11	48.11	43.72	43.72	14.52	14.52	50.09	50.09
Supplemental Burner Fuel (Oil - MMBtu/Hr)	0	43.53	0	24.75	0	44.75	0	42.05
Injection Steam (Lbs/Hr)	19,800	19,800	0	0	0	0	19,800	19,800

- Notes:**
- 1 Power output levels are based on Allison 501KH nominal specifications, and include provisions for inlet and outlet duct losses.
 - 2 All data is for ISO standard conditions (14.7 psia, 59 degF temperature, 60% relative humidity).
 - 3 Process steam at 205 psig. Figures are typical, based on 100% makeup water at 60 degF.

8. OPTIONS

Although the standard Series 7 offering has been designed to cover the majority of a typical customer's requirements, IPT provides certain equipment and service options. These allow tailoring of the Series 7 to fit a site's particular requirements.

Turbine Generating Set Options:

- Capability to operate on liquid fuel (No. 2 diesel or equivalent) rather than natural gas
- Dual (liquid and natural gas) fuel capability with ability to change under load
- Water injection capability for additional NO_x control during periods of low steam injection (can be combined with any fuel option)
- 15 kV class generating voltage (typically 12.4 or 13.8 kV) rather than 4160 kV
- Gas turbine shipping container
- Combustion air evaporative cooler
- Self-cleaning combustion air filtration system
- Water cooled lube oil cooler

HRSG and Supplemental Burner Options:

- Provision for future addition of soot blowers *
- Manual soot blowers *
- Automatic soot blowers *
- Modified fin spacing *
- Liquid fuel (no gas capability) supplemental burner system
- Dual fuel (liquid and gas) supplemental burner system

* For use where prolonged firing on fuel oil is anticipated

Control System Options:

- Additional OIU for redundancy
- Extension of Series 7 control system for control of auxiliary boiler or other equipment not supplied by IPT
- Remote monitoring capability
- Commodities metering systems for process steam and electricity
- Continuous Calculated Emissions Monitoring (CCEM) software model for emissions monitoring and reporting without the use of expensive emissions monitoring equipment
- Redundant controllers
- Automatic logging of reports
- Archival disk storage of operating data
- Computer interface unit for access to plant data with a PC
- Chairs and printer tables

Electrical Options:

- Provisions to allow synchronization and reconnection with the utility grid while running
- 4160/480 volt transformer for plant power
- Black start capability to allow startup of the Series 7 during a utility outage

Balance of Plant System Options:

- Different water treatment configurations to handle a wide variety of site water conditions
- Different gas compression and fuel treatment options to handle various site requirements
- Elimination of plant air module when existing facility system can meet cogeneration plant requirements
- Sump pumps for waste sump if gravity drainage is not available
- Foundation design for standard power island

Other Equipment:

- Building to enclose cogeneration plant
- Prefabricated control building for indoor or outdoor location. Includes space for OIU, recordkeeping, and toilet facilities
- Auxiliary boiler
- Condensate and treated water storage tank including pumps and controls
- Fuel oil tank and delivery system

Other Services:

Through its four divisions, IPT offers a broad range of other services associated with the installation, financing and operation of a cogeneration plant. These include:

- Complete environmental permitting services
- Utility contract evaluation and/or negotiation
- A complete range of financing alternatives, including leveraged lease, partnership, and municipal lease arrangements
- A complete range of operations and maintenance services offered through IPT. Alternatives include spare parts agreements, on-site supervisors, and complete operations and maintenance agreements.

