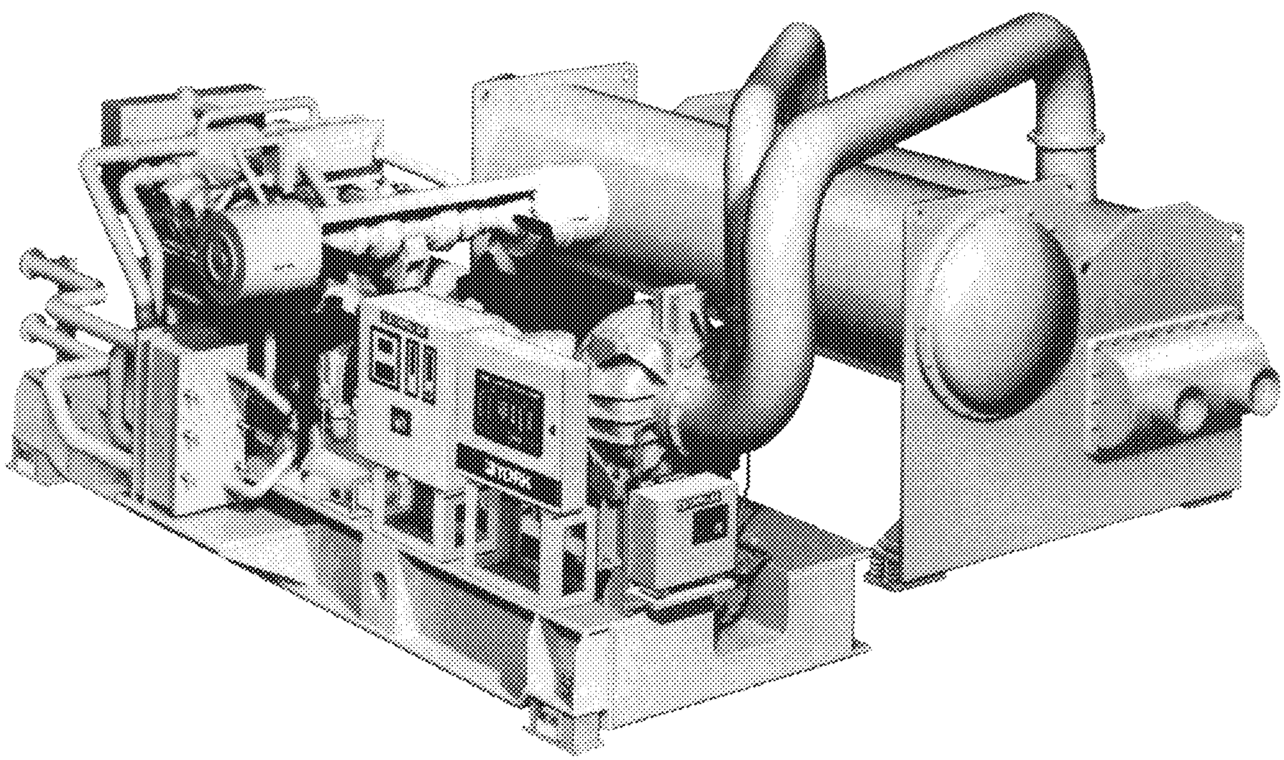
FORM 160.60-EG1 (1295)

MILLENNIUM ™

GAS-ENGINE-DRIVE CHILLERS

Design Level "A"



400 Through 2100 Tons
Utilizing HFC-134a

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NOMENCLATURE

The model number denotes the following characteristics of the unit:

YG RE RC J1 — G508 A

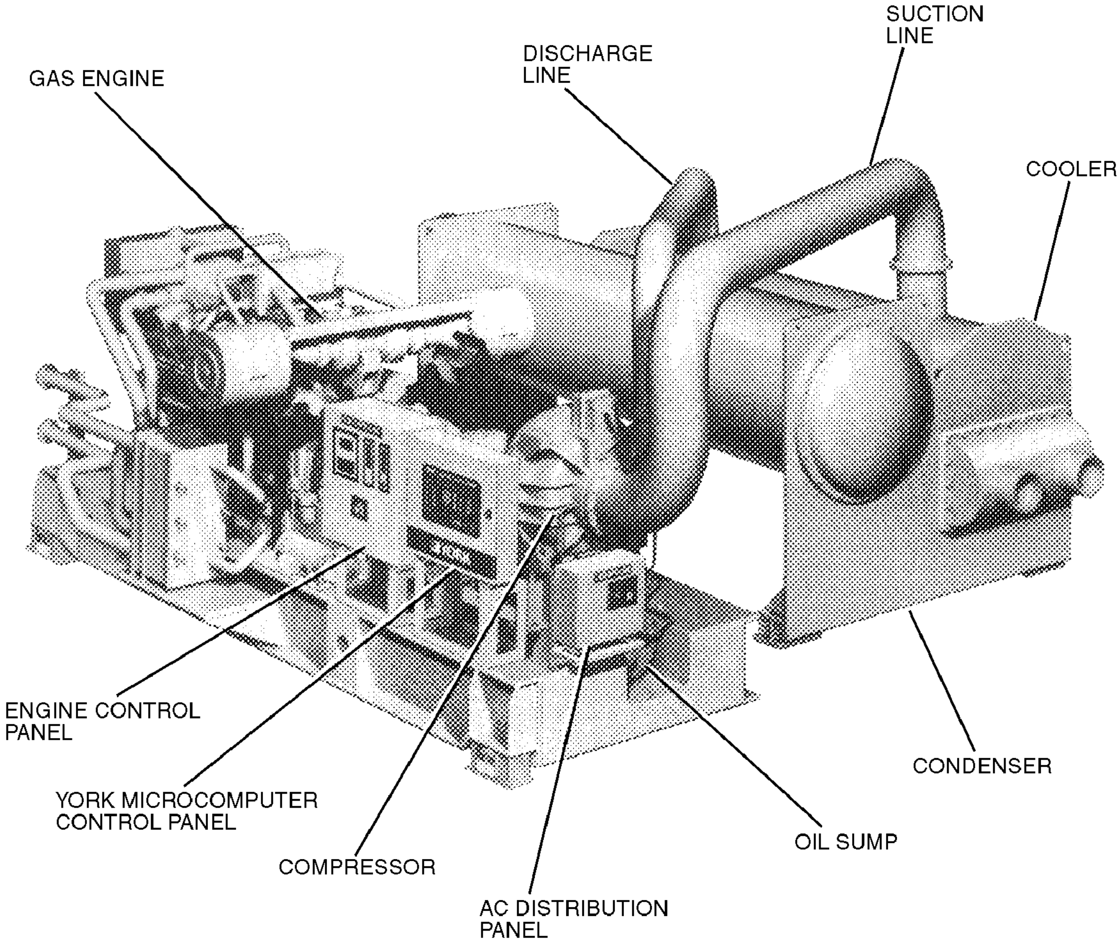
- YG – Model
- RE – Cooler Code
- RC – Condenser Code
- J1 – Compressor Code
- — – Power Supply - for 60 Hz
- G508 – Engine Size
- A – Design Level

Engine, Compressor and Shell Combinations

SHELLS	G4	H0	H1	H2	J1	J2	J3	J4
LBLB	G3408							
LBLC	G3408							
LCLB	G3408							
LCLC	G3408							
MBMB	G3408	G3408						
MBMC	G3408	G3408						
MCMB	G3408	G3408						
MCMC	G3408	G3408						
NBNB	G3408	G3408	G3412	G3412				
NBNC	G3408	G3408	G3412	G3412				
NCNB	G3408	G3408	G3412	G3412				
NCNC	G3408	G3408	G3412	G3412				
PBPB	G3408	G3408	G3408/3412	G3412/3508				
PBPC	G3408	G3408	G3408/3412	G3412/3508				
PCPB	G3408	G3408	G3408/3412	G3412/3508				
PCPC	G3408	G3408	G3408/3412	G3412/3508				
QBQB			G3408/3412	G3412/3508				
QBQC			G3408/3412	G3412/3508				
QCQB			G3408/3412	G3412/3508				
QCQC			G3408/3412	G3412/3508				
QDQB					G3508/3512	G3512/3516		
QDQC					G3508/3512	G3512/3516		
QEQB					G3508/3512	G3512/3516		
QEQC					G3508/3512	G3512/3516		
RBRB				G3508				
RBRC				G3508				
RCRB				G3508				
RCRC				G3508				
RDRB					G3508/3512	G3512/3516	G3516/3606	G3516/3606
RDRC					G3508/3512	G3512/3516	G3516/3606	G3516/3606
RERB					G3508/3512	G3512/3516	G3516/3606	G3516/3606
RERC					G3508/3512	G3512/3516	G3516/3606	G3516/3606
SDSB						G3512/3516	G3516/3606	G3516/3606
SDSC						G3512/3516	G3516/3606	G3516/3606
SESB						G3512/3516	G3516/3606	G3516/3606
SESC						G3512/3516	G3516/3606	G3516/3606

Introduction

YORK® *MILLENNIUM* ™ Gas-Engine-Drive (GED) Chiller 400 to 2100 Tons



The YORK Gas-Engine-Drive (GED) Chiller is the most efficient gas-cooling technology available today. The GED Chiller is the only natural-gas-engine chiller to be jointly designed, manufactured and tested by two world-class manufacturers; YORK and Caterpillar. The result is an environmentally friendly, high efficiency chiller with unprecedented product service and support.

HIGH EFFICIENCY RESULTS IN MAXIMUM OPERATIONAL COST SAVINGS

YORK has integrated Caterpillar's proven gas-engine design with its renowned Millennium centrifugal-chiller technology, resulting in a chiller with full load COPs as high as 2.0. Also, by using YORK's patented variable-speed technology, the GED is a true variable speed chiller capable of part load COPs as high as 2.5. The high efficiency natural gas driven GED chiller maximizes operational savings by avoiding the demand charges, ratchet rates and time-of-day charges associated with electrical use. And, because the engine's waste heat can be reclaimed to produce hot water for heating, many applications will not require a boiler - saving even more money.

ENVIRONMENTALLY FRIENDLY DESIGN

The YORK GED chiller is also an environmentally responsible choice for your cooling needs. GED chillers operate exclusively with HFC-134a, a CFC-free refrigerant with zero ozone-depletion potential. Using clean-burning natural gas, SO_X emissions are negligible while total CO_2 emissions are less per ton-hour than an electric chiller. Plus, GED chillers are equipped with the finest NO_X reduction technology available to address the most stringent air-quality control standards.

Ratings

CHILLER	MODEL	YGPBPBH1	YGPCPCH2	YGQEQCJ1	YGRERCJ2	YGSDSBJ3	YGSESCJ4
	CAPACITY (Tons)	550	800	925	1,350	1,750	2,075
	CONSUMPTION (Btu/Ton Hr)	6,472	6,499	6,082	6,219	6,482	6,270
	UNIT COP (PER HHV)	1.85	1.85	1.97	1.93	1.85	1.91
	REFRIGERANT	R 134a	R 134a	R 134a	R 134a	R 134a	R 134a
ENGINE	CATERPILLAR ENGINE MODEL	G3408	G3412	G3508	G3512	G3516	G3606
	MAX. ENGINE POWER (BHp)	451	675	717	1,077	1,435	1,765
	F.L. PERFORMANCE (Btu/BHp Hr)	8,241	7,968	7,874	7,869	7,939	7,685
	INLET GAS PRESSURE (Psi)	1.5 - 5	1.5 - 5	1.5 - 5	1.5 - 5	1.5 - 5	43 - 47
	RPM	1,800	1,800	1,500	1,500	1,500	1,000
EVAPORATOR	GPM (Gal/Min)	1,320	1,920	2,220	3,240	4,200	4,980
	ENTERING TEMPERATURE (°F)	54	54	54	54	54	54
	LEAVING TEMPERATURE (°F)	44	44	44	44	44	44
	PRESSURE DROP (Ft H_20)	14.7	20.9	15.7	17.9	21.2	21.7
CONDENSER	GPM (Gal/Min)	1,650	2,400	2,775	4,050	5,250	6,225
	ENTERING TEMPERATURE (°F)	85	85	85	85	85	85
	LEAVING TEMPERATURE (°F)	95	95	95	95	95	95
	PRESSURE DROP (Ft H_20)	17	17	17	17	17	17
DRIVELINE HX	GPM (Gal/Min)	165	215	395	430	400	415
	ENTERING TEMPERATURE (°F)	85	85	85	85	85	85
	LEAVING TEMPERATURE (°F)	104.1	104.4	104.9	104.8	104.9	104
	PRESSURE DROP (Ft H_20)	16.2	16.2	16.2	16.2	16.2	16.2
TOWER REQUIREMENTS	GPM (Gal/Min)	1,815	2,615	3,170	4,480	5,650	6,640
	ENTERING TEMPERATURE (°F)	95.8	95.8	96.2	95.9	95.7	95.6
	LEAVING TEMPERATURE (°F)	85	85	85	85	85	85
HEAT RECOVERY	JACKET WATER (Btu/Hr)	1,231,623	1,720,869	1,553,298	2,081,570	2,924,919	1,143,522
	EXHAUST TO 350°F (Btu/Hr)	503,503	585,576	792,973	1,333,523	1,862,646	2,686,223
PHYSICAL DATA	MECHANICAL SOUND @ 3 Ft (dBA)	97	99	98	98	99	102
	DIMENSIONS (L x W x H)	234 x 191 x 91	234 x 191 x 91	234 x 243 x 112	253 x 262 x 112	272 x 268 x 112	366 x 264 x 162
	OPERATING WEIGHT	47,855	52,390	75,090	94,140	110,675	176,105

COMPUTERIZED PERFORMANCE RATINGS

Each chiller is custom-matched to meet the individual building load and energy requirements. A large number of standard heat exchangers and pass arrangements are available to provide the best possible match.

It is not practical to provide tabulated performance for each combination, as the energy requirements at both full and part-load vary significantly with each heat exchanger and pass arrangement. Computerized ratings are available through each YORK sales office. These ratings can be tailored to specific job requirements.

PART-LOAD PERFORMANCE

A chiller should be chosen not only to meet the full-load design, but also for its ability to perform efficiently at lower loads and lower tower water temperatures. It is not uncommon for chillers with the same full-load BTU/TON to have an operating cost difference of over 10% due to part-load operation.

Part-load information can be easily and accurately generated by use of the computer. And because it is so important to an owner's operating budget, this information has now been standardized in the form of an Integrated Part-Load Value (IPLV), and Application Part-Load Value (APLV).

IPLV or APLV is a single BTU/TON value that describes part-load performance of a chiller. It was originally devised to satisfy the needs of the new ANSI/ASHRAE Standard 90.1 (Standard For Energy Efficient Design of New Nonresidential And High-Rise Residential Buildings). It is based on a schedule of "typical" operating hours spent at each load point. This allows direct comparison of each manufacturer's part-load performance on an equal basis. An example of the IPLV/APLV calculation is shown below.

$$\text{IPLV or APLV} = \frac{1}{\frac{0.17}{A} + \frac{0.39}{B} + \frac{0.33}{C} + \frac{0.11}{D}}$$

WHERE: A = BTU/TON HR AT 100% CAPACITY
B = BTU/TON HR AT 75% CAPACITY
C = BTU/TON HR AT 50% CAPACITY
D = BTU/TON HR AT 25% CAPACITY

% LOAD	ECWT	TONS	HP	BTU/HP HR	BTU/ TON	COP	WEIGHT
100	85.00	1325	1046	7,831	6,182	1.94	0.17
75	78.75	994	726	7,495	5,476	2.19	0.39
50	72.50	663	501	8,048	6,086	1.97	0.33
25	66.25	331	330	10,024	9,986	1.20	0.11

BTU/TON HR APLV FUEL INPUT	6,293
IPLV COP	1.91

While IPLV/APLV provides a quick method of comparing part-load capabilities, this should not be construed as being "typical" for every, or even the majority of jobs. The only valid information must take into account actual building load profiles, and local weather data. Part-load performance data should be obtained for each job using its own design criteria.

MILLENNIUM Control Center

The GED Control Center, furnished as standard on each Gas-Engine-Driven Chiller, provides the ultimate in efficiency and chiller protection. State-of-the-art microelectronics assure precise, reliable chiller control logic and safety annunciations. The control center allows direct interfacing with the YORK Integrated Systems Network (ISN) building automation system, allowing complete integration of chiller, airside, and building automation controls. This feature makes the YORK chiller the most versatile in the market place.

Information Display

Vital chiller operating information can be shown on the 40-character alphanumeric display. All information is in the English language with numeric data provided in English or metric units.

Information provided on all units as standard includes:

- Chilled liquid temperatures - entering and leaving
- Condenser liquid temperatures - entering and leaving
- Refrigerant pressures - evaporator and condenser
- Differential oil pressure
- % Engine load
- Operating hours
- Number of compressor starts
- Saturation temperatures - evaporator and condenser
- Discharge temperature
- Compressor thrust bearing oil temperature
- Engine RPM
- Engine manifold pressure
- Engine oil pressure
- Engine jacket water temperature

In addition, all operating and setpoint information can be transmitted to an optional remote printer through the RS-232 port to obtain data logs:

- At any time by pressing PRINT button
- At set time intervals by programming the panel
- Record of time and cause of safety and cycling shutdowns with all operating information just prior to shutdown
- History printout of last four shutdowns

Leaving Chilled Water Temperature Control

- Digital keypad entry of setpoint to 0.1°F.
- Verify actual vs. setpoint temperature via alphanumeric display.
- Remote reset capability standard with YORK ISN Building Automation System, optional for other analog or discreet remote signals.
- Adjustable remote reset range (up to 20°F) provides flexible, efficient use of remote signal depending on reset needs.

System Cycling Controls

- Programmable seven-day time clock for automatic start/stop of chiller, cooler and condenser water pumps, and cooling tower.
- Separate schedule input strictly for holidays.
- Remote cycling contacts available for other field-supplied signals.

System Shutdown Controls

The following safeties responsible for system shutdown are shown in English on the alphanumeric display. Each annunciation details the day, time, reason for shutdown and type of re-start required. All shutdowns are sequenced by the micro board except as noted.

Cycling - those controls which automatically reset and permit auto re-start of the system

- Time clock
- Low water temperature as sensed through the LWT sensor. If a drop in water temperature occurs, the unit is stopped at 4°F below the chilled liquid temperature setpoint. On a rise in water temperature, the unit re-starts automatically.
- Remote/local cycling devices (field supplied).
- Automatic re-start after power failure (a jumper plug is furnished if automatic re-start is desired).
- Multi-unit sequencing.
- Power fault relay.
- Low compressor oil temperature
- Aftercooler high inlet water temperature (Manual restart required)
- DC undervoltage
- Vanes open
- Low differential compressor oil temperature

Safety - those controls which (when employed) require a manual operation to depress the STOP-RESET switch and then COMPRESSOR START to re-start the system.

- Chilled water pump interlock or flow switch. Flow must be interrupted for a minimum of two seconds before shutdown will occur.
- High Compressor Discharge Temperature
  - fixed cutout provided by thermistor sensor.
- Compressor Thrust Bearing Position and Oil Temperature
  - combination proximity probe and oil temperature module shuts down compressor if either threshold limit is reached.
- High Compresssor Oil Reservoir Temperature
  - fixed cutout provided by thermistor sensor. Manual re-start after Power Failure (jumper plug furnished if automatic re-start is desired).
- High or Low Compressor Oil Pressure
  - fixed cutout provided by differential between separate transducer readings from the compressor sump and bearing feed line.
- Low Evaporator Pressure or High Condenser Pressure
  - to avoid nuisance cycling, the compressor capacity is held at cutout threshold for a safe period of time; if condition persists, a fixed cutout is provided by dedicated transducers.
- Remote stop (field-supplied signal).
- Differential between Leaving Chilled Water and Evaporator Saturation Temperatures
  - fixed cutout when value falls outside specified range to detect faulty sensors.
- Auxiliary shutdown
- Faulty discharge temperature sensor
- Compressor rotation fault
- Engine overload
- High engine water temperature
- Low engine oil pressure
- Evaporator transducer or probe error
- Clutch failure
- Manual engine shutdown
- Faulty compressor oil pressure transducer
- Faulty proximity probe
- Open thermocouple probe
- Engine cranking, overspeed, fault
- Engine panel shutdown
- Engine PLC failure
- Surge shutdown
- 24 V DC fault
- Faulty condenser pressure transducer

Control Mode Selection

There are three keys for the selection of the control center modes:

- ACCESS CODE permits access to the microcomputer PROGRAM and MODE buttons.
- PROGRAM permits the operator to program the setpoints.
- MODE permits the operator to select the following control modes:
  - LOCAL allows manual compressor start from the compressor switch located on the control center.
  - REMOTE allows remote start and stop of the compressor and remote reset of the chilled water temperature and load limit.
  - SERVICE allows manual operation of the compressor prerotation vanes and engine speed through the OPEN, CLOSE, HOLD and AUTO keys. Manual operation of the oil pump is also included.

Field Interlocks - Chiller Status

- Remote mode ready to start - contact closure indicates that the panel is in REMOTE mode and that the unit will start (all safeties and cycling devices satisfied) when a remote start signal is received.
- Cycling shutdown - contact closure indicates that a cycling shutdown has occurred and that the unit will re-start when the cycling control re-closes.
- Safety shutdown - contact closure indicates that a safety shutdown has occurred and that a manual reset is required to re-start.
- Run contact - closure indicates that the panel is providing a run signal to the engine.
- Remote engine load limit - PWM signal used to limit engine's demand for natural gas.

Mechanical Specifications

GENERAL

The YORK Gas Engine Drive Centrifugal Chiller consists of, and ships as two packages; a shell package and a driveline package. The shell package includes an evaporator and condenser with internal subcooler. The driveline package includes a compressor, compressor lubrication system, natural gas engine, clutch, speed increaser, torsional vibration reducing coupling, power panel, engine PLC panel and chiller control panel. Interconnecting piping is shipped separately for field connection. The chiller is painted with durable alkyd-modified, vinyl enamel machinery paint prior to shipment.

The initial charge of oil and refrigerant (HFC-134a) is supplied, shipped in containers and cylinders for field installation by YORK.

DRIVELINE

The driveline is a skid mounted, factory packaged assembly consisting of a heavy duty, industrial grade, turbocharged-aftercooled gas engine; clutch; speed increaser; torsional vibration reducing coupling; compressor; and compressor oil reservoir with submersible pump.

MOUNTING BASE - THREE POINT SUSPENSION

The engine, speed increaser, clutch, and compressor are mounted on a common base. The driveline base is designed and built by the engine manufacturer to resist deflection, maintain alignment, and to minimize linear vibration.

The driveline base will be of heavy duty I-beam construction reinforced to maintain equipment alignment during chiller operation. The base will be 21" for 3400 series engines, 24" for 3500 series engines and 36" for 3600 series engines. It will accommodate an accessory module which includes an expansion tank, heat exchanger, and all control panels.

The base will support the full driveline weight on steel spring isolators. The isolators will be bolted to the base in a 3-point mounting arrangement to help maintain shaft alignment. The isolators are installed between the driveline base and mounting surface and have a waffle or ribbed pad on their bottom surface.

ENGINE

The industrial gas engine is manufactured by Caterpillar Inc. The engine is a stationary, liquid-cooled, four-stroke design, vertical in-line or V-type configuration. The engine will be equipped with air filters, pressure gauges, lubricating oil cooler and filter, water pump and pressure gauge, service hour-meter, flywheel and flywheel housing.

Structure and Metallurgy - The design of the basic engine provides for maximum structural integrity to extend service life. Materials used in the engine incorporate the highest level of proven metallurgical and manufacturing technology.

The block is a one-piece design and cast of high tensile strength iron in the engine manufacturer's own foundry. Cylinder wear surfaces are induction hardened over their entire length. Pistons are a lightweight aluminum alloy which is elliptically ground across the skirt and tapered from crown to skirt. Compression rings in aluminum bodies have integral cast iron ring bands. Oil jets supply piston cooling and lubricating oil. Valves are hard-faced with replaceable inserts.

The crankshaft is a one-piece design. Connecting rods are fabricated of high strength steel with tapered pin bore.

Starting System - The engine starting system can be furnished as either electric or air start.

An electric starting system includes 24 volt DC starting motor(s), starter relay, and automatic reset circuit breaker to protect against butt engagement. Batteries are maintenance free, lead acid type mounted on a corrosion resistant rack near the starting motor.

An air start system includes air starting motor(s), silencer, start valve, and pressure regulator. The system requires an air supply at an operating pressure of 100 psig. (by others)

Both systems are capable of starting a properly equipped engine within 10 seconds at ambient temperatures greater than 70°F.

Engine Lubrication System - The lubrication oil pump is a positive displacement type that is integral with the engine and gear driven from the engine gear train. The system incorporates a full flow filtration with bypass valve to continue lubrication in the event of filter clogging.

The bypass valve is integral with the engine filter base or receptacle. Pistons are oil cooled by continuous jet spray to the underside or inside of the crown and piston ring.

Mechanical Specifications *(Continued)*

Gaseous Fuel System - The gaseous fuel system consists of gas pressure regulators and carburetors. A balance line between the regulator and engine inlet air manifold is provided to compensate for air cleaner restriction and turbocharger boost. Carburetors are of the diaphragm type with throttle body and a load screw for air-fuel ratio adjustment.

Ignition System - Units are equipped with an electronic ignition system, including detonation sensitive timing.

An accelerometer and electronic buffer unit are mounted on each side of the cylinder block to detect detonation level (if any). If detonation is detected, the electronic timing control will adjust ignition timing to eliminate detonation, or will shut down the unit if required.

Governor - The engine governor is a Woodward Electronic Governor with EG Electro-Hydraulic Actuator. Speed is sensed by a magnetic pickup off the engine flywheel ring gear. A provision for remote speed adjustment is included to allow the chiller control panel to adjust engine speed based on load.

Cooling System - All waterside heat rejection from the driveline is accomplished through a manifolded assembly of heat exchangers such that only a single point tower water supply and return connection is required. The engine jacket water cooling system is a closed circuit design with provision for filling, expansion, and deaeration. The engine water pump is driven by the engine. The engine jacket coolant loop is in turn cooled with a cleanable plate type heat exchanger operating with cooling tower water. Aftercooler and engine oil coolers are plate and frame type heat exchangers. The maximum design cooling tower water supply temperature is 85°F. Coolant pumps, required for heat exchangers or separate circuit aftercooling are engine driven. Coolant temperature is regulated to by-pass external cooling systems until operating temperature is achieved.

Inlet Air System - The engine air cleaner is engine mounted with dry element. If external ducting is required, maximum restriction to the combustion air inlet is limited to 27 in. H_2O.

Turbocharging - The turbocharger consists of an axial flow turbine driven by engine exhaust gases and direct-connected to the compressor supplying engine combustion air.

Aftercooling - The aftercooler reduces the temperature of the air/fuel mixture after compression. Aftercooler core air surfaces will be coated with a corrosion inhibitor to minimize oxidation.

Speed Increaser - The system driveline is equipped with a factory aligned gear-set that increases the rotating speed from full load engine RPM to 3600 RPM for input to the compressor. The speed increaser is supplied with face hardened, double helical gears and sleeve bearings.

Torsional Coupling - A torsional coupling is selected to assure that excissive torsional vibration levels are not transmitted to the gearbox and compressor at all operating speeds.

Air Actuated Clutch - The unit is equipped with a drive disconnect. The drum type clutch is air actuated and specifically designed and manufactured for heavy equipment applications. The clutch allows the engine to warm up before engaging and loading the compressor. The clutch also allows the engine to complete a cool down sequence, as recommended by the engine manufacturer, without the compressor being engaged.

COMPRESSOR

The compressor is a single stage centrifugal type. The housing is fully accessible with vertical circular joints. The complete operating assembly is removable from the compressor and scroll housing. The rotor assembly consists of a heat treated alloy steel drive shaft and impeller shaft with a cast aluminum, fully shrouded impeller. The compressor shaft is laser aligned to the speed increaser in the factory. The impeller is designed for balanced thrust, and is dynamically balanced, and overspeed tested for smooth, vibration free operation. Insert type journal bearings are fabricated of aluminum alloy, precision bored and axially grooved.

Internal single helical gears with crowned teeth are designed so that more than one tooth is in contact at all times to provide even distribution of the compressor load. Each gear is individually mounted in its own journal and thrust bearings to isolate it from impeller and drive forces.

The open drive compressor shaft seal consists of a spring loaded, precision carbon ring, high temperature elastometer "O" ring static seal, and stress relieved, precision lapped collars. The seal features a small face area and low rubbing speed. It provides an efficient seal under high pressure conditions. The seal is oil flooded at all times and is pressure-lubricated during compressor operation.

Capacity control is achieved by use of impeller speed variation and prerotation vanes. Engine speed and prerotation vane position are automatically controlled by the control panel to maintain leaving chilled liquid temperature at the desired setpoint without overloading the engine. Engine speed is set to optimize energy efficiency. The unit is capable of operating with lower water temperature cooling tower water during part load operation. At operating conditions requiring less than full impeller speed, engine speed is reduced to improve system efficiency.

COMPRESSOR LUBRICATION SYSTEM

Lubrication oil is force-fed to all bearings, gears, and rotating surfaces by an oil pump which operates prior to start-up and continuously during operation and coast-down. An oil reservoir, separate from the compressor, contains a submersible oil pump and two immersion-type oil heaters, thermostatically controlled to remove refrigerant from the oil. Oil is filtered by an externally mounted replaceable cartridge oil filter equipped with service valves, and cooled by a water cooled oil cooler before entering the compressor. Oil piping on the driveline is completely factory installed.

EVAPORATOR

The evaporator is of the shell-and-tube, flooded type, designed for 180 psig working pressure on the refrigerant side, and tested at 270 psig. The shell is fabricated from rolled carbon steel plate with fusion welded seams; has carbon steel tube sheets, drilled and reamed to accommodate the tubes; and intermediate tube supports spaced no more than three feet apart. The refrigerant side is designed, tested and stamped in accordance with AMSE Boiler and Pressure Vessel Code, Section VIII-Division 1.

Tubes are high efficiency, externally and internally enhanced type. Each tube is roller expanded into tube sheets providing a leak-tight seal. Tubes are 3/4" O.D., 23 BWG, copper alloy and individually replaceable.

Two liquid level sight glasses are located on the side of the shell to aid in determining proper refrigerant charge. The evaporator has a refrigerant relief device sized to meet the requirements of ASHRAE 15 Safety Code for Mechanical Refrigeration.

Water boxes are removable to permit tube cleaning and replacement. Stubout water box connections with 150 lb. ANSI raised face flange are provided. Water boxes are designed for 150 psig design working pressure and tested at 225 psig. Plugged 3/4" vent and drain connections are provided in each water box.

CONDENSER

The condenser is of the shell-and-tube type, designed for 180 psig working pressure on the refrigerant side, and tested at 270 psig. The shell is fabricated from rolled carbon steel plate with fusion welded seams; has carbon steel tube sheets, drilled and reamed to accommodate the tubes; and intermediate tube supports spaced no more than four feet apart. An internal refrigerant subcooler is provided for improved cycle efficiency. The refrigerant side is designed, tested and stamped in accordance with ASME Boiler and Pressure Vessel Code, Section VIII-Division 1.

Tubes are high efficiency, externally and internally enhanced type. Each tube is roller expanded into tube sheets providing a leak-tight seal. Tubes are 3/4" O.D., 23 BWG, copper alloy and individually replaceable.

Water boxes are removable to permit tube cleaning and replacement. Stubout water box connections with 150 lb. ANSI raised face flange are provided. Water boxes are designed for 150 psig design working pressure and tested at 225 psig. Plugged 3/4" vent and drain connections are be provided in each water box.

REFRIGERANT FLOW CONTROL

Refrigerant flow to the evaporator is controlled by a variable orifice. The variable orifice automatically adjusts to maintain proper refrigerant level in the condenser and evaporator. This will optimize unit performance at varying load and temperature conditions.

MICROCOMPUTER CONTROL CENTER

Each unit will be furnished complete with a micro-computer control center in a locked enclosure. The control center includes a 40 character alpha-numeric display showing all system parameters in the English language with numeric data in English or metric units.

Digital programming of setpoints through a color coded, non-tactile keypad includes: leaving chilled liquid temperature, percent engine load limit, seven day time clock for starting and stopping chiller and pumps (complete with holiday schedule), remote reset temperature range, and data logger.

Security access is provided to prevent unauthorized change of setpoints, to allow local or remote control of the chiller, and to allow manual operation of the prerotation vanes, engine speed, and compressor oil pump.

All safety and cycle shutdowns are annunciated through an alpha-numeric display and consist of day, time, cause of shutdown, and type of restart required.

Mechanical Specifications *(Continued)*

Safety shutdowns include: low evaporator pressure, high condenser pressure, auxiliary safety, high discharge temperature, faulty discharge temperature sensor, high compressor oil temperature, power failure (manual restart), compressor rotation fault, engine overload, loss of chilled water flow, high engine water temperature, low engine oil pressure, low compressor oil pressure, high compressor oil pressure, evaporator transducer or probe error, clutch failure, manual engine shutdown, faulty compressor oil pressure transducer, proximity sensor fault, high speed thrust bearing oil drain temperature, faulty proximity probe, open thermocouple probe, engine cranking, engine fault, engine overspeed, compressor overspeed, engine PLC fault, engine panel shutdown, 24V DC fault, faulty condenser, pressure transducer and remote stop (field supplied signal). Cycling shutdowns include: low compressor oil temperature, power failure (auto restart), low chilled water temperature, remote unit cycling, multi unit cycling, internal time clock, vanes open, compressor low differential oil temperature, DC under-voltage, aftercooler high water temperature (manual restart required), remote/local cycling devices and multi-unit sequencing.

System operating information includes: return/leaving chilled liquid temperature, return/leaving condenser liquid temperatures, evaporator/condenser refrigerant pressures, differential compressor oil pressure, percent engine load, evaporator/condenser saturation temperatures, compressor discharge temperature, compressor oil temperature, operating hours, number-of-starts counter, engine oil pressure, manifold pressure, engine jacket water temperature and engine speed.

The chiller is provided with an RS-232 port to output all system operating data, shutdown/cycling messages, and a record of the last four cycling or safety shutdowns to a remote printer (field supplied). The control center is programmable to provide data logs to the optional printer at a preset time interval.

The control center is capable of interfacing with a building automation system to provide remote chiller start/stop; reset of chilled water temperature; remote engine load limit; and status messages indicating chiller is ready to start, chiller is operating, chiller is shut down on a safety requiring a manual reset, and chiller is shut down on a cycling safety.

The operating program is stored in non-volatile memory (EPROM) to eliminate chiller failure due to AC power failure/battery discharge. In addition, programmed setpoints are retained in lithium battery backed TRC memory for a minimum of 5 years.

VARIABLE SPEED CONTROL

Capacity control is achieved by use of prerotation vanes and varying engine speed. Capacity control logic is matched to the specific chiller/compressor system. Control logic continually integrates the actual chiller operating conditions, including chilled water temperature and temperature set point, evaporator and condenser refrigerant pressures, engine speed and prerotation vane position. Prerotation vane position and engine speed are automatically controlled by the chiller control panel to maintain leaving chilled liquid temperature at the desired setpoint. Engine speed is set to optimize chiller energy efficiency. The unit is capable of operating with lower water temperature cooling tower water during part load operation. Prerotation vane position is automatically controlled by an external electric actuator.

POWER PANEL

The power panel enclosure houses the following components: single point wiring connection for incoming power supply; fused disconnect switch, main fuses, compressor oil pump motor starter with overloads; heater relay; circuit breakers for 115VAC, and 60 Hz, 3KVA control supply transformer.

NATURAL GAS ENGINE CONTROLS

The engine mounted instrument panel consists of a shock-mounted formed and welded enclosure primed for coastal environment and finished in semi-gloss enamel. Metric/English marked gauges with a minimum 2.5 inches diameter dial face are mounted in a brushed stainless steel face panel with pressure instruments piped to bulk head connections in the enclosure bottom. Read-outs include: engine oil pressure, oil filter differential, fuel pressure, and jacket water temperature. As part of the engine control/safety system the engine and related components are monitored and provided with gauges or safety shutdowns to protect against any system failures. Safety shutoffs include low oil pressure, high water temperature, low water level and overspeed.

ISOLATION MOUNTING

The unit is provided with vibration isolation mounts for both the driveline and shell assemblies. These level adjusting, spring type isolators are designed for one inch deflection. The driveline is balanced on four vibration isolator assemblies, using a three point mounting system. The isolator assemblies are installed between the driveline base and the mounting surface and have a waffle or ribbed pad on their bottom surface. The shell package is provided with four vibration isolation mounts. The vibration isolator assemblies are installed under the tube sheets and are provided with non-skid pads.

TESTING

Prototype Testing - YORK will certify that the engine, compressor, speed increaser, clutch, and controls have been tested as complete systems of representative engineering models (not on equipment sold).

Specific prototype tests include:

ENGINE:

- Performance (part load, full load)
- Oil Consumption
- Fuel Consumption
- Exhaust Emissions
- Noise Levels (mechanical and exhaust)
- Startability (cold and hot ambients)
- Piston, Ring, and Liner Wear Rates
- Piston Structural Integrity
- Lubrication System Evaluation
- Cooling System Evaluation
- Valve Train Overspeed Qualification
- Deep Thermal Cycle Endurance
- Field Endurance

GAS ENGINE COMPRESSOR DRIVELINE:

- Mechanical Compatibility
- Structural Integrity
- Mounting Evaluation
- Wiring Compatibility
- Control Panel Functionality
- Linear Vibration Measurement
- Torsional Vibration Analysis
- Part Load Performance
- Safety Shutdowns and Alarms
- Start-Stop Evaluations

Production Testing - Each Gas Engine Driveline is subjected to production performance tests and quality controls to insure reliable operation. The refrigerant compressor is air run tested at YORK's test facility prior to mounting on the driveline assembly. The driveline package will be run tested after assembly at conditions that fully load the engine. The assembled driveline is tested to insure smooth, defect free operation. Testing will only be done at the engine manufacturer's test facility. A certified report of these tests is available when requested at the time of chiller order.

START-UP AND OPERATOR TRAINING

Factory trained field service representatives will supervise the final leak testing, charging and the initial start-up. The complete installation will be checked for procedural and operational compliance by a factory trained service representative from YORK. YORK will retain factory trained service representatives of the engine manufacturer to provide start-up service and operator instruction for the gas engine.

WARRANTY AND SERVICE

The manufacturer's standard warranty is for a period of one year from the date of start-up or eighteen months from shipment, whichever occurs first. The warranty includes parts and labor during this period. Additionally, YORK will provide, at no additional cost to the owner, a complete one year service or 3000 operating hours, which ever comes first, contract. The contract includes all recommended service and preventative maintenance required by the chiller and engine manufacturers during the first year of operation or 3000 operating hours, which ever comes first. This service will be performed by YORK and Caterpillar factory trained and authorized service personnel. YORK will have a local direct service office that can provide factory trained service personnel, the required stock of replacement parts, technical assistance, and warranty administration. Engine maintenance will be performed by Caterpillar's local, factory trained, authorized representative.

Accessories and Modifications

BAS REMOTE CONTROL

A communication interface permitting complete exchange of chiller data with any BAS System is available with optional ISN translator. ISN translator also allows BAS System to issue commands to the chiller to control its operation. ISN translators come in two models, controlling up to 4 chillers and 8 chillers respectively.

JACKET WATER HEATER(S)

The engine cooling water must reach a stable operating temperature before the engine can be loaded. This option provides factory installed and tested jacket water heater(s) that will keep the engine cooling water at operating temperature. This will allow the engine to be started and loaded without having to wait for the jacket water to reach operating temperature.

OIL PRE-LUBE PUMP

This option provides a factory installed and tested continuous pre-lube oil pump. This pump will lubricate engine components prior to engine start.

WATER FLOW SWITCHES

These are paddle-type, vapor-proof water flow switches suitable for 150 psig DWP for chilled and condenser water circuits. Switch for 115v-1-60 service. A chilled water flow switch is required. Condenser water flow switch is optional.

SEQUENCE CONTROL KIT

For two, three or four units with chilled water circuits connected in series or parallel, the kit consists of return water thermostat, lead-lag selector switch for sequence starting, and time delay relay, with NEMA-1 enclosures, 115v-60 service.

REMOTE RESET CONTROLS

Option board card file allows for continuous reset of either leaving chilled water temperature or percent engine load with Building Automation System. 4 to 20 mA, 0 to 10 Vdc, or discrete stepped signals can be wired directly to panel terminal block on the card file without any external interfacing.

VICTAULIC CONNECTIONS

Stub-out water nozzle connections with victaulic grooves. Nozzles are suitable for either victaulic or welded connections and are capped for shipment. (Available on condenser connections only if pressure drop is > 17 ft. H_2O.) Please consult YORK marketing for details.

MARINE WATER BOXES

Marine water boxes allow service access for cleaning of the heat exchanger tubes without the need to break the water piping. Bolted-on covers are arranged for convenient access. Flanged nozzle connections are standard. Marine water boxes are available for condenser and/or evaporator.

KNOCK-DOWN SHIPMENT

The chiller can be shipped knocked down into major subassemblies (cooler, condenser, driveline, etc.) as required to rig into tight spaces. This is particularly convenient for existing buildings where equipment room access does not allow rigging a factory packaged chiller.

REFRIGERANT STORAGE/RECYCLING SYSTEM

A refrigerant storage/recycling system is a self-contained package consisting of a refrigerant compressor with oil separator, storage receiver, water-cooled condenser, filter drier and necessary valves and hoses to remove, replace and distill HFC-134a. All necessary controls and safety devices are a permanent part of the system.

Application Data

LOCATION

The Gas-Engine-Driven chiller operating weight should be considered when choosing the unit location. In selecting a site, consider structural support, access for service, and tube pull area. The unit site must be a floor, mounting pad or foundation which is level within 1/4" and capable of supporting the operating weight of the unit.

Sufficient clearance to permit normal service and maintenance work. A minimum of 36" should be provided all around and above the unit. Additional space equal to the shell length should be provided at one end of the unit to permit cleaning and removal of cooler and condenser tubes as required. A doorway or other properly located opening may be used.

The standard chiller should be installed in an indoor location where the temperature ranges from 50° to 110°F.

Ventilation

The ASHRAE Standard 15 Safety Code for Mechanical Refrigeration requires that all machinery rooms be vented to the outdoors utilizing mechanical ventilation by one or more power-driven fans. This standard, plus National Fire Protection Association Standard 90A, state, local, and other codes should be checked for specific requirements. These requirements should be compared to the requirements for engine ventilation to ensure the equipment room is properly ventilated. (See Form 160.60-AD1)

Driveline

An engine converts fuel into shaft horsepower and heat. This heat is removed through the jacket water system, aftercooler, exhaust gas system, and radiation from engine surfaces. As a result, engine drives require different installation considerations than electric motors.

Engine Driven Chiller equipment room considerations should include the following:

Fuel Supply - Natural gas fuel is a mixture of several gases, each having different characteristics (heat value, specific gravity, etc.). The composition of natural gas varies, but usually contains large amounts of methane, a smaller amount of ethane, and traces of other hydrocarbons. The amount of combustion air required will vary with the gas mixture provided by the local utility. The consumer must provide gas piping to the fuel inlet of the chiller driveline. (Gas pressure required per Table 1.) If other than pipeline natural gas is used as the fuel source, contact your local YORK sales office for project specific requirements.

Engine Radiation - Three to six percent of the input energy (fuel) is typically lost as heat radiated to the surrounding air. The removal of this radiated heat causes an additional ventilation requirement that is added to the combustion air. (Maximum radiation values are provided in Table 1.)

Exhaust Systems - The waste gases produced by the engine must be exhausted from the equipment room. See Form 160.60-AD1 for Exhaust Duct Details. Exhaust systems must be designed and installed to discharge

TABLE 1 - FULL LOAD ENGINE DATA

ENGINE MODEL	G3408	G3412	G3508	G3512	G3516	G3606
RPM	1800	1800	1500	1500	1500	1000
MAX BHP	451	675	717	1075	1435	1765
FULL LOAD BTU/BHP HR (HHV)	8255	8050	7880	7890	7950	7670
COMBUSTION AIR REQUIRED AT FULL LOAD (SCFM)	635	905	1575	2355	3160	4725
INLET GAS PRESSURE REQUIRED (PSIG)	1.5 - 5	1.5 - 5	1.5 - 5	1.5 - 5	1.5 - 5	43 - 47
MAXIMUM EXHAUST BACKPRESSURE (IN W.C.)	27	27	27	27	27	12
EXHAUST FLOW (LB/HR)	2815	6425	6522	8498	13842	20432
EXHAUST TEMP (°F)	965	690	795	845	870	865
RADIATION (BTU/MIN)	2165	3270	4030	4890	6090	10760
RECOVERABLE JACKET WATER HEAT (MBH) AT FULL LOAD	1130	1775	1560	2105	2940	1202
RECOVERABLE EXHAUST HEAT (MBH) AT FULL LOAD	480	600	790	1345	1870	2791
TOWER WATER FLOW (GPM)	165	215	395	430	400	415
MAX TEMP IN (°F)	85	85	85	85	85	85
TEMP OUT (°F)	105	105	105	105	105	100
NOx EMISSIONS (GRAM/BHP HR)	12	2	2	2	2	1

TABLE 2 – WATER FLOW RATE LIMITS (GPM)

SHELL CODE	PASS	COOLER		CONDENSER	
		MINIMUM	MAXIMUM	MINIMUM	MAXIMUM
LB	1	632	2,276	881	3,175
	2	316	1,138	441	1,588
	3	211	759	----	----
LC	1	739	2,664	1,031	3,714
	2	370	1,332	515	1,857
	3	246	888	----	----
MB	1	866	3,121	1,255	4,522
	2	433	1,561	627	2,261
	3	289	1,040	----	----
MC	1	1,006	3,626	1,473	5,307
	2	503	1,813	736	2,654
	3	335	1,209	----	----
NB	1	1,185	4,271	1,647	5,935
	2	593	2,136	824	2,968
	3	395	1,424	----	----
NC	1	1,387	4,999	1,940	6,990
	2	694	2,499	970	3,495
	3	462	1,666	----	----
PB	1	1,625	5,855	2,329	8,393
	2	812	2,928	1,165	4,196
	3	542	1,952	----	----
PC	1	1,898	6,841	2,743	9,885
	2	949	3,421	1,342	4,942
	3	633	2,280	----	----
QB, QD	1	2,224	8,014	3,077	11,085
	2	1,112	4,007	1,538	5,543
	3	741	2,671	----	----
QC, QE	1	2,598	9,364	3,612	13,015
	2	1,299	4,682	1,806	6,508
	3	866	3,121	----	----
RB, RD	1	3,038	10,948	4,310	15,528
	2	1,519	5,474	2,155	7,764
	3	1,012	3,649	----	----
RC, RE	1	3,556	12,814	5,066	18,255
	2	1,778	6,407	2,533	9,128
	3	1,185	4,271	----	----
SB, SD	1	4,158	14,984	6,088	21,935
	2	2,079	7,492	3,044	10,968
	3	1,386	4,995	----	----
SC, SE	1	4,864	17,531	7,140	25,727
	2	2,432	8,766	3,570	12,864
	3	1,621	5,844	----	----

exhaust gases as quickly and silently as possible with a minimum amount of backpressure. Excessive backpressure can cause horsepower losses and exhaust temperature increases. (Exhaust flows, temperatures and maximum back pressures are provided in Table 1.)

Heat Recovery - Heat is produced as a byproduct of combustion. 20% to 50% of the input energy to the engine must be removed by the cooling system. Engine heat is rejected into the oil cooler and engine jacket water. The YORK driveline is provided with a unit mounted heat exchanger that has been sized and pre-plumbed and tested at the factory to reject the heat from these sources to the cooling tower. This allows for a single customer cooling tower water connection to the driveline. (Tower water flows and temperatures are provided in Table 1.)

Heat can be recovered from the engine jacket water and the exhaust gas (minimum leaving exhaust temperature of 350°). Heat recovery can significantly increase the thermal efficiency of the system. The recovered heat can be used for any heating load required by the building or to power a single stage absorption chiller. (Recoverable heat is provided in Table 1.)

Cranckcase Fumes - Normal combustion pressures of the internal combustion engine cause a certain amount of blowby past the piston rings into the crankcase. To prevent pressure buildup in the crankcase, vent tubes are provided on the engine to allow the gas to escape. Crankcase gases must be discharged to the atmosphere and not into the equipment room. A separate ventilation system for the crankcase must be installed to connections provided on the engine.

Clutch Air Supply - A regulated clean air supply sufficient to provide 7SCFM @ 125 psig is required for pressurization of the air clutch. Instrument quality air is not required.

ENGINE STARTERS

The GED chiller is provided with factory mounted electric engine starting systems. Electric starting is the most convient, and adaptable for remote control and automation. The electric starting system includes a starting motor, batteries, battery pack and charger.

Air starters are available. The air starting system includes a starting motor(s), silencer, start valve, and pressure regulator. The system has an operating pressure of 100 psig.

Each of these items is discussed in detail in Form 160.60-AD1.

WATER CIRCUITS

Temperature Ranges - For normal water chilling duty, leaving chilled water temperatures may be selected between 40°F and 50°F for water temperature ranges between 3°F and 20°F.

Water Quality - The practical and economical application of liquid chillers requires that the quality of the water supply for the condenser and cooler be analyzed by a water treatment specialist. Water quality may affect the performance of any chiller through corrosion, deposition of heat-resistant scale, sedimentation or organic growth.

These will hurt chiller performance and increase operating and maintenance costs. Normally, performance may be maintained by corrective water treatments and periodic cleaning of tubes. If water conditions exist which cannot be corrected by proper water treatment, it may be necessary to provide a larger allowance for fouling, and/or to specify special materials of construction.

General Piping - All chilled water and condenser water piping should be designed and installed in accordance with accepted piping practice. Chilled water and condenser water pumps should be located to discharge through the chiller to assure positive pressure and flow through the unit. Piping should include offsets to provide flexibility and should be arranged to prevent drainage of water from the cooler and condenser when the pumps are shut down. Piping should be adequately supported and braced independent of the chiller to avoid the imposition of strain on chiller components. Hangers must allow for alignment of the pipe. Isolators in the piping and in the hangers are highly desirable in achieving sound and vibration control.

See Figure 1 for the Standard Flow Schematic.

Convenience Considerations - With a view to facilitating the performance of routine maintenance work, some or all of the following steps may be taken by the purchaser. Cooler and condenser water boxes are equipped with plugged vent and drain connections. If desired, vent and drain valves may be installed with or without piping to an open drain. Pressure gauges with stop cocks, and stop valves, may be installed in the inlets and outlets of the condenser and chilled water line as close as possible to the chiller. An overhead monorail or beam may be used to facilitate servicing.

Connections - The standard chiller is designed for 150 psig working pressure in both the chilled water and condenser water circuits. The connections (water nozzles) to these circuits are furnished with 150 # ANSI raised face flanges. Piping should be arranged for ease of disassembly at the unit for performance of such routine maintenance as tube cleaning. All water piping should be thoroughly cleaned of all dirt and debris before final connections are made to the chiller. Driveline connections include single point electrical power connection, gas supply connection, cooling water connection, exhaust, crankcase ventilation, clutch air supply, and air start supply (if applicable).

Chilled Water - The chilled water circuit should be designed for constant flow. A flow switch must be installed in the chilled water line of every circuit. The switch must be located in the horizontal piping close to the unit, where the straight horizontal runs on each side of the flow switch are at least five pipe diameters in length. The switch must be electrically connected to the chilled water interlock position in the unit control center. A water strainer of maximum 1/8" mesh must be field-installed in the chilled water inlet line as close as possible to the chiller. If located close enough to the chiller,

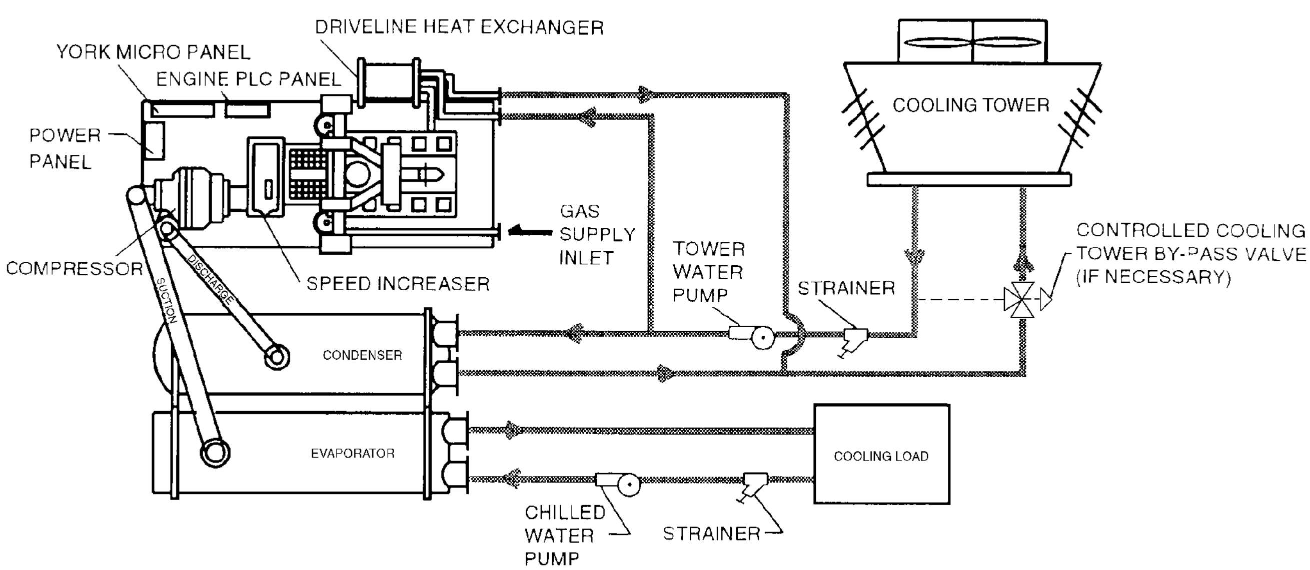


FIG. 1 - STANDARD FLOW SCHEMATIC - NO HEAT RECOVERY

the chilled water pump may be protected by the same strainer. The flow switch and strainer assure chilled water flow during unit operation. The loss or severe reduction of water flow could seriously impair the chiller performance or even result in tube freezeup.

Condenser Water - The chiller is engineered for maximum efficiency at both design and part load operation by taking advantage of the colder cooling tower water temperatures which naturally occur during the winter months. Appreciable power savings are realized from these reduced heads. Exacting control of condenser water temperature, requiring an expensive cooling tower bypass, is not necessary for most applications.

For the usual full load design of 10°F condenser water temperature range, the chiller only requires that the minimum entering condenser water temperature be at least 7°F higher than the leaving chilled water temperature.

The minimum entering condenser water temperature for other full and part load conditions is provided by the following equation:

Min. ECWT = LCHWT – C RANGE + 17

Where:
ECWT = entering condensing water temperature
LCHWT = leaving chilled water temperature
C RANGE = condensing water temperature range

At initial startup, entering condensing water temperature may be as much as 25°F colder than the standby chilled water temperature. Cooling tower fan cycling will normally provide adequate control of entering condenser water temperature on most installations.

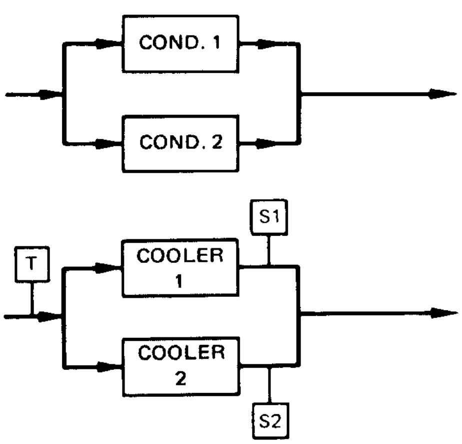
Additional tower water is required for driveline cooling. There is a connection on the driveline to provide cooling water to the driveline mounted heat exchanger. Maximum water temperature allowable to the heat exchanger is 85°F. Water flows and temperatures for each driveline are provided in Table 1.

MULTIPLE UNITS

Many applications require multiple units to meet the total capacity requirements as well as to provide flexibility and some degree of protection against equipment shutdown. There are several common unit arrangements for this type of application. The Millennium chiller has been designed to be readily adapted to the requirements of these various arrangements.

Parallel Arrangement (Refer to Fig. 2) - Chillers may be applied in multiples with chilled and condenser water circuits connected in parallel between the units. Assuming two units of equal size, each will reduce in capacity as the load decreases to about 40% of the total capacity, at which point one of the units will be shut down by a sequence control.

Assuming chilled water flow to the inoperative unit is stopped by pump shutdown and/or a closed valve, the remaining unit will pick up the total remaining load and continue to reduce in capacity as the load decreases. The unit will cycle off on the low chilled water temperature control when the load reduces below minimum unit



S – Temperature Sensor For Chiller Capacity Control

T – Thermostat For Chiller Capacity Control

FIG. 2 – PARALLEL COOLERS
PARALLEL CONDENSERS

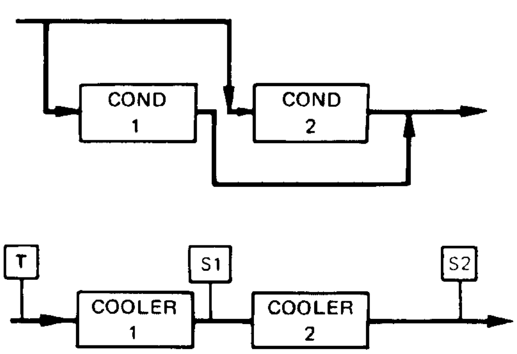


FIG. 3 – SERIES COOLERS
PARALLEL CONDENSERS

capacity. The controls can maintain constant (± 1/2°F) leaving chilled water temperature at all loads.

If chilled water continues to flow through the non-operating unit, the chilled water flowing through the operating unit will mix with the water leaving the non-operating unit to produce a common water supply to the load. Since control of the operating unit is from its own leaving chiller water temperature, the common temperature to the load will rise above the full load design temperature. This higher chilled water temperature occurs below 40% load when the dehumidification load in normal air conditioning applications is usually quite low. In such instances, this temperature rise will save additional energy.

The running time may be apportioned between both units by alternating the shutoff sequence.

Series Arrangement (Refer to Fig. 3) - Chillers may be applied in multiples with chilled water circuits connected in series and condenser water circuits connected in parallel. All of the chilled water flows through both coolers with each unit handling approximately one-half of the total load. When the load decreases to about 40% of the total capacity, one of the units will be shut down by sequence control. Since all water is flowing through the operating unit, that unit will cool the water to the desired temperature.

REFRIGERANT RELIEF PIPING

Each chiller is equipped with a dual pressure-relief valve. The purpose of the relief valve is to quickly relieve excess pressure of the refrigerant charge to the atmosphere, as a safety precaution in the event of an emergency such as fire. They are set to relieve at an internal pressure of 180 psig, are located on the cooler and are provided in accordance with the ASHRAE 15 Safety Code and ASME Code for Unfired Pressure vessels.

Sized to the requirements of applicable codes, a vent line must run from the relief device to the outside of the building. This refrigerant relief piping must include a cleanable, vertical-leg dirt trap to catch vent-stack condensation. Vent piping must be arranged to avoid imposing a strain on the relief connection and should include one flexible connection.

VIBRATION AND SOUND CONSIDERATIONS

A Gas-Engine-Driven Millennium chiller is not a source of objectionable vibration in normal air conditioning applications. The unit is furnished with vibration isolation. The driveline base is constructed with a three point vibration isolation mounting system. The shell package is shipped with standard, level-adjusting spring isolator assemblies designed for 1" static deflection.

Control of sound and vibration transmission must be taken into account in the equipment room construction as well as in the selection and installation of the equipment. Sound attenuation may be required for equipment room, exhaust gas systems, or mechanical noise. The design of the equipment room should address these sources of noise. (Additional information is provided in Form 160.60-AD1)

Millennium chiller sound pressure level ratings will be furnished on request.

THERMAL INSULATION

No appreciable operating economy can be achieved by thermally insulating the chiller. However, the chiller’s cold surfaces surfaces should be insulated with a vapor barrier insulation sufficient to prevent condensation. Insulation requirements are provided in Table 3.

TABLE 3 - INSULATION REQUIREMENTS

COOLER CODE	COOLER WITH COMPACT WATER BOXES (sq. ft.)	COOLER WITH MARINE WATER BOXES (sq. ft.)
L	265	275
M	280	290
N	310	325
P	345	365
Q	390	410
R	440	470
S	480	560

Muffler and exhaust pipe insulation is recommended to minimize radiation from these sources to the chiller room. This will minimize ventilation requirements.

ELECTRICAL DATA

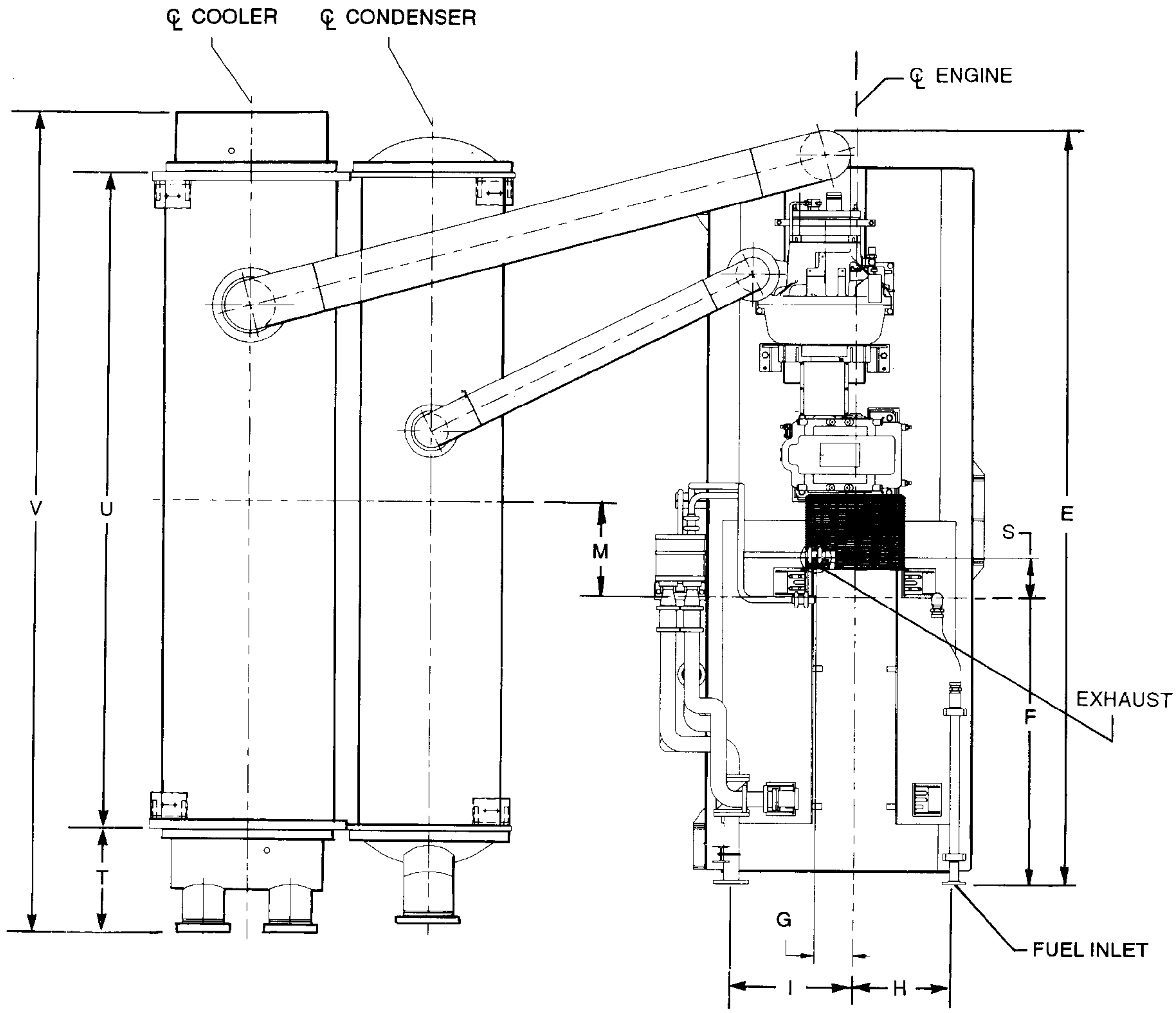
Table 4 contains unit electrical data.

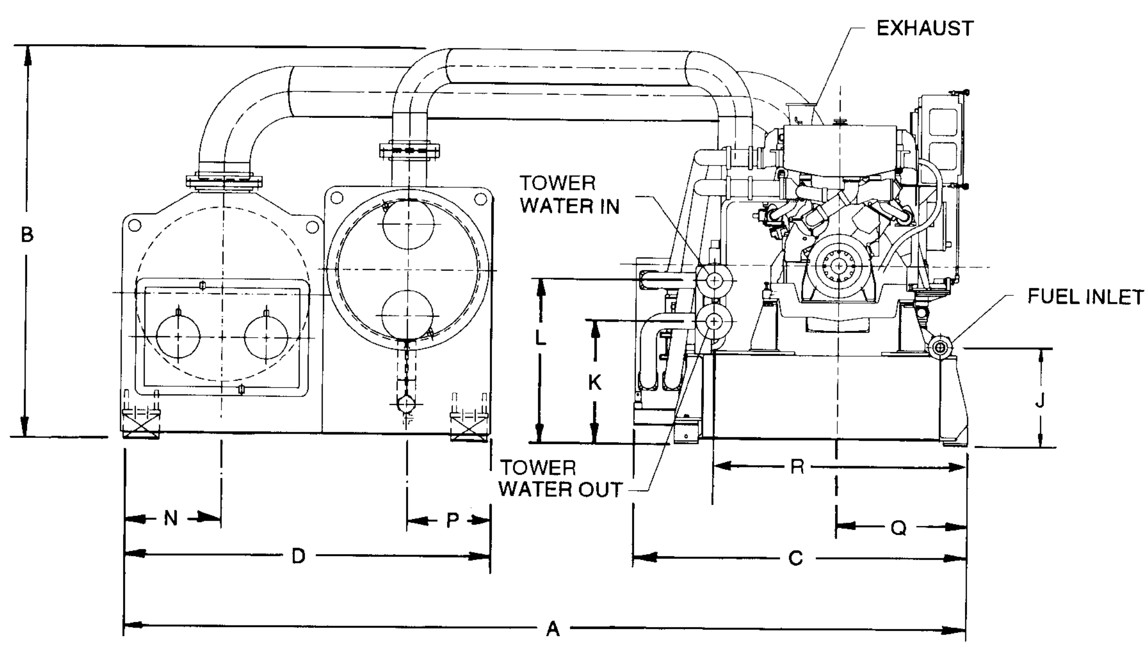
TABLE 4 - ELECTRICAL DATA

		WITH OPTIONAL JACKET WATER HEATER			
ENGINE SERIES	**AC POWER PANEL LUG SIZE RANGE**	**JACKET WATER HEATER KW**	**MIN. CIRCUIT AMPACITY**	**MIN. FUSE SIZE**	**MAX. FUSE SIZE**
3400	#14 - #4	3	17.1	25	30
3500	#14 - #4	6	21.8	30	35
3600	#14 - #4	18	40.6	50	70
		WITHOUT OPTIONAL JACKET WATER HEATER			
ALL	#14 - #4	N/A	12.4	15	20

NOTE: All values are for 460 V - 3 Phase - 60 Hz electrical service.

Dimensions *- 3400 Series Engines*

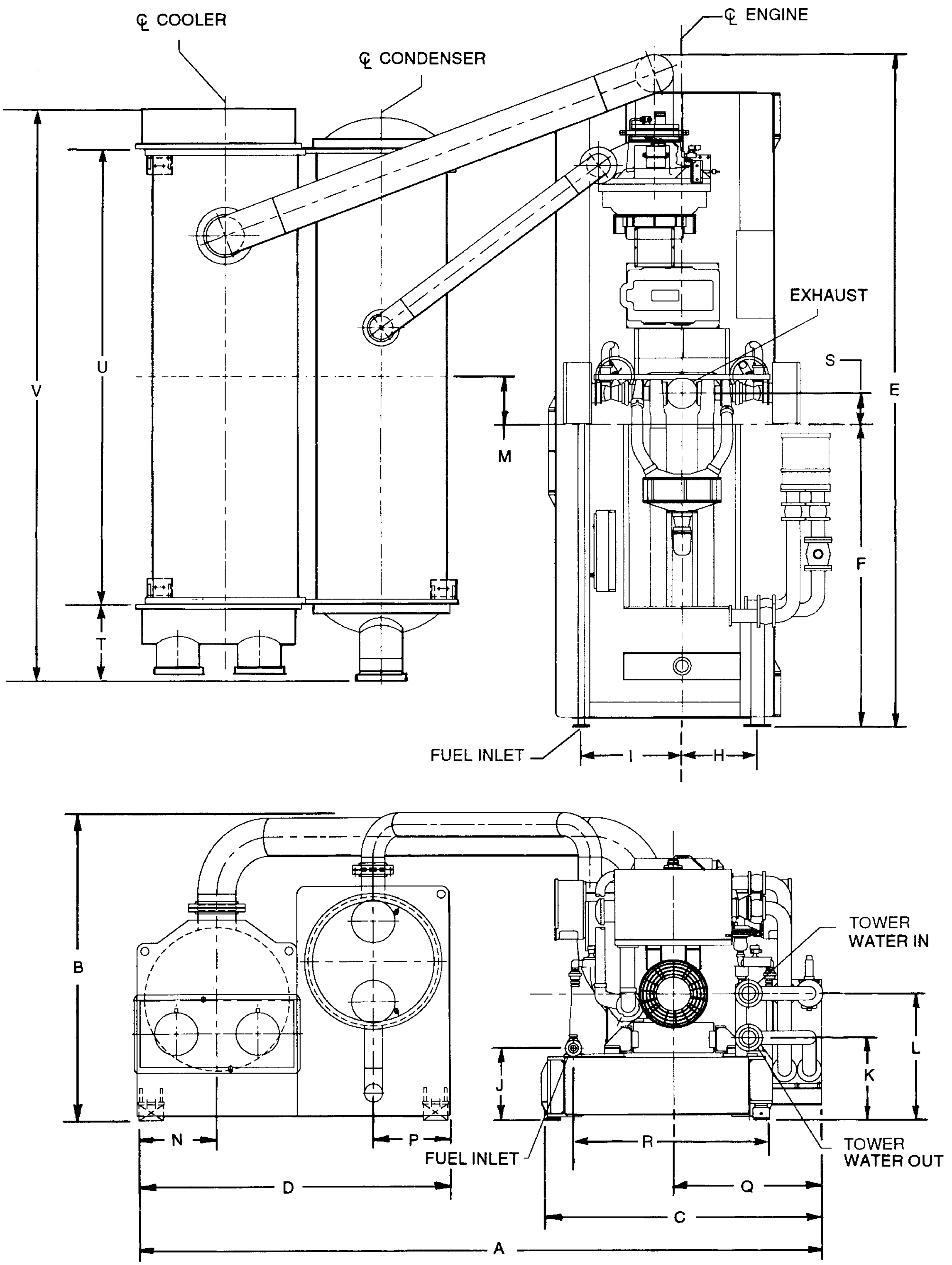




Dimensions - 3400 Series Engines

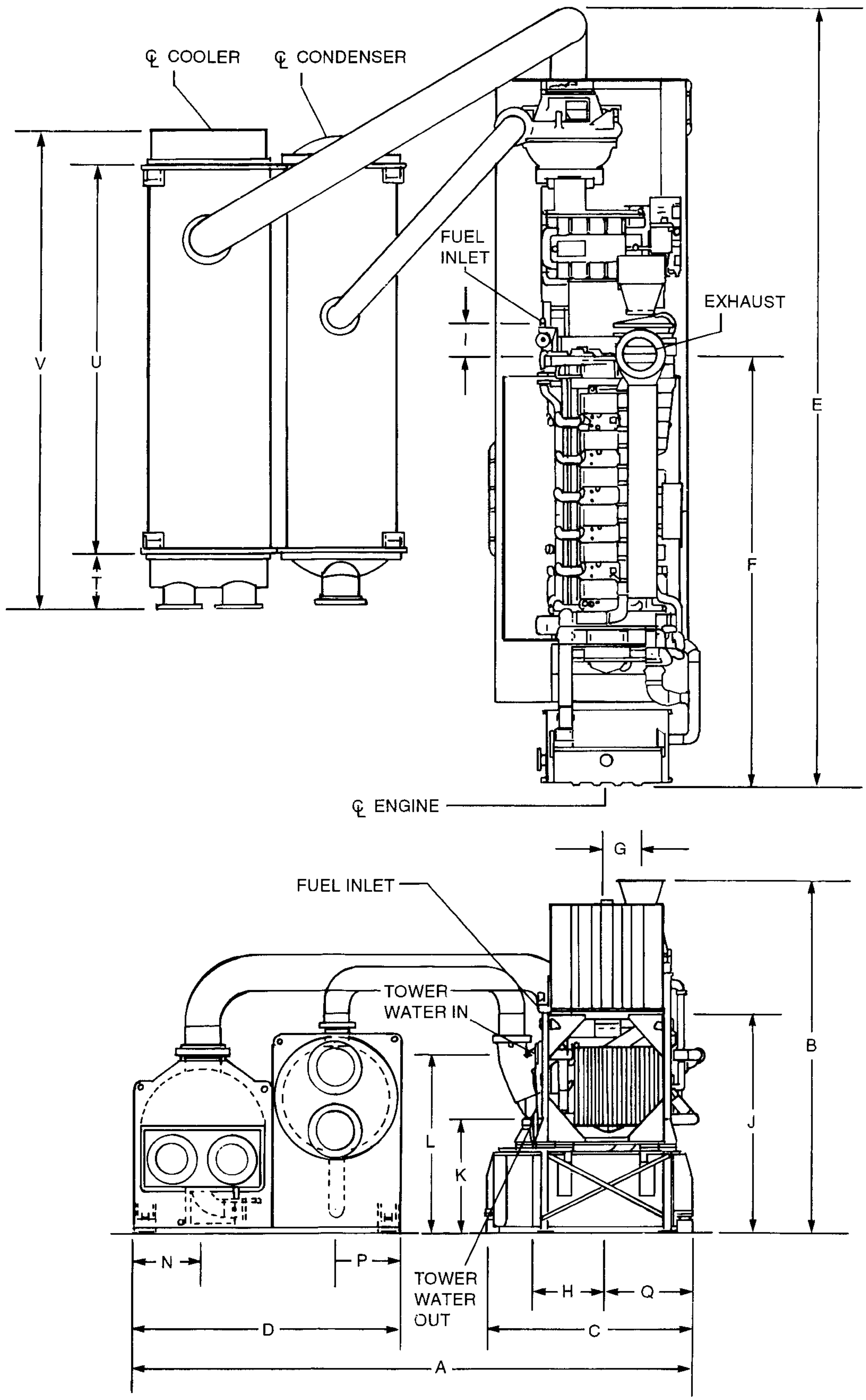
DIM.	G 3408 ENGINE - G4, H0 & H1 COMPRESSORS					G 3412 ENGINE - H1 & H2 COMPRESSORS		
	COOLER - CONDENSER CODE					COOLER - CONDENSER CODE		
	L-L	M-M	N-N	P-P	Q-Q	N-N	P-P	Q-Q
A	15’ 6-3/8"	15’ 7-3/8"	16’ 3-3/8"	16’ 9-7/8"	17’ 5-3/8"	16’ 3-3/8"	16’ 9-7/8"	17’ 5-3/8"
B	7’ 9-7/8"	7’ 9-7/8"	7’ 9-7/8"	7’ 9-7/8"	8’	7’ 9-7/8"	7’ 9-7/8"	8’ 1"
C	6’ 11-1/2"	6’ 11-1/2"	6’ 11-1/2"	6’ 11-1/2"	6’ 11-1/2"	6’ 11-1/2"	6’ 11-1/2"	6’ 11-1/2"
D	6’ 5"	6’ 6"	7’ 2"	7’ 8-1/2	8’ 4"	7’ 2"	7’ 8-1/2"	8’ 4"
E	15’ 3-1/8"	15’ 3-1/8"	15’ 3-1/8"	15’ 3-1/8"	15’ 3-1/8"	16’ 5-1/2"	16’ 5-1/2"	16’ 5-1/2"
F	5’	5’	5’	5’	5’	6’ 1-1/4"	6’ 1-1/4"	6’ 1-1/4"
G	9-7/8"	9-7/8"	9-7/8"	9-7/8"	9-7/8"	9-7/8"	9-7/8"	9-7/8"
H	2’ 1-1/2"	2’ 1-1/2"	2’ 1-1/2"	2’ 1-1/2"	2’ 1-1/2"	2’ 1-1/2"	2’ 1-1/2"	2’ 1-1/2"
I	2’ 7-1/8"	2’ 7-1/8"	2’ 7-1/8"	2’ 7-1/8"	2’ 7-1/8"	2’ 7-1/8"	2’ 7-1/8"	2’ 7-1/8"
J	2’ 5/8"	2’ 5/8"	2’ 5/8"	2’ 5/8"	2’ 5/8"	2’ 5/8"	2’ 5/8"	2’ 5/8"
K	2’ 6-5/8"	2’ 6-5/8"	2’ 6-5/8"	2’ 6-5/8"	2’ 6-5/8"	2’ 6-5/8"	2’ 6-5/8"	2’ 6-5/8"
L	3’ 4-7/8"	3’ 4-7/8"	3’ 4-7/8"	3’ 4-7/8"	3’ 4-7/8"	3’ 4-7/8"	3’ 4-7/8"	3’ 4-7/8"
M	2’ 11-1/4"	2’ 11-1/4"	2’ 11-1/4"	2’ 4"	2’ 4"	2’ 4"	2’ 4"	2’ 4"
N	1’ 8-1/2"	1’ 9-1/2"	2’	2’ 1-1/4"	2’ 3"	2’	2’ 1-1/4"	2’ 3"
P	1’ 6"	1’ 5-1/2"	1’ 7"	1’ 9"	1’ 11"	1’ 7"	1’ 9"	1’ 11"
Q	2’ 8-5/8"	2’ 8-5/8"	2’ 8-5/8"	2’ 8-5/8"	2’ 8-5/8"	2’ 8-5/8"	2’ 8-5/8"	2’ 8-5/8"
R	6’ 1-3/8"	6’ 1-3/8"	6’ 1-3/8"	6’ 1-3/8"	6’ 1-3/8"	6’ 1-3/8"	6’ 1-3/8"	6’ 1-3/8"
S	9-3/8"	9-3/8"	9-3/8"	9-3/8"	9-3/8"	10-1/8"	10-1/8"	10-1/8"
T	1’ 7-1/2"	1’ 7-1/2"	2’ 1/2"	2’ 1/2"	2’ 1/2"	2’ 1/2"	2’ 1/2"	2’ 1/2"
U	14’	14’	14’	14’	14’	14’	14’	14’
V	16’ 6-7/8"	16’ 6-3/8"	17’ 3-3/8"	17’ 3-3/8"	17’ 3-3/8"	17’ 3-3/8"	17’ 3-3/8"	17’ 3-3/8"

Dimensions - 3500 Series Engines



Dimensions - 3500 Series Engines

DIM.	G 3508 ENGINE H2 COMPRESSOR			G 3508 ENGINE J1 COMPRESSOR		G 3512 ENGINE J1 & J2 COMPRESSORS			G 3516 ENGINE J2, J3 & J4 COMPRESSORS	
	COOLER - CONDENSER CODE									
	P-P	Q-Q	R-R	Q-Q	R-R	Q-Q	R-R	S-S	R-R	S-S
A	19’ 2-3/8"	19’ 9-7/8"	21’ 4-3/8"	19’ 8-3/8"	21’ 7/8"	19’ 8-3/8"	21’ 7/8"	21’ 10-7/8"	20’ 1-7/8"	21’ 10-7/8"
B	7’ 1"	8’ 2-1/8"	8’ 8-7/8"	8’ 11-1/2"	9’ 4"	8’ 11-1/2"	9’ 4"	9’ 8-1/2"	9’ 8-1/2"	10’ 1-1/2"
C	8’ 7"	8’ 7"	8’ 7"	8’ 7"	8’ 7"	8’ 7"	8’ 7"	8’ 7"	8’ 7"	8’ 7"
D	7’ 8-1/2"	8’ 4"	9’ 10-1/2"	8’ 2-1/2"	9’ 7"	8’ 2-1/2"	9’ 7"	10’ 5"	9’ 7"	10’ 5"
E	18’ 7/8"	18’ 7/8"	18’ 7/8"	18’ 5-1/4"	18’ 5-1/4"	20’ 8-5/8"	20’ 8-5/8"	20’ 8-5/8"	23’ 2-5/8"	23’ 2-5/8"
F	7’ 1-1/8"	7’ 1-1/8"	7’ 1-1/8"	7’ 1-1/8"	7’ 1-1/8"	9’ 3-7/8"	9’ 3-7/8"	9’ 3-7/8"	10’ 7-3/8"	10’ 7-3/8"
H	2’ 3-5/8"	2’ 3-5/8"	2’ 3-5/8"	2’ 3-5/8"	2’ 3-5/8"	2’ 3-5/8"	2’ 3-5/8"	2’ 3-5/8"	2’ 3-5/8"	2’ 3-5/8"
I	3’ 3/4"	3’ 3/4"	3’ 3/4"	3’ 3/4"	3’ 3/4"	3’ 3/4"	3’ 3/4"	3’ 3/4"	3’ 3/4"	3’ 3/4"
J	2’ 2-1/2"	2’ 2-1/2"	2’ 2-1/2"	2’ 2-1/2"	2’ 2-1/2"	2’ 2-1/2"	2’ 2-1/2"	2’ 2-1/2"	2’ 2-1/2"	2’ 2-1/2"
K	2’ 6-1/4"	2’ 6-1/4"	2’ 6-1/4"	2’ 6-1/4"	2’ 6-1/4"	2’ 6-1/4"	2’ 6-1/4"	2’ 6-1/4"	2’ 6-1/4"	2’ 6-1/4"
L	3’ 10-3/4"	3’ 10-3/4"	3’ 10-3/4"	3’ 10-3/4"	3’ 10-3/4"	3’ 10-3/4"	3’ 10-3/4"	3’ 10-3/4"	3’ 10-3/4"	3’ 10-3/4"
M	1’ 6"	1’ 6"	1’ 6"	1’ 6"	1’ 6"	1’ 6"	1’ 6"	1’ 6"	1’ 3"	1’ 3"
N	2’ 1-1/4"	2’ 3"	2’ 7-1/4"	2’ 2-1/4"	2’ 5-1/2"	2’ 2-1/4"	2’ 5-1/2"	2’ 8"	2’ 5-1/2"	2’ 8"
P	1’ 9"	1’ 11"	2’ 4"	1’ 11"	2’ 4"	1’ 11"	2’ 4"	2’ 6-1/2"	2’ 4"	2’ 6-1/2"
Q	4’ 6-3/8"	4’ 6-3/8"	4’ 6-3/8"	4’ 6-3/8"	4’ 6-3/8"	4’ 6-3/8"	4’ 6-3/8"	4’ 6-3/8"	4’ 6-3/8"	4’ 6-3/8"
R	6’ 10-1/2"	6’ 10-1/2"	6’ 10-1/2"	6’ 10-1/2"	6’ 10-1/2"	6’ 10-1/2"	6’ 10-1/2"	6’ 10-1/2"	6’ 10-1/2"	6’ 10-1/2"
S	11-5/8"	11-5/8"	11-5/8"	11-5/8"	11-5/8"	11-5/8"	11-5/8"	11-5/8"	11-5/8"	11-5/8"
T	2’ 1/2"	2’ 1/2"	2’ 1/2"	2’ 1/2"	2’ 1/2"	2’ 1/2"	2’ 1/2"	2’ 1/2"	2’ 1/2"	2’ 1/2"
U	14’	14’	14’	14’	14’	14’	14’	14’	14’	14’
V	17’ 3-3/8"	17’ 3-3/8"	17’ 3-3/8"	17’ 3-3/8"	17’ 3-3/8"	17’ 3-3/8"	17’ 3-3/8"	17’ 3-3/8"	17’ 3-3/8"	17’ 3-3/8"

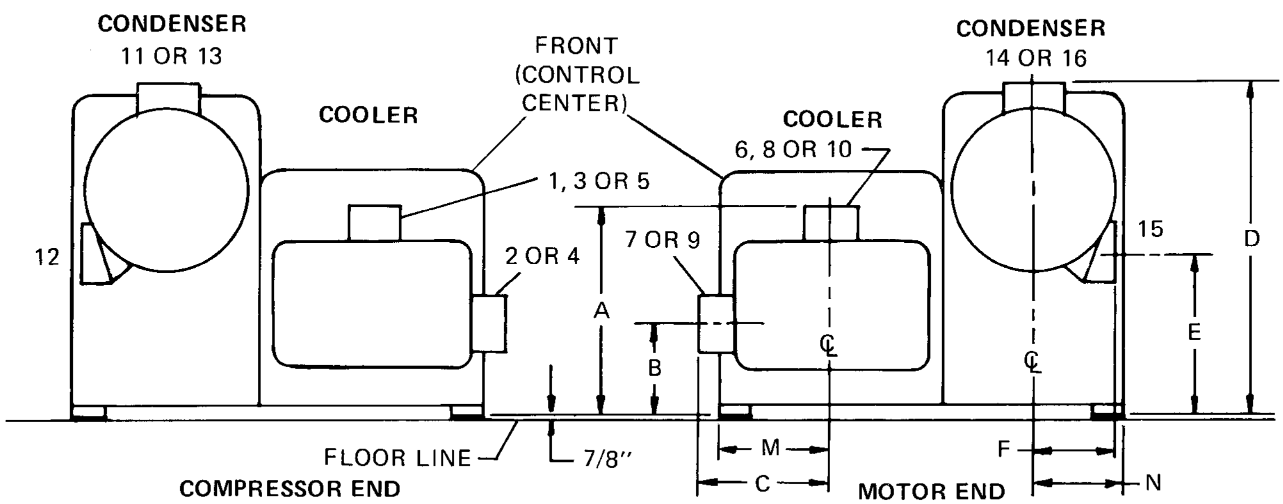


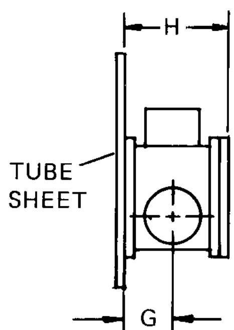
℄ COOLER
℄ CONDENSER
FUEL
INLET
EXHAUST
I
V
U
T
E
F
℄ ENGINE
G
FUEL INLET
TOWER
WATER IN
B
J
L
K
N
P
TOWER
WATER
OUT
H
Q
D
C
A

Dimensions - 3600 Series Engines

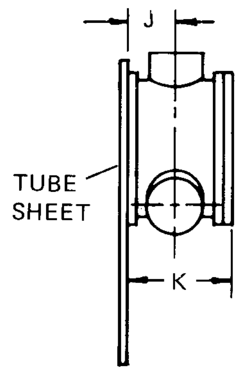
DIM.	G 3603 ENGINE - J3 & J4 COMPRESSORS	
	COOLER - CONDENSER CODE	
	R-R	S-S
A	20’ 7/8"	20’ 10-7/8"
B	10’ 2-1/8"	10’ 2-1/8"
C	7’ 5-7/8"	7’ 5-7/8"
D	9’ 7"	10’ 5"
E	28’ 3-1/2"	28’ 3-1/2"
F	14’ 8-1/4"	14’ 8-1/4"
G	1’ 3-1/8"	1’ 3-1/8"
H	2’ 6-3/8"	2’ 6-3/8"
I	1’ 2-7/8"	1’ 2-7/8"
J	8’ 1/8"	8’ 1/8"
K	4’ 1-3/4"	4’ 1-3/4"
L	6’ 6"	6’ 6"
N	2’ 5-1/2"	2’ 8"
P	2’ 4"	2’ 6-1/2"
Q	3’ 1-5/8"	3’ 1-5/8"
T	2’ 1/2"	2’ 1/2"
U	14’	14’
V	17’ 3-3/8"	17’ 3-3/8"

Dimensions - *Nozzle Arrangements (Marine Water Boxes)*

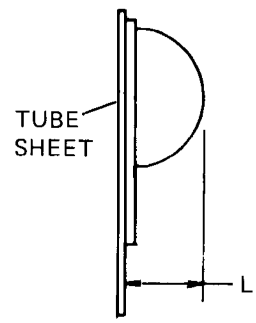




COOLER NOZZLES



CONDENSER NOZZLES



REAR HEAD 2-PASS CONDENSER

WATER BOX DIMENSIONS

COMP. CODE	SHELL CODE		COOLER A	COOLER B 2 PASS	COOLER B 3 PASS	COOLER C	COOLER M	CONDENSER D 1 PASS	CONDENSER D 2 PASS	CONDENSER E	CONDENSER F	CONDENSER N
G & H	L		3' 3-1/2"	1' 5-1/2"	1' 4-1/2"	2' 2"	1' 8-1/2"	4' 6-3/4"	4' 7-1/4"	1' 11-3/4"	1' 5-1/4"	1' 6"
	M		3' 4-1/2"	1' 6-1/2"	1' 5-1/2"	2' 2"	1' 9-1/2"	4' 9-3/4"	4' 9-3/4"	1' 11-1/4"	1' 4-3/4"	1' 5-1/2"
	N		3' 9-5/8"	1' 6-3/4"	1' 4-5/8"	2' 5"	2' 0"	5' 1-3/4"	5' 1-1/4"	1' 7-3/4"	1' 6-1/4"	1' 7"
	P		3' 10-3/8"	1' 7-1/2"	1' 5-3/8"	2' 5"	2' 1-1/4"	5' 8-1/4"	5' 6-3/4"	1' 11-3/4"	1' 8-1/4"	1' 9"
	Q		4' 0-1/4"	1' 9-3/4"	1' 8-1/4"	2' 7-1/4"	2' 3"	5' 11-3/4"	5' 11-3/4"	2' 0-3/4"	1' 10-1/4"	1' 11"
	R		4' 1"	1' 11"	1' 10"	2' 10-1/4"	2' 7-1/4"	6' 10-3/4"	6' 10-3/4"	2' 2-1/4"	2' 3-1/4"	2' 4"
J	Q	D	4' 3-1/2"	2' 1"	1' 11-1/2"	2' 7-1/4"	2' 2-1/4"	6' 6-3/4"	6' 6-3/4"	2' 7-3/4"	1' 10-1/4"	1' 11"
		E	4' 4-1/4"	2' 1-3/4"	2' 0-1/4"							
	R	D	4' 5-1/4"	2' 3-1/4"	2' 2-1/4"	2' 10-1/4"	2' 5-1/2"	7' 5-3/4"	7' 5-3/4"	2' 9-1/4"	2' 3-1/4"	2' 4"
		E	4' 6"	2' 4"	2' 3"							
	S		6' 10"	1' 10-1/2"	1' 8-1/2"	2' 7-1/4"	2' 8"	7' 11-1/4"	7' 11-1/4"	2' 8-3/4"	2' 5-3/4"	2' 6-1/2"

Dimensions - *Nozzle Arrangements (Marine Water Boxes)*

COOLER NOZZLE DIMENSIONS

SHELL CODE	NO. OF PASSES	G	H
L	1	10-1/8"	1' 10"
	2	9-1/8"	1' 8"
	3	8-1/8"	1' 6"
M	1	10-1/8"	1' 10"
	2	9-1/8"	1' 8"
	3	8-1/8"	1' 6"
N	1	11-1/8"	2' 0-1/2"
	2	10-1/8"	1' 10-1/2"
	3	9-1/8"	1' 8-1/2"
P	1	1' 0-1/8"	2' 2-1/2"
	2	10-1/8"	1' 10-1/2"
	3	9-1/8"	1' 8-1/2"
Q	1	1' 1-1/8"	2' 4-3/4"
	2	11-1/8"	2' 0-3/4"
	3	10-1/8"	1' 10-3/4"
R	1	1' 2"	2' 6-3/4"
	2	1' 0-1/8"	2' 2-3/4"
	3	11-1/8"	2' 0-3/4"
S	1	1' 4-1/4"	2' 11-1/8"
	2	1' 2-3/4"	2' 8-1/8"
	3	1' 1-3/4"	2' 6-1/8"

CONDENSER NOZZLE DIMENSIONS

SHELL CODE	NO. OF PASSES	J	K	L
L	1	9-7/8"	1' 9"	-
	2	8-7/8"	1' 7"	6-7/8"
M	1	11"	1' 11-1/2"	-
	2	10"	1' 9-1/2"	7-5/8"
N	1	1' 1-3/8"	2' 4-3/8"	-
	2	10-3/8"	1' 10-3/8"	8-3/8"
P	1	1' 1-5/8"	2' 5"	-
	2	11-5/8"	2' 1"	9-3/8"
Q	1	1' 2-5/8"	2' 7-1/4"	-
	2	1' 0-5/8"	2' 3-1/4"	10-3/8"
R	1	1' 3-1/8"	2' 8-3/4"	-
	2	1' 2-1/8"	2' 6-3/4"	11-3/4"
S	1	1' 4-1/2"	2' 11-5/8"	-
	2	1' 4-1/2"	2' 11-5/8"	1' 1-5/8"

NOZZLE ARRANGEMENTS

NO. OF PASSES	COOLER		CONDENSER	
	IN	OUT	IN	OUT
1	1	6	11	14
	6	1	14	11
2	2	3	12	13
	7	8	15	16
3	4	10	-	-
	9	5	-	-

NOZZLE SIZES

COOLER CODE	COOLER			CONDENSER	
	NO. OF PASSES			NO. OF PASSES	
	1	2	3	1	2
L	10"	8"	6"	10"	8"
M	10"	8"	6"	12"	10"
N	12"	10"	8"	16"	10"
P	14"	10"	8"	16"	12"
Q	16"	12"	10"	18"	14"
R	18"	14"	12"	18"	16"
S	18"	16"	14"	18"	18"

NOTE:

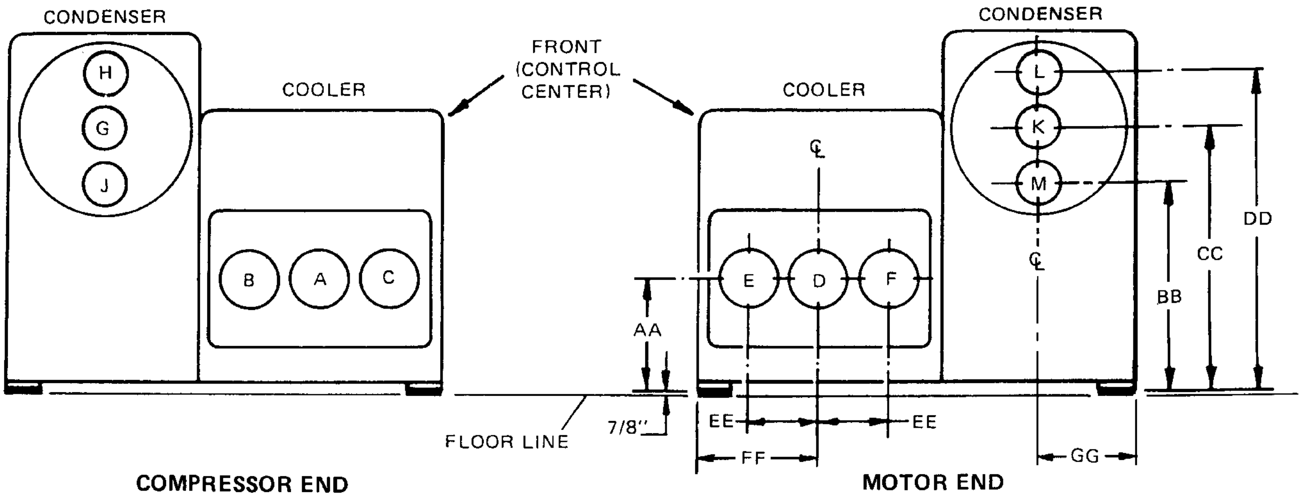
1. All dimensions are approximate. Certified dimensions are available upon request.

2. Standard water nozzles are furnished with 150 lb. ANSI raised face flanges. Companion flanges, nuts, bolts and gaskets are not furnished. Victaulic groove connections, suitable for victaulic or welded connections, are available (Consult YORK Marketing for exact availability of victaulic connections for condenser water circuit.)

3. One, two and three pass nozzle arrangements are available only in pairs shown and for all shell codes. Any pair of cooler nozzles used in combination with any pair of condenser nozzles. Compact water boxes on one heat exchanger may be used with marine water boxes on the other heat exchanger.

4. Condenser water must enter the water box through the bottom connection for proper operation of the sub-cooler to achieve rated performance.

Dimensions - *Nozzle Arrangements (Compact Water Boxes)*



WATER BOX DIMENSIONS

COMP. CODE	SHELL CODE		COOLER AA	COOLER EE	COOLER FF	CONDENSER BB	CONDENSER CC	CONDENSER DD	CONDENSER GG
G & H	L		1' 9"	8-1/2"	1' 8-1/2"	2' 2-1/4"	2' 10-3/4"	3' 7-1/4"	1' 6"
	M		1' 10"	8-1/2"	1' 9-1/2"	2'2-3/4"	3' 0-1/4"	3' 9-3/4"	1' 5-1/2"
	N		1' 11-5/8"	10"	2' 0"	2' 3-1/2"	3' 1-3/4"	4' 0"	1' 7"
	P		2' 0-3/8"	11"	2' 1-1/4"	2' 6-1/4"	3' 5-3/4"	4' 5-1/4"	1' 9"
	Q		2' 2-1/4"	11"	2' 3"	2' 8-1/8"	3' 8-3/4"	4' 9-3/8"	1' 11"
	R		2' 3"	1' 1"	2' 7-1/4"	3' 0-3/4"	4' 2-3/4"	5' 4-3/4"	2' 4"
J	Q	D	2' 6-1/4"	11"	2' 2-1/4"	3' 3-1/8"	4' 3-3/4"	5' 4-3/8"	1' 11"
		E	2' 7"						
	R	D	2' 7-1/4"	1' 1"	2' 5-1/2"	3' 7-3/4"	4' 9-3/4"	5' 11-3/4"	2' 4"
		E	2' 8"						
	S		2' 11-3/4"	1' 3"	2' 8"	3' 7-7/8"	4' 11-3/4"	6' 3-5/8"	2' 6-1/2"

NOZZLE ARRANGEMENTS

NO. OF PASSES	COOLER IN	COOLER OUT	CONDENSER IN	CONDENSER OUT
1	A	D	G	K
	D	A	K	G
2	B	C	J	H
	C	B	M	L
	E	F	-	-
	F	E	-	-
3	A	D	-	-
	D	A	-	-

NOZZLE SIZES

SHELL CODE	COOLER NO. OF PASSES 1	COOLER NO. OF PASSES 2	COOLER NO. OF PASSES 3	CONDENSER NO. OF PASSES 1	CONDENSER NO. OF PASSES 2
L	10"	8"	6"	10"	8"
M	10"	8"	6"	12"	10"
N	12"	10"	8"	16"	10"
P	14"	10"	8"	16"	12"
Q	16"	12"	10"	18"	14"
R	18"	14"	12"	18"	16"
S	18"	16"	14"	18"	18"

NOTES:

1. All dimensions are approximate. Certified dimensions are available upon request.
2. Standard water nozzles are furnished with 150 lb. ANSI raised face flanges. Companion flanges, nuts, bolts and gaskets are not furnished. Victaulic groove connections, suitable for victaulic or welded connections, are available (Consult YORK Marketing for exact availability of victaulic connections for condenser water circuit.
3. One, two and three pass nozzle arrangements are available only in pairs shown and for all shell codes. Any pair of cooler nozzles used in combination with any pair of condenser nozzles. Compact water boxes on one heat exchanger may be used with marine water boxes on the other heat exchanger.
4. Condenser water must enter the water box through the bottom connection for proper operation of the sub-cooler to achieve rated performance.
5. Connected piping should allow for removal of compact water box for tube access and cleaning.

Guide Specifications

Furnish and install where indicated on the drawings _____Gas-Engine-Driven Centrifugal Liquid Chilling Unit(s). Each unit shall produce a capacity of _____ tons cooling ______GPM of water from_____°F to _____ °F when supplied with ______ GPM of tower water at 85°F. Shaft power requirements shall not exceed______HP. Unit COP shall not be less than ______ at full load. The cooler shall be selected for 000025 fouling factor with a maximum chilled water pressure drop of______feet. Evaporator water side shall be designed for 150 psig working pressure. The condenser shall be selected for .00025 fouling factor with a maximum condenser water pressure drop of _____ feet. Condenser water side shall be designed for 150 psig working pressure. The driveline cooling system heat exchanger shall be selected for .00025 fouling factor with a maximum tower water pressure drop of _____feet when supplied with_____GPM of tower water. Power shall be supplied to the unit at 460 volts-3 phase-60 hertz.

Each unit shall ship as two packages; a shell package and a driveline package. Units with the engine mounted on the same base as the shells are not acceptable unless the manufacturer provides a 20 year guarantee against tube failure. The shell package shall include an evaporator, and condenser with integral subcooler. The driveline package shall include a compressor, compressor lubrication system, natural gas engine, air actuated clutch, speed increaser, torsional vibration reducing coupling, power panel, engine PLC panel, and chiller control panel. Interconnecting piping and wiring shall ship loose for field connection. The chiller shall be painted with durable alkyd-modified, vinyl enamel machinery paint prior to shipment.

The unit shall operate with an HFC refrigerant. Chillers that operate with refrigerants having phase out dates are not acceptable. R-11,12, 22, or 500 are not acceptable refrigerants.

The initial charge of oil and refrigerant (HFC-134a) shall be supplied, shipped in containers and cylinders for field installation by the manufacturer.

Driveline

The driveline shall be a skid mounted, factory packaged assembly consisting of a heavy duty, industrial grade, turbocharged-aftercooled gas engine; speed increaser; torsional vibration reducing coupling; air actuated clutch; compressor; and oil reservoir with submersible pump.

Mounting Base --Three Point Suspension

The engine, speed increaser, clutch, and compressor shall be mounted to a common base by the engine manufacturer. The driveline base shall be designed and built by the engine manufacturer to resist deflection, maintain alignment, and to minimize linear vibration.

The driveline base shall be of heavy duty I - beam construction reinforced to maintain equipment alignment during chiller operation. The base shall be a minimum of 18". It shall accommodate an accessory module which shall include an expansion tank, heat exchanger, and instrument panel with engine controls.

The base shall support the full driveline weight on steel spring isolators. The isolators shall be bolted to the base in a 3-point mounting arrangement to help maintain shaft alignment. The isolators shall be installed between the driveline base and mounting surface and shall have either a waffle or ribbed pad on their bottom surface.

Engine

The industrial gas engine shall be manufactured by Caterpillar Inc. The engine shall be a stationary, liquid-cooled, 1000-1800 rpm, four-stroke design, vertical in-line or V-type configuration. The engine shall be equipped with air filters, pressure gauges, lubricating oil cooler and filter, water pump and pressure gauge, service hour-meter, flywheel and flywheel housing.

Structure and Metallurgy - The design of the basic engine shall provide for maximum structural integrity to extend service life. Materials used in the engine shall incorporate the highest level of proven metallurgical and manufacturing technology.

The block shall be of one piece design and cast of high tensile strength iron in the engine manufacturer's own foundry.

Counterboring for cylinder liners shall not be permitted. Cylinder wear surfaces shall be induction hardened over their entire length. Pistons shall be a lightweight aluminum alloy which is elliptically ground across the skirt and tapered from crown to skirt. For medium and high speed engines, compression rings in aluminum bodies shall have integral cast iron ring bands. Compression rings in steel piston crowns shall seat in hardened steel groves. Oil jets shall supply piston cooling and lubricating oil. Valves shall be hard-faced with replaceable inserts.

The crankshaft shall be a one piece design. Multiple section crankshaft will not be acceptable. Connecting rods shall be of high strength steel with tapered pin bore. Drilled passages to supply oil from rod bearing for piston cooling and lubricating oil will not be permitted.

Starting System - The engine starting system shall be either electric or air start.

The electric starting system shall include 24 volt DC starting motor(s), starter relay, and automatic reset circuit breaker to protect against butt engagement. Batteries shall be maintenance free, lead acid type mounted on a corrosion resistant rack near the starting motor.

An air start system shall include air starting motor(s), silencer, start valve, and pressure regulator. The system shall have an operating pressure of 100 psig.

Both systems shall be capable of starting a properly equipped engine within 10 seconds at ambient temperatures greater than 70° F.

Engine Lubrication System - The lubrication oil pump shall be positive displacement type that is integral with the engine and gear driven from the engine gear train. The system shall incorporate full flow filtration with bypass valve to continue lubrication in the event of filter clogging. The chiller manufacture shall be able to provide an optional continuous pre-lube oil pump to lubricate engine components prior to engine starting.

The bypass valve must be integral with the engine filter base or receptacle. Systems with bypass valves located in the replaceable oil filter are not acceptable. Pistons shall be oil cooled by continuous jet spray to the underside or inside of the crown and piston ring.

Gaseous Fuel System - The gaseous fuel system shall consist of gas pressure regulators and carburetors. A balance line between the regulator and engine inlet air manifold shall be provided to compensate for air cleaner restriction and turbocharger boost. Carburetors shall be of the diaphragm type with throttle body with a load screw for air-fuel ratio adjustment.

Ignition System - The unit shall be equipped with an electronic ignition system. The unit shall include detonation sensitive timing. The ignition system shall incorporate a control system that senses and reacts to combustion detonation by controlling ignition timing.

An accelerometer and electronic buffer unit shall be mounted on each side of the cylinder block to detect detonation level (if any). If detonation is detected the electronic timing control shall adjust ignition timing to eliminate detonation.

Governor - The engine governor shall be a Woodward Electronic Speed Control with EG Electro-Hydraulic Actuator. Speed shall be sensed by a magnetic pickup off the engine flywheel ring gear. A provision for remote speed adjustment shall be included to allow the chiller control panel to adjust engine speed based on load.

Cooling System - All waterside heat rejection from the driveline shall be accomplished through a manifolded assembly of heat exchangers such that only a single point tower water supply and return connection is required. The engine jacket water cooling system shall be a closed circuit design with provision for filling, expansion, and deaeration. The engine water pump shall be driven by the engine. The engine jacket coolant loop shall in turn be cooled with a plate type heat exchanger operating with cooling tower water. The chiller manufacturer shall be able to provide an optional jacket water heater to warm the engine water to operating levels prior to starting. Aftercooler and engine oil coolers shall be plate and frame type heat exchangers. Coolant pumps required for heat exchangers or separate circuit aftercooling shall be engine driven. Coolant temperature shall be regulated to disconnect external cooling systems until operating temperature is achieved.

Inlet Air System - The engine air cleaner shall be engine mounted with dry element. If external ducting is required, maximum restriction to the combustion air inlet shall be 27 in H_2O.

Turbocharging - Only single stage turbocharging shall be allowed. The turbocharger shall be of the axial turbine type driven by engine exhaust gases and direct - connected to the compressor supplying engine combustion air.

Aftercooling aftercooler(s) shall be provided to lower the air\fuel mixture's temperature after compression. Aftercooler core air surfaces shall be coated with a corrosion inhibitor to minimize oxidation.

Speed Increaser - The system driveline shall be equipped with a factory aligned gear-set that increases the rotating speed from full load engine RPM to 3600 RPM for input to the compressor. The speed increaser shall be supplied with face hardened, double helical gears and sleeve bearings.

Torsional Coupling - A torsional coupling shall be selected to assure that excessive torsional vibration levels are not transmitted to the gearbox and compressor at all operating speeds.

Air Actuated Clutch - The unit shall be equipped with a drive disconnect. The drum type clutch shall be air actuated and specifically designed and manufactured for heavy equipment applications. The clutch shall allow the engine to warm up before engaging and loading the compressor. The clutch shall also allow the engine to complete a cool down sequence, as recommended by the engine manufacturer, without the compressor being engaged. Units without a clutch shall not be considered.

Compressor

The compressor shall be a single stage centrifugal type. Screw compressors are not acceptable. The housing shall be fully accessible with vertical circular joints. The complete operating assembly shall be removable from the compressor and scroll housing. Compressor castings shall be designed for a minimum working pressure of 200 psig and hydrostatic pressure tested at a minimum of 300 psig. The rotor assembly shall consist of a heat treated alloy steel drive shaft and impeller shaft with a cast aluminum, fully shrouded impeller. The compressor shaft shall be laser aligned to the speed increaser in the factory. The impeller shall be designed for balanced thrust and is dynamically balanced, and overspeed tested for smooth, vibration free operation. Insert type journal bearings shall be fabricated of aluminum alloy, precision bored and axially grooved.

Internal single helical gears with crowned teeth shall be designed so that more than one tooth is in contact at all times to provide even distribution of the compressor load. Each gear shall be individually mounted in its own journal and thrust bearings to isolate it from impeller and drive forces.

The open drive compressor shaft seal shall consist of a spring loaded, precision carbon ring, high temperature elastometer "O" ring static seal, and stress relieved, precision lapped collars. The seal shall feature a small face area and low rubbing speed. It shall provide an efficient seal under high pressure conditions. The seal shall be oil flooded at all times and pressure-lubricated during compressor operation.

Capacity control shall be achieved by use of impeller speed variation and prerotation vanes. Engine speed and prerotation vane position shall be automatically controlled by the chiller control panel to maintain leaving chilled liquid temperature at the desired setpoint without overloading the engine. Engine speed shall be set to optimize energy efficiency. At operating conditions requiring less than full impeller speed, engine speed shall be reduced to improve system efficiency. The unit shall be capable of operating with entering condenser water as low as 60° F at full load without need for a condenser water bypass. Also, the chiller shall be able to operate with lower condenser water temperature during part load operation.

Compressor Lubrication System

Lubrication oil shall be force-fed to all bearings, gears, and rotating surfaces by an oil pump which operates prior to start-up and continuously during operation and during coastdown. A gravity-fed oil reservoir shall be built into the top of the compressor to provide lubrication during coastdown in the event of a power failure. An oil reservoir, separate from the compressor, shall contain a submersible oil pump and two immersion-type oil heaters, thermostatically controlled to remove refrigerant from the oil. Oil shall be filtered by an externally mounted replaceable cartridge oil filter equipped with service valves, and cooled by a water cooled oil cooler before entering the compressor. Oil piping on the driveline shall be completely factory installed. Interconnecting oil piping between the shell and driveline skid must be provided for and installed in the field.

Evaporator

The evaporator shall be of the shell-and-tube, flooded type, designed for 180 psig working pressure on the refrigerant side, and tested at 270 psig. The shell shall be fabricated from rolled carbon steel plate with fusion welded seams; have carbon steel tube sheets, drilled to accommodate the tubes; and intermediate tube supports spaced no more than three feet apart. The refrigerant side shall be designed, tested and stamped in accordance with ASME Boiler and Pressure Vessel Code, Section VIII-Division 1. Tubes shall be high efficiency, externally and internally enhanced type. Each tube shall be roller expanded into tube sheets providing a leak-proof seal. Tubes shall be individually replaceable. Water velocity through the tubes shall not exceed 12 FPS. Two liquid level sight glasses shall be located on the side of the shell to aid in determining proper refrigerant charge. The evaporator shall have a refrigerant relief device sized to meet the requirements of ASHRAE 15 Safety code for Mechanical Refrigeration.

Water boxes shall be removable to permit tube cleaning and replacement. Stubout water box connections with 150 lb ANSI raised face flanges shall be provided. Water boxes shall be designed for 150 psig design working pressure and be tested at 225 psig. Vent and drain connections with plugs shall be provided in each water box.

Condenser

The condenser shall be of the shell-and-tube type, designed for 180 psig working pressure on the refrigerant side, and tested at 270 psig. The shell shall be fabricated from rolled carbon steel plate with fusion welded seams; have carbon steel tube sheets, drilled to accommodate the tubes; and intermediate tube supports spaced no more than four feet apart. An integral refrigerant subcooler shall be provided for improved cycle efficiency. The refrigerant side shall be designed, tested and stamped in accordance with ASME Boiler and Pressure Vessel Code, Section VIII-Division 1. Tubes shall be high efficiency, externally and internally enhanced type. Each tube shall be roller expanded into tube sheets providing a leak-proof seal. Tubes shall be individually replaceable. Water velocity through the tubes shall not exceed 12 FPS.

Water boxes shall be removable to permit tube cleaning and replacement. Stubout water box connections with 150 lb ANSI raised face flanges shall be provided. Water boxes shall be designed for 150 psig design working pressure and be tested at 225 psig. Vent and drain connections with plugs shall be provided in each water box.

Refrigerant Flow Control

Refrigerant flow to the evaporator shall be controlled by a variable orifice. The variable orifice control shall automatically adjust to maintain proper refrigerant level in the condenser and evaporator. This shall be controlled by monitoring refrigerant liquid level in the condenser, assuring optimal subcooler performance.

Chiller Microcomputer Control Center

Each unit shall be furnished complete with a micro computer control center in a locked enclosure. The chiller shall be controlled through a single panel. The panel shall have the capability to control inlet guide vane position as well as engine speed in response to chiller load requirements. The control center shall include a 40 character alphanumeric display showing all system parameters in the English language with numeric data in English or metric units.

Digital programming of setpoints through a color coded, non-tactile keypad shall include: leaving chilled liquid temperature, percent engine load limit, seven day time clock for starting and stopping chiller and pumps (complete with holiday schedule), remote reset temperature range, and data logger.

Security access shall be provided to prevent unauthorized change of setpoints, to allow local or remote control of the chiller, and to allow manual operation of the prerotation vanes and compressor oil pump.

All safety and cycle shutdowns shall be annunciated through an alpha numeric display and consist of day, time, cause of shutdown, and type of restart required. Safety shutdowns shall include: low evaporator pressure, high condenser pressure, auxiliary safety, high discharge temperature, faulty discharge temperature sensor, high compressor oil temperature, power failure (manual restart), compressor rotation fault, engine overload, loss of chilled water flow, high engine water temperature, low engine oil pressure, low compressor oil pressure, high compressor oil pressure, evaporator transducer or probe error, clutch failure, manual engine shutdown, faulty compressor oil pressure transducer, proximity sensor fault, high speed thrust bearing oil drain temperature, faulty proximity probe, open thermocouple probe, engine cranking, engine fault, engine overspeed, compressor overspeed, engine PLC fault, engine panel shutdown, surge shutdown, 24V DC fault, faulty condenser pressure transducer and remote stop (field supplied signal). Cycling shutdowns shall include: low compressor oil temperature, power failure (auto restart), low chilled water temperature, remote unit cycling, multi unit cycling, internal time clock, vanes open, compressor low differential oil temperature, DC under-voltage, and aftercooler high water temperature (manual restart required), remote/local cycling devices and multi-unit sequencing.

System operating information shall include: return/leaving chilled liquid temperature, return/leaving condenser liquid temperatures; evaporator/condenser refrigerant pressures; differential compressor oil pressure, percent engine load, evaporator/condenser saturation temperatures, compressor discharge temperature, compressor oil temperature, operating hours, number of starts counter engine oil pressure, engine manifold pressure, engine jacket water temperature and engine speed.

The chiller shall be provided with an RS-232 port to output all system operating data, shutdown/cycling messages, and a record of the last four cycling or safety shutdowns to a remote printer (field supplied). The control center shall be programmable to provide data logs to the optional printer at a preset time interval.

The control center shall be able to interface with a building automation system to provide remote chiller start/stop; reset of chilled water temperature; remote engine load limit; and status messages indicating chiller is ready to start, chiller is operating, chiller is shutdown on a safety requiring a manual reset, and chiller is shutdown on a cycling safety.

The operating program shall be stored in non-volatile memory (EPROM) to eliminate chiller failure due to AC power failure\battery discharge. In addition, programmed setpoints shall be retained in lithium battery-backed TRC memory for a minimum of 5 years.

Variable Speed Control

Capacity control shall be achieved by use of prerotation vanes and varying engine speed. Capacity control logic shall be matched to the specific chiller/compressor system. Control logic shall continually integrate the actual chiller operating conditions, including chilled water temperature and temperature set point, evaporator and condenser refrigerant pressures, engine speed and prerotation vane position. Prerotation vane position and engine speed shall be automatically controlled by the chiller control panel to maintain leaving chilled liquid temperature at the desired setpoint. Engine speed shall be set to optimize chiller energy efficiency. The unit shall be capable of operating with lower water temperature cooling tower water during part load operation. Prerotation vane position shall be automatically controlled by an external electric actuator.

Power Panel

The power panel enclosure shall house the following components: single point wiring connection for incoming power supply; fused disconnect switch, main fuses, compressor oil pump motor starter with overloads; heater relay; circuit breakers for 115 VAC, 60 Hz, 3 KVA control supply transformer.

Natural Gas Engine Controls

The engine mounted instrument panel shall consist of a shock-mounted formed and welded enclosure primed for coastal environment and finished in semi-gloss enamel. Metric/English marked gauges with a minimum 2.5 inches diameter dial face shall be mounted in a brushed stainless steel face panel with pressure instruments piped to bulk head connections in the enclosure bottom. Gauges shall include: engine oil pressure, oil filter differential, fuel pressure, and jacket water temperature. As part of the engine control/safety system the engine and related components shall be monitored and provided with gauges or safety shutdowns to protect against any system failures. The safety shutoffs shall be low oil pressure, high water temperature, low water level and overspeed.

Isolation Mounting

The unit shall be provided with vibration isolation mounts for both the driveline and shell assemblies. These level adjusting, spring isolators shall be designed for one inch deflection. The driveline shall be balanced on four vibration isolator assemblies using a three point mounting system. The isolator assemblies shall be installed between the driveline base and the mounting surface and shall have a waffle or ribbed pad on their bottom surface. The shell package shall be provided with four vibration isolation mounts. The vibration isolator assemblies shall be installed under the tube sheets and shall be provide with non-skid pads.

Testing

Prototype Testing - The system manufacturer must be able to certify that the engine, compressor, speed increaser, and controls have been tested as complete systems of representative engineering models (not on equipment sold).

Specific prototype tests shall include:

ENGINE:

Performance (part load, full load)
Oil Consumption
Fuel Consumption
Exhaust Emissions
Noise Levels (mechanical and exhaust)
Startability (cold and hot ambients)
Piston, Ring, and Liner Wear Rates
Piston Structural Integrity
Lubrication System Evaluation
Cooling System Evaluation
Valve Train Overspeed Qualification
Deep Thermal Cycle Endurance
Field Endurance

GAS ENGINE COMPRESSOR DRIVELINE:

Mechanical Compatibility
Structural Integrity
Mounting Evaluation
Wiring Compatibility
Control Panel Functionality
Linear Vibration Measurement
Torsional Vibration Analysis
Part Load Performance
Safety Shutdowns and Alarms
Start-Stop Evaluations

Production Testing - The refrigerant compressor shall be air run tested at the compressor manufacturers test facility prior to mounting on the driveline assembly. The engine shall be run tested at full and part loads prior to assembly of the driveline. The driveline package shall be run tested after assembly at conditions that fully load the engine at the engine manufacturer's test facility. The testing of the assembled driveline shall insure smooth, defect free operation. Field or assembly shop tests are not acceptable. A certified report of these tests shall be available when requested at the time of chiller order.

Start-up and Operator Training

Factory trained field service representatives shall supervise the final leak testing, charging and the initial start-up. The complete installation shall be checked for procedural and operational compliance by a factory trained service representative from the chiller manufacturer. The chiller manufacturer shall retain factory trained service representatives of the engine manufacturer to provide start up service and operator instruction for the gas engine.

Warranty and Service

The manufacturer's standard warranty shall be for a period of one year from the date of start-up or eighteen months from shipment, whichever occurs first. The warranty shall include parts and labor during this period. Additionally, the unit manufacturer shall provide, at no additional cost to the owner, a complete one year service contract. The contract shall include all recommended service and preventative maintenance required by the chiller and engine manufacturer during the first year of operation or 3000 operating hours, whichever comes first. This service shall only be performed by factory trained service personnel. The chiller manufacturer shall have a local direct service office that can provide factory trained and authorized servicemen, the required stock of replacement parts, technical assistance, and warranty administration. Engine maintenance shall only be performed by the engine manufacturer's local, factory trained, authorized representative.

SI Metric Unit Conversion

Values provided in this manual are in the English inch-pound (I-P) system.
The following factors can be used to convert from English to the most common SI Metric values.

MEASUREMENT	MULTIPLY THIS *ENGLISH* VALUE	BY	TO OBTAIN THIS *METRIC* VALUE
CAPACITY	TONS REFRIGERANT EFFECT (ton)	3.516	KILOWATTS (kW)
POWER	KILOWATTS (kW)	NO CHANGE	KILOWATTS (kW)
	HORSEPOWER (hp)	0.7457	KILOWATTS (kW)
FLOW RATE	GALLONS / MINUTE (gpm)	0.0631	LITERS / SECOND (L/s)
LENGTH	FEET (ft)	304.8	MILLIMETERS (mm)
	INCHES (in)	25.4	MILLIMETERS (mm)
WEIGHT	POUNDS (lb)	0.4536	KILOGRAMS (kg)
VELOCITY	FEET / SECOND (fps)	0.3048	METERS / SECOND (m/s)
PRESSURE DROP	FEET OF WATER (ft)	2.989	KILOPASCALS (k Pa)
	POUNDS / SQ. INCH (psi)	6.895	KILOPASCALS (k Pa)

TEMPERATURE

To convert degrees Fahrenheit (°F) to degrees Celsius (°C), subtract 32° and multiply by 5/9 or 0.5556.

To convert a temperature range (i.e., 10°F or 12°F chilled water range) from Fahrenheit to Celsius, multiply by 5/9 or 0.5556.

EFFICIENCY

In the English I-P system, chiller efficiency is measured in kW / ton:

$$\text{kW / ton} = \frac{\text{kW input}}{\text{tons refrigerant effect}}$$

In the SI Metric system, chiller efficiency is measured in Coefficient of Performance (COP).

$$\text{COP} = \frac{\text{kW refrigeration effect}}{\text{kW input}}$$

kW / ton and COP are related as follows:

$$\text{kW / ton} = \frac{3.516}{\text{COP}}$$

$$\text{COP} = \frac{3.516}{\text{kW / ton}}$$

INTEGRATED PART LOAD VALUE (IPLV)

In the English I-P system, IPLV is calculated by the following formula. A full explanation is shown on page 3:

$$\text{IPLV or APLV} = \frac{1}{\frac{0.17}{A} + \frac{0.39}{B} + \frac{0.33}{C} + \frac{0.11}{D}}$$

Where:
- A = kW / ton at 100% Load
- B = kW / ton at 75% Load
- C = kW / ton at 50% Load
- D = kW / ton at 25% Load

In SI Metric, the formula is:

$$\text{IPLV or APLV} = 0.17A + 0.39B + 0.33C + 0.11D$$

Where:
- A = COP at 100% Load
- B = COP at 75% Load
- C = COP at 50% Load
- D = COP at 25% Load

FOULING FACTOR

ENGLISH I-P (ft^2 °F hr/Btu)	EQUIVALENT SI METRIC (m^2 °C/W)
0.00025	0.000044
0.0005	0.000088
0.00075	0.000132

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